Strategic alliances and financial constraints from patent assertion entities' lawsuits

Abstract

The detrimental effects of patent lawsuits filed by patent assertion entities (PAEs) have received significant attention in past research. It has been shown that these lawsuits impose substantial costs to alleged infringing companies, thereby altering their financing opportunities. However, much less research exists on potential coping strategies defendant companies may implement to face the financial burdens of PAE lawsuits. In this study, we argue that the cost impact of PAE litigation increases defendant companies' financial vulnerability, leading them to form strategic alliances in response. Partnership formation is viewed as a resource-providing mechanism that defendant companies can activate to alleviate the financial constraints induced by PAE litigation. With a panel data set of U.S. high-tech companies, we confirm that those suffering from PAE litigation form more partnerships than their non-PAE-litigated counterparts. We also corroborate that the association between partnership formation rate and PAE-litigation status relates to defendant companies' financial vulnerability. PAE-litigated companies are more financially constraints than non-PAE-litigated companies, and increases in defendant companies' financial vulnerability amplify the effect of PAE litigation on partnership formation. Compared to non-PAE litigations, our results suggest that PAE lawsuits are sufficiently costly to trigger defendant companies' partnership formations to mitigate involved financial constraints.

Keywords: Strategic alliances, patent assertion entities, patents, litigation costs, financial constraints, financing strategies.

JEL codes: G32, K41, M41, O34

1. Introduction

The growth of patent lawsuits in the U.S. has raised significant concerns due to the financial burdens imposed on defendant companies (Bessen and Meurer, 2012; Mezzanotti and Simcoe, 2019). These concerns are mainly raised in patent lawsuits involving patent assertion entities (PAEs), intermediary agents in technology markets specialized in building patent portfolios monetized through licensing fees and litigation (Bessen et al., 2018; Fischer and Henkel, 2012; Pénin, 2012). Past research shows that PAEs aim to maximize compensation awards from alleged patent infringements (Chien, 2008; Geradin et al., 2012; Orsatti and Sterzi, 2023; Reitzig et al., 2007). PAEs reach overcompensations partly due to the legal rules governing damage awards, which strongly safeguard the rights of patent holders (Mezzanotti, 2021; Reitzig et al., 2007), thereby exacting substantial costs upon infringing companies. Several studies have underscored defendants' detrimental effects from PAE litigations, including reductions in research and development (R&D) investments (Cohen et al., 2016; Smeets, 2014) and innovation rates (Pohlmann and Opitz, 2013). Also, PAE litigation is associated with start-ups' difficulties in growing (Appel et al., 2019) and securing financial funds from venture capital markets (Kiebzak et al., 2016). Moreover, PAE litigations have been shown to cause negative spillover effects affecting market value and R&D strategies of sued companies' technological peers (Chen et al., 2023). All these impacts are sizable for the U.S. economy if we consider the increasing rate of PAE litigation observed in the last decades (Abrams et al., 2019).

While extant literature predominantly concentrates on evaluating the impact of PAE assertions on defendant companies, a comprehensive understanding requires an examination of the coping mechanisms these companies may activate in response to the consequences of PAE litigations. Identifying these mechanisms is helpful as they may clarify significant shifts in defendants' behavior and facilitate an appraisal of the nature of the impact of the PAE litigation.

In this study, we argue that, by creating financial vulnerability, PAE litigation leads defendant companies to form strategic alliances in response. This vulnerability arises because defendant companies must divert resources initially devoted to financing their operating costs to cover substantial litigation expenses. Also, PAE litigation worsens financiers' perceptions about the defendant companies' prospects to reach profits, making it harder to access these companies for external financing. By using

theory based on the resource-based view (RBV), we posit that strategic alliances serve as a mechanism for resource provision during challenging circumstances (Eisenhardt and Schoonhoven, 1996; Lavie, 2006; Miner et al., 1990), with PAE litigation representing a salient adverse event requiring remedy actions. Next, we link the RBV theory on strategic alliances with studies on financial economics analyzing the role of partnership formation in financing firms' activities amidst financial constraints (Czarnitzki and Hottenrott, 2017; Lerner et al., 2003; Levitas and McFadyen, 2009). From these studies, we contend that partnership formation may alleviate the financial constraints related to PAE litigation by facilitating access to complementary assets and accelerating new product launches.

In line with the previous arguments, and based on data from a sample of U.S. high-intense-technology companies for 2003-2008, we first document evidence showing a strong positive association between firms' strategic alliance formation rate and PAE litigation status. Empirical estimations conducted under various specifications corroborate that PAE-litigated companies form more strategic alliances vis-à-vis non-PAE-litigated counterparts, even after accounting for factors potentially driving both strategic alliance formation and PAE litigation status. In contrast, no association is observed between the firms' partnership formation rate and litigation status for non-PAE lawsuits. This result supports the idea that PAE-litigation is sufficiently costly to encourage partnership formation. The average treatment effect on the treated (ATT) obtained from an endogenous treatment effect estimation reveals that the average firm in the PAE-litigated condition announces 1.88 more strategic alliances than it would announce if it were not PAE-litigated. Also, it is observed that differences in the partnership formation rate between PAE-litigated and non-PAE-litigated companies remain for several periods and that these differences are robust to treatment effect heterogeneity.

Following, we examine whether the positive association between firms' strategic alliance formation and PAE-litigation status is induced by sued companies' needs to alleviate financial constraints related to PAE litigation. To reach this, we first examine whether PAE-litigated companies are more financially constrained than their non-PAE-litigated counterparts. Our evidence confirms that PAE-litigated companies experience higher sensitivities of their operating costs to internal liquidity stocks than non-PAE-litigated companies, signaling that the former are more financially constrained. This finding aligns with the idea that PAE-litigated companies depend more on their internal financial

resources to fund their operations, possibly because of difficulties in obtaining external financing. Second, we examine whether variations in financial vulnerability drive the induced impact of PAE litigations on the firms' partnership formations. We use variations in both the firms' internal liquidity stocks and litigation costs to examine changes in financial vulnerability. We assume that financial vulnerability increases as firms' internal liquidity stocks decrease and litigation costs rise. We expect PAE litigation's provoked effect on firms' partnership formations to magnify as financial vulnerability increases. Our results confirm this expectation, showing that reductions in the firms' internal liquidity stocks and increases in litigation costs amplify the formation of strategic alliances incited by PAE litigation.

Our research makes the following contributions to related literature. First, it contributes to the scarce literature examining firms' reactions to PAE litigation. Research in the area primarily considers the effects of PAE assertion activities on the behavior of potential targets. Unlike previous studies, we look at the behavior of defendant companies directly involved in lawsuits. For instance, Reitzing et al. (2007) and Henkel and Reitzing (2010) theoretically predict that potential PAE targets may want to substitute technologies with a high infringement risk before infringing such technologies. Chen et al. (2023) empirically corroborate that prediction, reporting evidence that PAE-litigated companies' technological peers increase their R&D investments in workaround technologies to reduce their dependency on technologies subject to high PAE litigation risks. Similarly, Abrams et al. (2019) and Orsatti and Sterzi (2023) report reductions in the number of citations a patent receives after being acquired by a PAE, suggesting that firms avoid investments related to patents being transferred to PAEs to reduce involved litigation risks. In contrast, our evaluation explicitly considers defendant companies' reactions regarding partnership formations as a response to PAE litigation. Another distinction is that we focus on examining strategies mitigating the harmful effects of PAE litigation on sued companies rather than examining preventive actions potential targets may adopt to forestall PAE litigation consequences.

Second, our research contributes to the literature analyzing the financial benefits of partnership formation (Czarnitzki and Hottenrott, 2017; Lerner et al., 2003; Levitas and McFadyen, 2009). This literature examines the role of strategic alliances in alleviating financial constraints that affect the firms'

financing of R&D activities. Funding R&D is troublesome, given the asymmetric information between the firms and financiers regarding the value of these activities (Hall, 2009; Himmelberg and Petersen, 1994). As a result, external financing becomes less accessible, pushing firms to accrue internal liquidity to fund part of their R&D (Fazzari and Petersen, 1993; Levitas and McFadyen, 2009). Our research identifies PAE litigation as a different cause of financial constraints that may affect not only R&D financing but also the funding of the firms' operating costs. Our evidence shows that more financial vulnerability involved by PAE litigations leads companies to form strategic alliances, strongly suggesting that partnership formation is activated because of its potential benefits in providing resources that sued companies cannot fund from external financing at commensurable costs.

Finally, this research contributes to the literature examining the financial impact of PAE litigation. This literature focuses on assessing the effects on the financing of new ventures (Appel et al., 2021; Kiebzak et al., 2016), while other studies determine the impact on sued companies' equity financing (Bessen et al., 2011; Bessen and Meurer, 2008). We complement these studies by showing that PAE-litigated companies depend more on their internal liquidity stocks than their non-PAE-litigated counterparts to finance their operating costs. This new evidence indicates that PAE-litigated companies suffer from financial constraints, proving that PAE-involved financing restrictions affect both start-ups and publicly traded companies.

Next, we present the background used to frame the problem of the study. Then, we describe the data used in the empirical analysis. The methods and empirical examinations are subsequently reported. Finally, the paper presents a discussion and concluding remarks.

2. Background

2.1 To hide, seek and sue: Features of a PAE's business model

With the transformation of modern economies into systems that generate knowledge, the technology markets have gained relevance, and with them, the exchanges of intellectual property rights (IPRs) (McDonough III, 2006). This evolution has given rise to intermediary agents, such as non-practicing entities (NPEs), who specialize in managing these exchanges (Orsatti and Sterzi, 2023). A significant feature of NPEs is that they barely or never practice their patents, focusing their attention instead on monetizing their IPRs through licensing fees and patent litigation. As indicated by Pénin

(2012), practicing a patent entails manufacturing and commercializing the products protected by the patent and then capturing the rents that patent protection can yield. In contrast, NPEs do not earn revenues by producing and selling tangible products.

As identified in prior research, NPEs can be broadly categorized into two groups (Abrams et al., 2019; Leiponen and Delcamp, 2019; Pénin, 2012). The first comprises patent brokers who facilitate transactions between inventors lacking resources and companies capable of bringing patented products to markets. In terms of Abrams et al. (2019), these agents behave as 'benign middleman' because they enhance market efficiency and stimulate innovation among individual inventors and small entities (Benassi and Di Minin, 2009; Geradin et al., 2012; McDonough III, 2006; Shrestha, 2010). The second category encompasses patent assertion entities (PAEs), whose primary objective is to extract economic rents through patent enforcement rather than innovation (Bessen et al., 2011; Reitzig et al., 2010). This category includes what Abrams et al. (2019) view as 'stick-up artist', or agents exploiting the patent system rules to extract rents. A way to conceive the business model of PAEs is to use the characterization of Henkel and Reitzig (2008), who define these entities by three actions: hide, seek, and sue. A PAE hides its patents, seeks alleged infringers, and then sues them to generate revenues.

PAE assertion activities have witnessed significant growth in the U.S., particularly within high-tech industries (Chen et al., 2023; Cohen et al., 2019; Fischer and Henkel, 2012; Leiponen and Delcamp, 2019). This growth can be attributed to various institutional factors, including favorable litigation frameworks and the ambiguity of patent boundaries, which are especially prevalent in sectors like the software industry. Despite debates surrounding the role of NPEs in technology markets, concerns persist regarding the adverse effects of PAEs' activities on targeted companies. Legislative efforts, such as the Leahy-Smith America Invents Act (AIA) of September 2011, have been introduced to curb these activities. However, evidence indicates that PAE activities continue to expand, raising concerns about the potential damages inflicted by these entities.

2.2 PAE litigation impact on firms' financial constraints

The underlying idea of our study is that PAE litigation enhances the vulnerability of sued companies by increasing their financial constraints. This is due to the substantial costs imposed on defendant companies associated with PAE litigation. These costs may distort the financing options of

sued companies by altering how they use their internal resources and reducing their chances of securing funds from capital markets. The impact of PAE litigation costs put sued companies in vulnerable strategic positions for which resources available through strategic alliances would be beneficial.

2.2.1 Costs of PAE litigation

Patent litigation imposes substantial costs on infringing companies. The American Intellectual Property Law Association (AIPLA)'s (2013) estimates that the average litigation costs for a patent dispute, only considering legal fees, can range from $650,000 for trials when less than $1 million is at risk to $5 million if more than $25 million are at risk. These costs are particularly sizable in the case of PAE litigation (Chen et al., 2023; Tucker, 2014). The reason is that PAEs develop enhanced bargaining power during patent disputes. Several factors explain this issue. First, they gain negotiation power by exploiting holdup situations. In our context, a holdup problem arises when an alleged infringer has invested heavily in designing, manufacturing, and commercializing a product with features infringing a PAE's patent (Reitzig et al., 2007). Lemley and Shapiro (2006) show that this holdup problem is exacerbated when a preliminary injunction threat exists. In this case, this threat commonly pushes alleged infringers to overcompensate PAEs during patent disputes. Second, PAEs can negotiate overcompensations because litigated companies cannot countersue them (Chen et al., 2023). Companies often engage in a tacit "Intellectual Property Truce", where neither firm is willing to sue others for infringing on its patents, as the threat of being countersued is a deterrent (Lemus and Temnyalov, 2017). For instance, this is the case in information and communication industries where patent thickets and cross-licensing are commonplace (Ziedonis, 2004). In these industries, potential litigation costs induce companies to be stuck to tacit non-aggression strategies (Reitzig et al., 2007). In contrast, while PAEs do not either design, manufacture, or commercialize any product, they are not affected by the threat of being countersued by their targets. For instance, as PAEs are non-practicing entities, they are immune to preliminary injunction threats during patent lawsuits and do not fear being borne with high costs from countersuits.

Finally, legal environments increasing patent-holders' rights also improve PAEs' bargaining positions. As suggested by Mezzanotti (2021), having substantial patent rights may increase frivolous patent litigation based on guarantees the legal system rules give to patent holders. PAEs commonly use

existing legal loopholes to be overcompensated in courts, demonstrating that "being infringed" is a more valuable strategy than ex-ante licensing (Henkel and Reitzig, 2008; Reitzig et al., 2010).

To illustrate the impact that PAE litigation costs may impose on sued companies, let us consider the Congressional testimony of John Boswell, current Senior Vice President, Chief Legal Officer, and Corporate Secretary of SAS, the known software company, regarding a legal fight against a PAE (Executive Office of the President, 2013):

> *"(...) If SAS ultimately wins this case, it will be a Pyrrhic victory at best. We spent $8 million and huge amounts of developer time and executive time, etc., for what? This victory does not resolve the other patent troll[1] cases that we face or will face in the future. This $8 million and the millions more we are spending on other cases is money SAS no longer has to invest in people, facilities, research, or product development, and we are a relatively small player in this world... It does not cost much to be a troll and to make broad, vague demands. On the other hand, the risk to the company receiving a troll threat is enormous."*

This testimony allows us to identify two critical sources of litigation costs. First, we find direct costs or those Bessen and Meurer (2007) identify as legal costs, including expenses associated with patent infringement disputes like attorney fees, court expenses, and damage awards. Second, we find indirect costs, or those Bessen and Meurer (2007) classify as business costs of litigation, which comprise elements such as the opportunity costs of time invested by managers in preparing firms' defense in courts, management distractions, disclosure of strategic information during trials, and changes in the alleged infringing firms' strategies. Chien (2013) views the indirect costs as having a significant operational impact, implying that they potentially affect how alleged infringing firms exploit their business models. Besides, Bessen and Meurer (2007) posit that the indirect costs can be much larger than the direct ones, indicating that a suitable assessment of the risk of inadvertent infringements requires considering both sources of costs.

Additional estimations by Bessen and Meurer (2008) show that patent lawsuits filed by PAEs cost defendant companies $29 billion. This amount raises to $80 billion annually when indirect costs like employee distractions are considered[2]. These figures are economically relevant considering that

[1] The term "patent troll" in this context refers to PAEs' litigation cases faced by the company.
[2] Bessen (2014, December 11): Why supreme courts' Alice ruling doesn't solve patent troll problem. The Hill. https://thehill.com/blogs/congress-blog/technology/223656-why-supreme-courts-alice-ruling-doesnt-solve-patent-troll/

U.S. businesses spend on R&D $247 billion per year. Thus, only considering the direct costs of PAE litigations, they may consume approximately 11% of the resources that could be invested in R&D[3].

2.2.2 Defendant companies' financial constraints

We argue that the costs of PAE litigation exacerbate the financial constraints sued companies face in several ways. One is by leading defendant companies to deviate resources from their primary business activities to cover others associated with their defense over the PAE litigation process (Bessen et al., 2011; Federal Trade Commission, 2016; Kiebzak et al., 2016). This fact reduces the resources available to finance the defendant companies' operating costs (Arena and Ferris, 2017). Another is by reducing defendant companies' possibility of securing funds from external sources. The reason for this lies in the perceived risks investors and lenders have about the impact of PAE litigation costs on the business-doing of sued companies. As fundamentals in financial economics predict (Hall, 2009; Himmelberg and Petersen, 1994; Myers and Majluf, 1984), firms' possibilities to secure funds from capital markets is a function of the financiers' perceived risk on the rate of the investments' returns. If the magnitude of PAE-litigation costs is sizable, this risk is expected to rise, thus affecting defendant companies' access to external financing. For instance, PAE litigation may increase the costs of debt financing because lenders will impose risk premia on their required rate of returns to compensate for the risks of the potential consequences of PAE litigation on the functioning of defendant companies. Alleged infringing companies in patent disputes may also experience increases in loan spreads, higher up-front borrowing charges, and more financial covenants and collateral requirements (Arena and Ferris, 2017).

Also, PAE litigation may increase the costs of equity financing. If publicly traded, PAE-litigated companies may face reductions in their market valuation. In doing so, PAE litigation impacts defendant companies' equity financing opportunities. Market value reductions are explained by the perceptions of potential investors in stock markets that PAE litigation can reduce the possibilities of defendant companies to generate profits.

The problem is that investors and lenders find it difficult to disentangle whether the realized firms' outcomes result from their management or prevailing environmental conditions (i.e., patent

[3] Joe Mullin (March 3, 2012). New study, same authors: Patent trolls cost economy $29 billions yearly. *ArsTechnica*. https://arstechnica.com/tech-policy/2012/07/new-study-same-authors-patent-trolls-cost-economy-29-billion-yearly/

enforcement rules and legal system functioning). In line with Arrow (1962) and financial economists (Fazzari et al., 1988; Greenwald et al., 1984; Levitas and McFadyen, 2009; Myers and Majluf, 1984), asymmetric information between firms and lenders/inventors about firms' prospects generates risks and frictions in capital markets that may impede access to external financing at commensurate costs.

Results from prior studies on patent infringement are consistent with the idea that the costs of PAE litigation affect the financial constraints of defendant companies. For instance, Appel et al. (2019) and Kiebzak et al. (2016) show that start-ups involved in PAE lawsuits encounter challenges securing venture capital, further intensifying their financial constraints. Bessen and Meurer (2012) find a 2% market value decline for PAE-litigated firms around the time of lawsuit filings, reflecting the negative perception among investors due to such litigation. In line with this, other studies report evidence that ongoing litigation risk can lower the potential value of firms' initial public offerings (Hanley and Hoberg, 2012; Lowry and Shu, 2002). In addition, Chen et al. (2023) indicate that the loss of market value spills over to sued companies' technology peers, resulting in significant losses for the peers' shareholders. Furthermore, Mezzanotti (2021) shows that reductions in litigation costs positively affect incentives and financial abilities of firms to conduct R&D and innovate.

The upcoming section considers arguments that PAE-litigated companies can leverage strategic alliances to mitigate the detrimental impact of PAE-litigation costs on their financing. This rationale relies on the premise that strategic partnerships enhance defendant companies' access to valuable resources, alleviating their need for additional external funding and reducing dependence on internal financial resources.

2.3 Strategic alliances as a coping strategy to PAE litigation

Now, we study the role of strategic alliances as mechanisms mitigating the financial constraints derived from the costs of PAE litigation. Coherent with RBV studies, we examine the capacity of strategic alliances to finance firms, particularly in unfavorable financial market conditions. When referring to strategic alliances, we consider those voluntary cooperative arrangements among independent firms designed to access, exchange, or share resources to achieve mutually beneficial goals (Grant and Baden-Fuller, 2004; Gulati, 1998; Kogut, 1988). They can take different forms, from collaborative R&D and manufacturing agreements to co-marketing arrangements.

2.3.1 A resource-based view for strategic alliance formation

The RBV is used to motivate the alliance formation behavior of PAE-litigated companies. According to the RBV, firms are conceived as bundles of resources (Peteralf, 1993; Wernerfelt, 1984), which play a critical role in sustaining competitive advantages. Extensions to the RBV of alliance formation consider that firms can improve their performance by leveraging their internal resources with those owned by others (Lavie, 2006). Particularly relevant to our context is the work of Eisenhardt and Schoonhoven (1996) that use strategic motives for explaining alliance formation within the RBV framework. The idea is that strategic alliances are formed when firms facing vulnerable strategic positions need resources that partnerships can provide. Alliance resources include tangible ones like financial assets and technology and intangible ones like reputation and managerial skills (Eisenhardt & Schoonhoven, 1996, p. 137). We apply this reasoning to explain why defendant companies may form strategic alliances in response to PAE lawsuits.

In Eisenhardt and Schoonhoven (1996), a vulnerable strategic position occurs when firms are in difficult market situations or implement risky or expensive strategies. For instance, a vulnerable market situation includes intense market competition. In this case, alliance formation may render a high payoff, given its potential to facilitate access to resources that overcome vulnerability and improve strategic position. For instance, in highly competitive markets, firms are in vulnerable strategic positions because of their low profitability. Resources acquired through alliances may improve these positions by allowing firms to increase their margins through sharing costs or differentiating products. Vulnerability also arises when firms deploy risky strategies. In our context, this may occur when the risk of inadvertently infringing a patent is high. Under previously described circumstances, alliance formation appears because firms suffering vulnerable strategic positions can obtain high payoffs from partnerships. The "need" in a vulnerable position drives the underlying logic explaining alliance formation in Eisenhardt and Schoonhoven's (1996) work.

We use the same "need logic" to justify alliance formation's contribution to improving PAE-litigated companies' strategic position. We argue that PAE litigation creates vulnerability by compromising the financing of sued companies. Substantial litigation costs force companies to divert talent, managerial time, and financial resources away from their primary business activities to cover

such costs (Bessen et al., 2011; Cohen et al., 2014; Federal Trade Commission, 2016; Tucker, 2014), thus distorting sued companies' choices on the utilization of their internal resources. These distortions may produce delays in hiring strategic human capital (Appel et al., 2019) or interruptions in developing new business lines (Chien, 2013), thus creating vulnerability. In addition, given the uncertainty created by the potential impact of PAE litigation costs, sued companies face limited access to external financing. In contrast, in the absence of PAE litigation costs, more financing possibilities would be available to the firm, and much less necessity would exist to seek alternative financing options in partnership formations.

As the theory in Eisenhardt and Schoonhoven (1996) predicts, the payoffs of alliance formation, materialized in our context in reducing own resource requirements and increasing access to alternative external financing sources, would justify the engagement of sued companies in partnerships. In the next section, we identify potential mechanisms through which sued companies may obtain financing from strategic alliances.

2.3.2 The financing role of strategic alliances

Past research on alliance formation highlights the multiple benefits partnerships generate for the involved participants (Ahuja, 2000; Gulati, 1998; Kogut, 1988), with accessing needed resources as one of the most highlighted benefits (Hamel et al., 1989; Levitas and McFadyen, 2009; Park et al., 2002). Although firms' participation in strategic alliances does not yield a direct cash stream, these arrangements may alleviate the firms' need to accrue liquidity for deploying their business operations. Several mechanisms explain how strategic alliances reach this. As Levita and McFadyen (2009) indicated, partnerships may reduce financing needs in at least two ways. One is avoiding the need to acquire and finance complementary assets they access through these agreements, like production facilities or a sales force. Another is by accelerating the product development process and then the prospect of generating cash flows from commercializing new products. In addition, strategic alliances create "options" for exploiting future technological and business opportunities (Kogut, 1991). This fact substantially increases flexibility in the firm's timing to finance these opportunities. These options will require financing resources in the future, depending on how the prospects for emerging opportunities materialize. Our argument is that all these benefits are particularly critical for companies experiencing financial vulnerability. In the absence of vulnerability, these benefits are potentially less relevant. In this

case, firms may exploit their own resources to deploy their strategies, avoiding the costs of partnership formation.

Several studies show how engagement in strategic alliances significantly contributes to mitigating firms' financial constraints. For instance, Levita and McFadyen (2009) find that marketing and commercialization alliances significantly reduce firms' liquidity needs, which supports the conjecture that these alliances mitigate the firms' financial constraints. Czarnitzki and Hottenrott (2017) show that firms participating in collaboration agreements face fewer financial constraints when financing their R&D investments. Hamel et al. (1989) use the case of NEC and its alliances, particularly with Honeywell, to argue how the company leveraged its in-house R&D by exploiting resources accessed through partnerships. In doing so, NEC invested less in R&D as a percentage of revenues than competitors like Texas Instruments and L.M. Ericsson. Lerner et al. (2003) show that when public markets are poor, biotechnology companies are more likely to finance their projects using strategic alliances like research contracts. In line with the notion of strategic vulnerability proposed by Eisenhardt and Schoonhoven (1996), Park et al. (2002) find that firms with a poor endowment of resources are more likely to form strategic alliances, while Han (2023) argues that a firm will strategically decide to ally when its resource constraints can lower its performance.

2.4 Hypothesis

Based on the previous discussion, we hypothesize that PAE-litigated companies have a higher propensity to form strategic alliances than non-PAE-litigated companies. Strategic vulnerability triggered by PAE litigation costs and materialized by enhanced sued companies' financial constraints is conjectured as the factor inducing the positive association between strategic alliance formation and PAE litigation.

Nonetheless, there are reasons to believe that PAE litigation may produce the opposite effect of what we hypothesize on strategic alliance formation. A competitive hypothesis would be that the risk raised by PAE-litigation costs drives away potential partners, making it difficult for PAE-litigated companies to form strategic alliances. Despite the plausibility of this rival hypothesis, several reasons lead us to rule out that possibility. Even in environments with high litigation risks, firms operating in high-tech industries may possess unique capabilities and resources desirable to potential partners. By

forming alliances, those potential partners can leverage these complementary strengths to address market opportunities or challenges they may not be able to tackle independently. Also, some potential partners may take a long-term view of the alliance relationships and be willing to accept short-term risks in exchange for potential long-term benefits. In the context of technological standards, Jones et al. (2021) posit that strategic alliances may create substantial benefits associated with pooling resources among partners that incentivize future cooperation even after critical patent litigation conflicts among partners.

The evidence about the negative spillovers from defendants to associate firms in PAE disputes is mixed. For instance, Tucker (2014) finds that PAE disputes reduce defendant companies' sales without producing this impact on either surrounding products or firms. Lucena and Martin-Sanchez (2020) do not find evidence that market value penalties faced by defendant companies in PAE disputes spill out to their alliance partners. These findings diverge from those of Chen et al. (2023), who document market value penalties imposed on defendant companies' technology peers. One plausible explanation for these disparities is that negative spillovers are contingent upon the degree of technological similarity between PAE-litigated companies and associated firms, as suggested by Chen et al. (2023), thus implying that the existence of negative spillovers is not a generalized phenomenon. The implication is that defendant companies in PAE disputes might face difficulties forming strategic alliances only when they share high technological similarities with their potential partners.

3. Empirical analysis

3.1 Data

We combine data from five sources. First, we obtain company and accounting data from the North America Annual Compustat. Second, we use CorpWatch API data to track corporate name changes in our Compustat sample and examine their business affiliations. Several firms in Compustat changed their names during our sample period, making it challenging to match firm-level data with litigation, strategic alliance, and patent data. Information from CorpWatch contributes to solving this issue. Third, we gather data coming from RPX Corporation. This data includes a comprehensive collection of patent lawsuit cases registered in the U.S. district courts, allowing the identification of PAE lawsuits. Fourth, we use Thomson's Security Data Corporation (SDC) database to identify strategic alliance announcements in our sample of firms. The SDC database comprehensively tracks alliance

announcements made by two or more separate entities worldwide. Finally, we extract data from the Worldwide Patent Statistical Database (PATSTAT) to obtain information on the patent activities of the companies in our sample.

Information for 3,433 publicly listed companies operating in high-intensive technology industries in the U.S. for 2003-2008 is finally collected. This time frame is chosen because, on the one hand, CorpWatch starts tracking data on corporate structure composition since 2003, and on the other, data from SDC report a large share of unconfirmed alliances from 2009, the year from which a significant share of announcements are classified as pending agreements. To ensure the reliability of the data, we extend our sample until 2008.

3.1.1 Firm data

Our sample gathers information on companies operating in industries with the following two-digit Standard Industrial Classification (SIC) codes: 28, 35, 36, 38, 48, and 73. These sectors are chosen because they concentrate a significant share of PAE litigations in the U.S. (Chien, 2013). This sort of lawsuit is prominent in computing, telecommunications, and mobile communications (Henkel and Reitzig, 2008), electronics (Pénin, 2012), and software (Pénin, 2012; Reitzig et al., 2007). Also, the pharmaceutical industry is included following the suggestion of Feldman and Price (2014) that PAEs have started to operate in this sector. Next, we use CorpWatch API to identify corporate name changes and companies' subsidiaries in our sample. The information on these elements has been available since 2003 on the website: http://api.corpwatch.org/. CorpWatch API uses parsers to retrieve companies' names and subsidiary relationship information from Exhibit 21 of U.S. companies' 10-K filings required by the Securities and Exchange Commission (SEC).

3.1.2 Litigation data

We define PAE litigation cases as those in which plaintiffs are PAEs. We face the challenge that PAEs act in secrecy, making it harder to identify their activities (Abrams et al., 2019). To solve this issue, we proceed as follows. First, we implement the notion of frequent litigator proposed by Kiebzak et al. (2016), which considers that PAEs are entities commonly involved in a sizable number of lawsuits as their business model aims to extract rents through litigations. The idea of defining PAEs according to how much they litigate is also found in Leiponen and Delcamp (2019, p. 302), who identify

independent licensing firms as those litigating patents with a larger frequency than other types of NPEs. These observations are consistent with the work of Chen et al. (2023), showing that PAEs bring lawsuit cases with a significantly greater frequency than other plaintiffs. Next, from RPX data, we build a list of all the plaintiffs participating in patent disputes from 2003 to 2015, assigning them the number of defendants involved in each suit. We operationalize a frequent litigator as a plaintiff suing at least 16 defendants, threshold corresponding to the ninetieth percentile of the observed distribution of defendants in the data.

To minimize misidentification, we conduct the following refinements. We use information extracted from the Stanford Non-Practicing Entity (NPE) Litigation Dataset to compare our list of frequent litigators with the entities classified as PAEs by the Stanford database[4]. This database identifies 12 types of NPEs, from which PAEs are defined by the following categories: acquired patents, corporate heritage, and corporate-invertor-started company. Miller et al. (2017) describe these categories as follows. Acquired patent entities are entities primarily asserting patents acquired from other organizations. In this category, we find entities like Acacia and Intellectual Venture. Corporate heritage entities fundamentally assert patents, but when the original inventor of the patents is also the owner/founder of the entity. This category includes liability companies like Ronald A. Katz Technology Licensing, LLC. Finally, corporate-inventor-started entities include technology development companies that generally negotiate exclusive licenses with the same producer firms recurrently. Next, we generate a refined list of 1,093 entities considered frequent litigators in our data and listed as PAEs by Miller et al. (2017). In addition, we compare this refined list with others reported by law, management, and economics studies, including, for instance, those reported by Shrestha (2010), Benassi and Di Minin (2009), Bessen et al. (2011), and Fisher and Henkel (2012). Finally, we manually checked our resulting refined list, reviewing all the cases not found in the consulted lists. Following Fischer and Henkel (2012) and Reitzig et al. (2010), we also search for the websites of doubtful cases. If no websites are found, we look for information about these entities on patent-litigation specialized sites, technology-oriented sites,

[4] Specifically, we got access to a random sample containing 20% of all the cases examined by the analysts building the Stanford database.

and newspapers[5]. Implementing all these checks results in a list of 1,171 entities considered PAEs in the analysis[6].

One advantage of our litigation data is that it identifies all the alleged infringers involved in each case where the plaintiff is a PAE. Before applying the AIA in September 2011, PAEs commonly filed lawsuits against multiple defendants in a suit. As our data litigation includes patent dispute before 2011, it is critical to identify all the defendants involved in each suit. Other studies recognize suffering from this identification problem (Kiebzak et al., 2016; Smeets, 2014). For example, Kiebzak et al. (2016, p. 221) acknowledge that the effects reported in their study, particularly the one referring to the PAE litigation costs, would likely be more substantial if they could identify all the defendants involved in each case.

3.1.3 Strategic alliance data

Data on strategic alliance announcements come from SDC. Compared to alternative sources such as MERIT-CATI, CORE, and RCAP, the SDC database offers comprehensive coverage and a consistent description of the formation of all kinds of alliances globally. We collect alliance data for companies with a primary SIC code[7] matching the abovementioned industries. As most alliance announcements reported by SDC appear to be pending agreements from 2009, there is a high risk that many did not materialize in current alliances. To avoid the risk of including too many false positives in the sample, we set the study time frame from 2003 until 2008, a period where the alliance data coverage in SDC is more reliable. For this period, we use FACTIVA to validate the alliance information collected from SDC. In our sample, we retrieved 34,727 alliance agreements announced by firms in our Compustat and CorpWatch samples over the 2003-2008 period.

3.1.4 Patent data

We gather patent information from PAPSTAT to obtain firm-level patent information. The focus is on patent data corresponding to the United States Patent Trademark Office (USPTO), given the

[5] Some of the reviewed sites include: https://trollingeffects.org/index2168.html?q=patent-owners; https://www.thepatentscam.com/help; https://trollala.com/possibletrolls.php#list.
[6] The resulting list is available from the authors upon request.
[7] A primary SIC code is the defined by the four-digit SIC code where the firm generates the largest portion of its revenues (Rosenkopf and Schilling, 2007).

context of our study. We collect data for the analysis, including measures such as patent applications and patent-granted claims.

3.2 Data assembling

The previous data is assembled as follows. First, firms in our Compustat sample are matched to data on CorpWatch using the CIK identifiers. In this process, we retrieve the subsidiaries of Compustat firms, whether public or private. With this, we can consolidate data at the corporate level, aggregating lawsuits, strategic alliances, and patent data for corporations and their subsidiaries. Second, the resulting data is subsequently matched with the rest of the databases. The lack of a common identifier leads us to implement a corporate-name matching approach for assembling the final data (Thoma et al., 2010). Our approach rests on Raffo and Lhuillery (2009) and implies the following steps. We first standardize and disambiguate the names of companies comprising the different datasets as in the NBER patent data project [8]. Second, we apply a vectorial decomposition of corporate names to measure the similarity between paired names, as in Galasso et al. (2013). The algorithm is based on the Levenshtein distance approach that compares paired names. Matching between pairs is successful when the algorithm reports a degree of similarity equal to 1. We adopt this criterion for the matching. Finally, we conduct an extensive manual review of all the matching pairs with a degree of similarity ranging from 0.8 to 1 to retrieve additional pairs that are considered valid. The manual check allows us to recover pairs in which the matching failure is due to cases such as misspelling names and discordances in the company names among databases. Appendix A1 provides more details about the data assembly procedure used in our analysis.

3.3 Descriptive statistics

Our primary sample and variables are measured at the firm-year level. Table 1 reports descriptive statistics for our main variables over the sample period. The sample shows a wide distribution of firm sizes in terms of market value ranging from $5.9 million (tenth percentile) to $2.5 billion (ninetieth percentile). We observe an average of 31 patent applications per firm-year, with an average investment of $126.9 million in R&D activities per firm-year. The fixed asset ratio's average (median) value is 14,3% (8%).

[8] Retrieving from: https://sites.google.com/site/patentdataproject/Home

[Insert Table 1 here]

Figure 1 provides a first look at the relationship between strategic alliance formations and PAE litigation status. The average strategic alliance formation is observed to be larger for PAE-litigated companies than for non-PAE-litigated companies across the sample period, thus providing preliminary evidence that a positive association exists between the strategic alliance formation rate and the firms' PAE litigation status. However, differences in the patterns of partnership formations reported in Figure 1 may be affected by omitted factors correlated with the formation of strategic alliances and the propensity to suffer PAE-litigations. A subsequent empirical analysis will be conducted to account for this possibility.

[Insert Figure 1 here]

Finally, Table 2 reports differences in partnership formations and PAE litigations across industries. Alliance formation is particularly prominent in the commercial machinery, computer equipment, and business service industries, with less prominence in the communication sectors. As expected, complex industries like commercial machinery, computer equipment, and communications concentrate a significant proportion of PAE litigations compared to discrete industries like chemical and allied products. In the full sample, the average rate of PAE litigation is equal to 7.6%, similar to that reported by other studies[9], while the average rate of partnership announcement reaches 33.8%.

[Insert Table 2 here]

4. Differences in the formation of strategic alliances between PAE- and non-PAE-litigated companies

We use regression analysis to examine differences between PAE- and non-PAE-litigated companies in their strategic alliance formation. We model the number of strategic alliances announced by the firms each year ($Strategic\ Alliances$) as determined by a variable defining the PAE-litigation status of each firm in our sample ($PAE\ litigation$), which takes the value of one anytime a firm is sued by an entity classified as a PAE and zero otherwise. As the number of strategic alliances is a non-negative integer-valued measure and our data has a longitudinal design, we implement exponential regression models with panel data in the estimation. The general model is specified as follows:

[9] For instance, Chen et al. (2023) reports a NPE litigation rate of 7.7%.

$$Strategic\ Alliances_{it} = e^{\beta PAE\ litigation_{it} + \boldsymbol{X}'_{it-1}\boldsymbol{\theta} + c_i + \eta_k + \varepsilon_t + \epsilon_{it}} \quad (1)$$

As predicted by our hypothesis, if PAE-litigated companies announce more strategic alliance formations than non-PAE-litigated companies, we expect $\hat{\beta} > 0$. While focusing on forming strategic alliances, we consider factors potentially leading firms to participate in partnerships. Accordingly, $\boldsymbol{X'_{it-1}}$ is a vector of controls including the first lag of the following variables: firms' *R&D intensity* to account for firms' absorptive capacity (Cohen and Levinthal, 1989) defined by the ratio of R&D expenses to total operating expenditures, *Firm size* to control for scale effects (Almeida et al., 2003; Cao et al., 2009), proxied by the number of firms' employees; *Stock of patent applications* to consider firms' value creation strategies from their IPRs, measured according to the perpetual inventory method with a depreciation rate of 15% (Hall et al., 2005; McGahan and Silverman, 2006), *Fixed assets* to account for the firms' incentives to leverage their complementary assets in partnerships (Teece, 1989), defined as the ratio fixed assets to total assets, and the binary indicator *U.S. company*, which takes the value of one if the firm has been incorporated in the U.S, to account for differences between American and non-American firms in their propensity to form alliances. Vector $\boldsymbol{X'_{it-1}}$ also includes the first lag of the linear and square terms for the variables *R&D intensity* and *Firm size* to account for the fact that larger and more R&D-orientated companies form more strategic alliances because of their absorptive capacity and richness of resources. However, after trespassing certain thresholds, firms may form fewer partnerships to evade opportunistic behaviors and associated transaction costs (Rothaermel and Deeds, 2004). Table 3 describes the control variable definitions. Finally, η_k and ε_t are the industry- and time-fixed effects, respectively, c_i, characterizes the firm-fixed effects while ϵ_{it} is the error term.

[Insert Table 3 in here]

Equation (1) is estimated using alternative specifications, which allows us to evaluate the impact of distinct estimation strategies on assessing the main results. First, we estimate a pooled data Poisson model with clustered-robust standard errors at the firm's level to control for overdispersion and arbitrary serial dependence across time. Second, we implement a Poisson random effects specification to consider the influence of unobservable firm-specific characteristics, c_i, in driving the firms' strategic alliance behavior, assuming uncorrelatedness between c_i and the model's explanatory variables.

Next, we relax the uncorrelatedness assumption by implementing a Poisson fixed effects specification, adjusting the standard errors using the robust version proposed by Wooldridge (1999) to better account for overdispersion. As the Poisson fixed effects specification does not allow us to identify the parameter estimates of time-invariant covariates, we further implement a Generalized Estimating Equation (GEE) regression model (Liang and Zeger, 1986) using a Correlated-Random-Effect (CRE) specification (Wooldridge, 2010). In doing so, we account for the influence of unobserved heterogeneity in two ways. First, we use an exchangeable correlation structure to model potential correlations across time within firm-observations. Second, we model c_i by adopting the Chamberlain-Mundlack approach[10], allowing the possibility that the firm-fixed effects correlate with the model's explanatory variables. Specifically, c_i is characterized as being determined by the within means of the time-varying model's covariates according to the following specification: $c_i = \varpi + \overline{\boldsymbol{Z}}'_i\boldsymbol{\psi} + \xi_i$. Here, $\boldsymbol{Z}$ includes both the *PAE litigation* variable and the time-varying covariates belonging to $\boldsymbol{X}$, while ϖ and $\boldsymbol{\psi}$ are parameter estimates and ξ_i represents the associated error term.

Table 4 reports the Poisson regression results comparing alliance formation between PAE-litigated and non-PAE-litigated companies. In all cases, it is observed that $\hat{\beta} > 0$, and statistically significant, indicating that PAE-litigated companies announce more strategic alliance formations than their non-PAE-litigated counterparts do. These results are robust to distinct ways of treating the potential influence of unobserved firm-specific characteristics on their propensity to form strategic alliances. Also, in further examinations, we observe that the results remain similar when using other specifications like Negative Binomial models with either random or fixed effects[11].

[Insert Table 4 about here]

By estimating the marginal effects and using the Delta Method, we further obtain the exponentiated coefficients for the variable $PAE\ litigation$ that facilitate the interpretation of the results. Results are reported at the bottom of Table 4. This estimation gives us the ratio of the mean potential outcome (i.e., strategic alliances) under the PAE litigation condition to the mean potential outcome under the non-PAE litigation condition. The pooled Poisson estimation reports the largest ratio, where

[10] For more details, see Chamberlain (1982) and Mundlack (1978).
[11] Results are available upon request.

the mean number of strategic alliances announced in the PAE litigation condition is over 1.474 times the average number of strategic partnerships announced under the non-PAE litigation regime. When controlling for the presence of firm-fixed effects, the ratio reduces so that the mean number of strategic alliances announced in the PAE-litigation condition is over 1.217 times the average number of strategic partnerships announced in the non-PAE litigation regime.

All the previous results support the hypothesis that PAE-litigated companies announce more strategic alliances than non-PAE-litigated companies.

4.1 Additional analysis

4.1.1 The effect of non-PAE litigations

We repeat the previous estimations by considering non-PAE litigation cases. We expect to find a weaker correlation between the firms' strategic alliance formation rate and non-PAE litigation status based on differences in the cost impact between PAE and non-PAE litigations. Table A2 in the Appendix reports the results. We find a positive but insignificant association between firms' strategic formation rate and non-PAE litigation status. Compared to non-PAE lawsuits, these results align with the idea that PAE litigations seem to be sufficiently costly to incentivize sued companies to form strategic alliances to activate their financial benefits.

4.1.2 The role of value creation sources in driving the results

We inspect if our results are robust when accounting for distinct forms of value creation. This issue is relevant because firms with high-value creation capacity can more successfully attract potential partners, as well as PAEs looking for rent extraction opportunities. Ignoring this might affect our estimation by raising the risk of an omitted variable bias. To minimize this concern, we re-estimate model (1) by controlling for distinct value creation mechanisms. Specifically, we add to model (1) the variable *Tobin's Q*, measured as the logarithm of the ratio of market value to total assets, commonly adopted by innovation studies as a proxy for the firm's capacity to create market value from its assets (Arora et al., 2021; Griliches, 1986; Hall et al., 2005). Also, we replace the stock of patent applications with the variables *Granted patent claims* and *Family patent forward citations*, respectively. These measures reflect the firm's capacity to create value from its patent portfolios (Rassenfosse and Jaffe,

2018). We adopt the most conservative estimation strategy by choosing the GEE regression model specification with CRE to better control for several sources of unobserved heterogeneity[12].

Table A3 in the Appendix summarizes the main results. In all cases, we observe that PAE-litigated companies form more strategic alliances than non-PAE-litigated firms, as $\hat{\beta}$ remains positive and statistically significant. It is observed that the firm's capacity to create market value and its patent-granted claims positively contribute to forming strategic alliances. Moreover, the results at the bottom of Table A3 show that the average number of alliance announcements in the PAE litigation condition is larger than the average number of alliance announcements in the non-PAE litigation case. These findings support our hypothesis.

4.1.3 Endogenous treatment effect estimation

We extend the analysis by considering unobserved sources of heterogeneity potentially affecting both strategic alliance formation and the firms' propensity to be PAE-litigated. To reach this, we estimate a Poisson model for the number of strategic alliance announcements with the PAE litigation status viewed as an endogenous binary variable. Specifically, we estimate this model by imposing a given correlation structure between unobservables affecting the announcements of strategic alliances and the firms' prospects of PAE litigation. Strategic alliance formation is modeled by equation (1), while the firms' prospects of PAE litigation are modeled as follows:

$$PAE\ litigation_{it} = 1[\boldsymbol{W}'_{it-1}\boldsymbol{\gamma} + \omega_k + \nu_t + u_{it} > 0] \quad (2)$$

Where $\boldsymbol{W}'_{\boldsymbol{it-1}}$ includes factors in $\boldsymbol{X}'_{\boldsymbol{it-1}}$, along with the following covariates: the first lag for the variable $PAE\ litigation$ to consider experience effects in driving the current risk of PAE litigation, the first lag of the variable $Strategic\ Alliances$ to minimize risks of endogeneity due to reverse causality. Moreover, we include the first lag of the variable *Cash flow* (in logs) because prior studies indicate that PAEs commonly targets companies with high liquidity (Cohen et al., 2019). We re-estimate equation (1) along with equation (2) using the maximum likelihood estimator proposed by Terza (1998), assuming that ϵ_{it} and u_{it} are bivariate normal with mean 0 and covariate matrix $\boldsymbol{\Omega}$[13].

[12] We further compare the results of the GEE specification with those generated from the models described above, finding that they are robust across distinct specifications.

[13] Specifically, $\boldsymbol{\Omega}$ is defined as follows: $\boldsymbol{\Omega} = \begin{bmatrix} \sigma & \sigma\rho \\ \sigma\rho & 1 \end{bmatrix}$

Table 5 shows the results for estimating equations (1) and (2). The Wald test of independence equations indicates that we can reject the null hypothesis of no correlation between the errors in the PAE-litigation status model and strategic alliance formation model. As in the previous cases, we observe that the propensity to form strategic alliances is larger for PAE-litigated companies than non-PAE-litigated firms. From the marginal effects, and for this specification, we can also estimate the average treatment effect on the treated (ATT)[14]. In our context, the ATT defines the difference in the number of alliances announced by the average firm under the PAE-litigated scenario and the number of partnerships announced if it did not receive any PAE lawsuit. From our estimation, we get that the $\widehat{ATT} = 1.88$, which is statistically significant ($p < 0.01$). Thus, we have that the average firm in the PAE-litigated population will announce 1.88 more strategic alliances than it would announce if it were not litigated by PAEs.

[Insert Table 5 about here]

4.1.4 Treatment effect heterogeneity and dynamic effects

We now employ a difference-in-difference (diff-and-diff) approach to examine how treatment effect heterogeneity and dynamic effects can influence our results. A potential concern in our context is that differences in strategic alliance formation between PAE-litigated and non-PAE-litigated companies differ across time and groups[15]. Recent literature on diff-and-diff has shown that under treatment effect heterogeneity, two-ways-fixed-effects (TWFE) might not be robust in regression analysis when earlier treated-groups are used as controls in the estimation (Callaway and Sant'Anna, 2021; de Chaisemartin and D'Haultfœuille, 2024; Sun and Abraham, 2021). Accordingly, we adopt recent advancements in diff-and-diff methods that generate robust estimations of potential treatment effect heterogeneity. These methods allow us to account for multiple periods and variations in treatment timing. In our setting, PAEs can litigate companies at different times and once litigated, defendants remain sued for the rest of the panel, thus creating a staggered diff-and-diff design.

[14] Specifically, we use the instruction "etpoisson" to estimate the model. After that, we estimate the marginal effect for the PAE litigation binary variable by restricting the sample to the set of PAE-litigated companies.
[15] In our context, the notion of groups here refers to the cohort of firms being treated at the same period.

From the various heterogenous-robust diff-and-diff methods available for staggered timing, we select the approach proposed by de Chaisemartin and D'Haultfoeuille (2024), hereafter referred to as dCdH. We choose this method because it can linearly control for time-varying covariates and handle potential trends in time-invariant covariates. The dCdH estimator facilitates estimating instantaneous and dynamic treatment effects, testing parallel trends assumptions, and presenting results in an event-study graph, thus making interpretation straightforward.

The idea is to estimate both instantaneous and dynamic treatment effects, accounting for the heterogeneity of treatment effects across groups and over time. To do so, we calculate the average diff-and-diff estimate over the study's period for each time point t on firms that were untreated before t but experienced a PAE litigation for the first time at t (referred to as switcher firms). This is then compared to firms that remained untreated at t (referred to as not-yet-treated firms). For dynamic effects, we compare the strategic alliance announcement evolution from $t-1$ to $t+\ell$ between switcher firms at t and firms whose treatment remained unchanged until $t+\ell$ and have the same treatment status as switchers at period one. Since switchers may appear at various points between 2004 and 2008, multiple diff-and-diff comparisons arise, which must be aggregated into an estimator of the average effect of experiencing PAE litigation on firms' strategic alliance formations.

In the estimation, we test the parallel trend assumptions using Placebo estimators, comparing switchers and non-switchers' strategic alliance formation trends before the switchers change. In the assessment, we control for the factors included in the Poisson exponential models, adding also the first lag of the variable $Strategic\ Alliances$ to account for previous experience in engaging in strategic alliances. Including control variables in the analysis allows us to be conservative by comparing the evolution of the firms' strategic alliance formation between switchers and non-switchers, which is not explained by changes in covariates.

Table A4 in the Appendix reports the instantaneous and dynamic treatment effect results. We observe a positive and significant instantaneous impact in line with our previous results. In addition, a dynamic effect exists with a positive and significant impact until three years after switchers change their treatment for the first time (normalized at period zero). Additionally, we estimate Placebo effects for strategic alliance formation evolution between consecutive periods before switchers change. These

findings depend on parallel trend assumptions, tested using Placebo effects. We find no significant differences between switchers and non-switchers before the treatment period at zero. We cannot reject the null hypothesis that the joint Placebo effects are equal to 0 either ($p = 0.266$). These findings indicate that the parallel trends seem to hold for our case. Figure 2 shows the results.

[Insert Figure 2 about here]

Moreover, we use Stata's package "honestdid", which allows us to implement sensitivity analysis on parallel trends assumptions for diff-and-diff designs, according to Rambachan and Roth (2019). Our results show that our estimations are robust in violation of the parallel trends assumption, particularly in the case of dynamic effect estimations[16].

Table A5 in the Appendix shows the aggregate treatment effect estimation, which summarizes the impact of the previously described instantaneous and dynamic effects. We observe that the aggregate impact of PAE litigation is positive and significant on the firms' engagements in strategic alliances.

5. Role of firms' financial constraints in the link between PAE litigation strategic alliance formation

The previous results support the hypothesis that PAE-litigated companies announce more strategic alliances than non-PAE-litigated companies. Now, our attention is on examining whether the relationship between firms' strategic alliance formation and PAE litigation status is induced by the need of sued companies to mitigate the financial constraints related to PAE litigation. To do so, we conduct two additional examinations. First, we analyze whether PAE-litigated companies are more financially constrained than non-PAE-litigated companies. Because of the impact of PAE litigation costs, we expect to observe that PAE-litigated companies face greater financial constraints than non-PAE-litigated companies. If so, we expect sued companies to face also more incentives to form strategic alliances. This expectation leads us to the second examination. We inspect whether reductions in the firms' internal liquidity, viewed as a critical resource for the firms' financing (Himmelberg and Petersen, 1994), magnify the induced effect of PAE litigation on the announcement of strategic alliances. With this, we expect to confirm whether financial vulnerability induces sued companies to form strategic alliances. Finally, we examine whether increases in the litigation costs faced by sued firms also amplify the impact

[16] Results are available upon request.

of PAE litigation on the announcement of strategic alliance formations. This expectation aligns with the idea that the costs of patent litigation impact firms' financing, thus leading them to form strategic alliances to alleviate such impact.

5.1 Financial constraints and PAE litigation

Are PAE-litigated companies more financially constrained than non-PAE-litigated companies in financing their operating costs? To answer this, we build on prior financial economics research detecting financial constraints by the firms' sensitivities of investments to existing financial resources (Bond and Van Reenen, 2007; Czarnitzki and Hottenrott, 2017; Himmelberg and Petersen, 1994; Levitas and McFadyen, 2009). In our context, we assess the sensitivities of firms' operating costs to internal liquidity. High sensitivities imply a firm's enhanced dependency on internal financing to cover its operating costs, which signals the presence of financial constraints. When comparing PAE-litigated and non-PAE-litigated companies, we expect to observe a positive and stronger relationship between liquidity and operating costs in the case of PAE-litigated companies than in the case of non-PAE-litigated companies. If so, sued companies are probably facing more frictions when financing their operational activities from capital markets.

To examine the relationship between liquidity and operating costs, we proceed as follows. First, we use the variable WC that measures the firms' stock of working capital as a proxy of liquidity. This option avoids the limitations of cash flow as a measure of liquidity that prior studies document (Czarnitzki and Hottenrott, 2017; Hall and Kruiniker, 1995). The variable WC characterizes a firm's financial resource as the stock of working capital reflects the accumulation of financial funds (retained cash inflows) needed for investments (Fazzari and Petersen, 1993). We use the indicator *Operating expenditures* as the primary dependent variable in the analysis. It is calculated as the sum of the firms' expenditures on R&D, marketing, and administrative activities. Second, we estimate the sensitivities of operating expenses to liquidity for PAE-litigated and non-PAE-litigated companies using an adaptation of Czarnitzki and Hottenrott's empirical framework (2017). Then, we estimate two separate slope parameters for the internal liquidity variable according to the firms' PAE litigation status. Given the nature of our dependent variable, we implement linear panel data models according to the following specification:

$$Log(Operating\ expenditures)_{it} = \gamma_L WC_{it-1} x PAE\ litigation_{it-1} + \gamma_N WC_{it-1} x(1 - PAE\ litigation_{it-1}) + \beta^c PAE\ litigation_{it-1} + \boldsymbol{V}'_{it-1}\boldsymbol{\theta}^c + c_i^c + \eta_k^c + \varepsilon_t^c + \epsilon_{it}^c \quad (3)$$

Where WC_{it-1} is the stock of working capital. $\boldsymbol{V}'_{it-1}$ denotes a vector of controls, including the indicator *Debt ratio* defined as the ratio of debts to total assets that accounts for credit market' access (Czarnitzki & Hottenrott, 2017), *Firm size* and *Fixed assets* to control for the presence of scale effects, and *Stock of patent applications* to account for factors improving financing opportunities from the exploitation of the firms' IPRs. We also account for differences between American and non-American companies by including the binary variable *U.S. company*. See Table 3 for a description of the control variables. The parameter estimates of interests are γ_L and γ_N, which measure the sensitivity of operating expenditures to working capital stocks for PAE-litigated and non-PAE-litigated companies, respectively. If sued companies are more financially constrained, we expect that $\gamma_L > \gamma_N$. Here, η_k^c and ε_t^c represent the industry- and time-fixed effects, respectively, c_i^c characterizes the firm-fixed effects, whereas ϵ_{it}^c is the error term.

Columns one and two of Table 6 present the results for random and fixed effects specifications. In column one, the coefficients γ_L and γ_N are both positive and statistically significant, but γ_L is significantly larger than γ_N ($\chi^2 = 4.98$, *p-value* < 0.026). This result suggests that PAE-litigated companies have a higher dependency on internal liquidity stocks for financing their operating costs than non-PAE-litigated firms, which suggests that sued companies are more financially constrained than their non-PAE-litigated counterparts. These results are robust after controlling for the firm fixed effects. In column two it is also observed that γ_L is significantly larger than γ_N ($\chi^2 = 3.97$, *p-value* < 0.046), in line with the idea that PAE-litigated companies are more financially constrained.

[Insert Table 6 about here]

PAE-litigated companies seem to be more financially constrained, a condition used in our reasoning to motivate why these companies are interested in forming strategic alliances.

5.2 Liquidity and litigation costs as magnifying the impact of PAE litigation on strategic alliance formation

To examine whether variations in internal liquidity and litigation costs influence the impact of PAE litigation on the formation of strategic alliances, we proceed as follows. First, we estimate the

individual-level effects of PAE litigation on the strategic alliance announcements for each PAE-litigated company employing the approach developed by Czarnitzki and Licht (2006)[17]. The individual-level impact is defined as follows: $\alpha_i^{PAE} = SA_i - \widehat{SA}_i^c$, where α_i^{PAE} is the difference between the number of strategic alliances announced by the PAE-litigated company "i" (SA_i), and the counterfactual number of strategic alliances that company "i" would have had in the absence of PAE litigation ($\widehat{SA}_i^c$). For example, if a sued firm forms three alliances and under the counterfactual state would have formed just one, the individual-level impact would be equal to two. We observe SA_i from the data but not the counterfactual $\widehat{SA}_i^c$. We use a matching approach to solve this issue. Matching generates the counterfactual outcome by identifying non-PAE-litigated twins, which are equivalent in observable characteristics to the PAE-litigated firms. By the conditional independence assumption (Rubin, 1977), we use twin firms to get a valid proxy for the counterfactual outcome of PAE-litigated firms. To satisfy this assumption, it is necessary to identify equivalent firms based on important characteristics that influence the selection into the treatment (Caliendo and Kopeinig, 2008). We estimate the probability of being litigated, the propensity score, to select twin firms by using the specification of equation (2). In line with prior research, covariates in equation (2) include critical factors determining the probability of PAE litigation (Cohen et al., 2019; Smeets, 2014). Table A6 in the Appendix shows the results of the propensity-score model.

A standard propensity score nearest neighbor matching (PSM) is employed to find twin firms, following the implementation of Smeet (2014). To ensure quality matches, we impose a 0.05 caliper restriction on the PSM[18], ensuring only twin firms are matched (Caliendo and Kopeinig, 2008). Besides, given the panel design of the data, we also impose that the PAE-litigated and their non-litigated twins must belong to the same year and industry to be matched. Table A7a in the Appendix compares PAE-litigated and non-PAE-litigated companies in terms of observable characteristics confirming significant differences between them. For instance, PAE-litigated companies are richer, larger and have greater stocks of patents than their non-litigated counterparts. Also, PAE-litigated companies are more exposed

[17] This approach is widely adopted in several studies on technology policy evaluation, including Beck et al., (2016) and Hottenrott and Lopes-Bento (2014), among others.
[18] We adopt the approach outlined by Austin (2011) and opt for a caliper derived from half the standard deviation of the propensity score.

to prior PAE disputes and have more experience forming strategic alliances. Table A7b reports the same comparison after the matching. Differences in the mean of observable characteristics are no longer statistically significant, in line with the idea that the matching is balanced. As Table A7b shows, the mean of partnership formation rate between PAE-litigated and non-PAE-litigated companies is statistically significant after the matching, supporting our previous results.

Next, we regress α_i^{PAE} against the first lag of our indicator of operating liquidity (WC) to determine whether reductions in firms' liquidity amplify the impact of PAE litigation on forming strategic alliances. Similarly, we regress α_i^{PAE} against proxies for litigation costs to check whether increases in litigation costs magnify the effect of PAE litigation on the rate of strategic alliance formation. To characterize these costs, we employ the idea that complexity in a legal process directly relates to its litigation expenses. Following the approach of Kesan and Ball (2006) and Smeets (2014), and using our litigation data from RPX, we employ the duration of patent lawsuits, captured by the first lag of the variable *Days in litigation*, as a proxy for estimating patent litigation costs. Besides, we use the count of legal documents filed in a patent lawsuit, given by the first lag of the variable *Number of dockets*, as an alternative measure of complexity in a legal process. We extend the analysis by including additional measures of litigation complexity. Specifically, we employ the number of asserted patents, defined by the first lags of the variables *Patents in suit*, and number of accused products, given by the variable *Accused products*. Alternatively, we build the index *Litigation cost* from the principal component extracted from the previous measures. This index is a composite variable formed from the linear combination of these measures so that each indicator is weighted by its corresponding factor loading (Hair et al., 2010)[19]. We also estimate the Cronbach's alpha to verify the degree of internal reliability of the resulting composite index. We obtain an alpha value of 0.863, showing satisfactory internal reliability. We normalized the index in the range 0-1. See Table 3 for a description of the litigation cost variables.

[19] Formally, this index is defined as follows: $\sum_j \omega_j v_j$, where v_i stands for the standardized value of the indicator j, whereas ω_j is the corresponding factor loading of j. Each factor loading represents the correlations existing among the included indicators and their corresponding principal component.

Table 7 reports the results. Column one reports the parameter estimate of firms' liquidity stocks, which is negative and statistically significant. This result indicates that PAE litigation's impact on forming strategic alliances magnifies when firms' liquidity stocks reduce, which is coherent with the idea that PAE-litigated firms facing lack of internal liquidity also have more incentives to engage in strategic alliances. Results from columns 2-6 report the effect of variations in litigation cost proxies on the induced impact of PAE litigation on strategic alliance formation. We analyze each indicator's impact independently given the high correlation existing among these indicators. Unless for the case of days in litigation, it is observed that the coefficient estimates are positive and statistically significant, indicating that the induced effect of PAE litigation on forming strategic alliances amplifies as litigation costs rise. Column six shows the results when the litigation cost index is considered. Consistent with the previous results, the parameter estimate is positive and statistically significant, suggesting that the more costly the litigation process is, the greater the impact of PAE litigation on the sued firms' announcements of strategic alliances. These results align with the idea that expensive litigation processes exacerbate the firms' needs to form strategic alliances.

[Insert Table 7 about here]

6. Discussion and conclusions

The intermediation role of NPEs in technology markets can generate substantial benefits in firm innovation and technological diffusion (Leiponen and Delcamp, 2019; Pénin, 2012). However, these benefits are contingent on the incentives patent systems create to defend the patent holders' rights fairly. As several studies indicate, patent systems where fuzzy claims are allowed and where the enforcement rules overprotect patent holders may also create incentives that severely distort the intermediation role of NPEs (Chen et al., 2023; Cohen et al., 2019; Mezzanotti and Simcoe, 2019). The emergence and evolution of PAEs' litigation activities and their impact on American companies confirm the existence of distortions in how intermediation works in these markets (Bessen et al., 2018).

Several studies have assessed the impact of these distortions. Yet, much less attention has been paid to the coping strategies defendant companies may implement to face the consequences of PAE litigation. This is the focus of our study. It contributes by identifying partnership formation as a potentially helpful strategy defendant companies may implement to deal with the cost impact of PAE

litigation on their financial positions. This study argues that this impact primarily creates financial constraints that affect the sued companies' financing options. In line with RBV research (Eisenhardt and Schoonhoven, 1996; Lavie, 2006) and works on the economic benefits of strategic alliances (Czarnitzki and Hottenrott, 2017; Lerner et al., 2003; Levitas and McFadyen, 2009), we argue that sued companies react to these financial constraints by seeking alternative financing sources like those provided by strategic alliances. Vulnerability induced by PAE litigation pushes sued companies to form strategic alliances to secure needed resources. We posit that partnership formation allows sued companies to diminish their necessities to accrue internal liquidity for funding their business operations. Also, it facilitates accessing partners' complementary assets, thus relaxing the need to obtain external funds from capital markets.

Our empirical analysis shows that companies form strategic alliances at a higher rate when they face PAE litigations. Given this result, we examine whether the positive association between strategic alliance formation and firms' PAE litigation status varies according to the financial vulnerability induced by PAE litigation. Our inspection shows that PAE-litigated companies are more financially constrained in funding their operating costs than their non-PAE-litigated counterparts. We think this motivates sued companies to form strategic alliances. To confirm this, we conduct additional examinations to study the association between firms' internal liquidity stock variations and the induced PAE litigation impact on their strategic alliance formations. Our findings reveal a negative association, consistent with the premise that PAE litigation's impact on the firms' strategic alliance formations magnifies when financial constraints increase. In the same direction, our examination uncovers a positive association between variations in litigation costs faced by sued companies and the induced impact of PAE litigation on their formations of strategic alliances. This result aligns with the notion that firms facing high litigation costs have more incentives to participate in strategic alliances due to their potential benefits in mitigating financial constraints.

Although we do not claim that our estimates of these relationships are causal, the patterns of association uncovered are consistent with the idea that sued companies respond to the financial constraints induced by PAE litigation by forming strategic alliances. These findings are maintained even after controlling for firm fixed effects and various time-varying firm characteristics.

The study's results generate managerial and policy implications. For managers, our analysis highlights the importance of the alliance management process for companies operating in a business environment with high litigation risk. Activities such as monitoring potential partners, selecting allies, and negotiating deals become critical because they may condition the functioning of a partnership and access to valuable financial resources. For finance managers, our results suggest that companies can widen the options for financing their operations amidst adverse contexts like PAE litigations. However, carefully evaluating the costs involved in forming partnerships is critical to determine the adequacy of these arrangements to face PAE disputes. Our result also reveals that coordination between distinct strategic activities is needed to face the consequences of PAE litigation. For instance, cooperation between managers responsible for the firm's alliance management and financing decisions gains relevance to yielding the alleviating effects of strategic alliances on funding PAE-litigated firms. Another critical implication is that PAE litigations could produce positive externalities in cases where these patent disputes lead defendant companies to form strategic alliances they would not have formed otherwise. For instance, additional positive effects arise when defendant companies gain experience in alliance management that they would not have developed without PAE disputes. Therefore, managers should evaluate not only the costs and distortions associated with PAE lawsuits but also the potential positive effects.

For policymakers, our results identify the harmful effects of PAE litigation on the financial position of sued companies, thus revealing the necessity of disincentivizing frivolous litigation activities. Our results suggest that policies limiting frivolous litigations would contribute by reducing distortions in the sued companies' financing opportunities and their detrimental effects on business operations.

Our study provides relevant insights into the effects of PAE litigation and remedy actions. However, we would like to point out some limitations of our study that open future research opportunities. First, our research could underestimate the impact of PAEs' activities since we focus on patent disputes involving filing patent lawsuits. There are other ways PAEs' activities could affect the financial constraints of their targets, such as sending demand letters to encourage ex-ante settlements. However, prior research has documented the relatively high importance of filling lawsuits compared to

demand letters as rent extraction mechanisms (Mezzanottri, 2021). For instance, Cohen et al. (2016) discuss how PAEs make their claims more credible by filing a lawsuit rather than issuing demand letters. Second, a more detailed examination of sued companies' costs when forming partnerships is required. Our results suggest that PAE-litigated companies form strategic alliances to mitigate the financial constraints involved in PAE litigation. Viewed as a financing option, using partnerships generates significant costs that should be considered when evaluating the firms' financing strategies. Third, related to the previous issue, more research is needed to determine whether the induced effects of PAE litigation distort the optimal strategy of sued companies' alliance formation. Several studies show that the costs of forming alliances surpass the involved benefits when firms enlarge their alliance portfolios beyond a critical threshold. A question remains: How does patent litigation affect this threshold?

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Table 1. Descriptive statistics for main variables

Variable	Obs.	Mean	SD	Distribution		
				10^{th}	50^{th}	90^{th}
R&D expenditures (millions)	9,850	126.89	612.69	2.33	10.21	136.17
Number of employees (miles)	10,765	5.035	20.47	0.02	0.27	7.90
Fixed asset share (Fixed assets to total assets)	11,594	0.142	0.16	0.03	0.08	0.18
Cash Flow (millions)	11,586	216.00	876.44	0.312	16.15	350.33
Market value	9,674	2264.59	13191.38	5.94	135.67	2471.39
Tobin's q	9,206	11.39	228.50	0.94	1.67	6.80
Granted patent claims	12,157	275.19	1,813.92	0	0	297
Family patent forward citations	12,157	1005.19	6,489.41	0	8	1,186
Patent applications	12,157	30.95	194.86	0	1	31
Stocks patent applications	20,598	48.04	430.84	0	0	31.55

Table 2. Summary statistics for the number of strategic alliance announcements and PAE litigations across industries

		Strategic alliances		PAE litigations	
Industries (Two-digit SIC codes)	Obs. (NxT)	Frequency	Mean	Frequency	Mean
Chemicals and allied products (28)	3445	1353	0.393	29	0.008
Industrial-commercial machinery and computer equipment (35)	521	244	0.468	117	0.225
Electronic and other electrical equipment and components (36)	2243	526	0.235	213	0.095
Measuring, analyzing, and controlling instruments (38)	1697	360	0.212	29	0.017
Communication (48)	1091	176	0.161	316	0.290
Business services (73)	3160	1447	0.458	220	0.070
Total	**12157**	**4106**	**924**	**0.338**	**0.076**

Table 3. Explanatory variable definition

Variable	Description	Source
Strategic alliances	Reported number of partnerships announced yearly at the corporate level	SDC
PAE litigation	Number of lawsuits from PAE plaintiffs. PAE identification explained in the text	RPX
R&D intensity	Ratio R&D expenditures to total operating costs as in Smeet (2014)	Compustat
Patent application stock	Calculated using the perpetual inventory method with a depreciation rate of 15%	PAPSTAT
Firm size	Number of employees	Compustat
Fixed assets	Ratio net fixed assets to total firms' assets	Compustat
U.S. company	1 if company has been incorporated in the U.S.	Compustat
Cash	Level of cash at the current fiscal year reported in the firm's current assets	Compustat
Working capital (WC)	Ratio of the difference between current assets and liabilities to total firms' assets	Compustat
Debt ratio	Ratio liabilities to total firms' assets as in Czarnitzki and Hottenrott (2017)	Compustat
Days in litigation	Number of days in which the corporation has been involved in patent lawsuits	RPX
Number of dockets	Number of documents for patent lawsuits in which the corporation is involved	RPX
Patents in suit	Number of asserted patents in the lawsuits faced by the corporation	RPX
Accused products	Number of litigated products in the lawsuits faced by the corporation	RPX
Litigation costs	Principal component extracted from litigation cost items, as explained in the text	RPX

Table 4. Results for Poisson model estimations with panel data on the firms' number of announced strategic alliances

Independent variables	(1) Poisson pooled data	(2) Poisson random effects	(3) Poisson fixed effects	(4) Poisson GEE with CRE
PAE litigation	0.388***	0.258***	0.197**	0.208***
	(0.093)	(0.078)	(0.083)	(0.071)
R&D intensity	1.532***	0.432	-1.029***	-1.034***
	(0.529)	(0.285)	(0.334)	(0.399)
R&D intensity squared	-1.185**	-0.313	0.243**	0.202
	(0.542)	(0.225)	(0.111)	(0.222)
Stock of patent applications (log value)	0.159***	0.192***	0.118	0.093**
	(0.034)	(0.031)	(0.073)	(0.040)
Firm size (log values)	0.080	0.062	-0.197	-0.087
	(0.065)	(0.071)	(0.204)	(0.158)
Firm size squared (log value)	0.016***	0.014**	0.026	0.014
	(0.005)	(0.006)	(0.017)	(0.013)
Fixed asset share	-0.731**	-0.591**	0.113	0.266
	(0.339)	(0.284)	(0.545)	(0.440)
U.S. company	0.774***	0.631***	_	0.768***
	(0.129)	(0.133)		(0.080)
Industrial-commercial machinery and computer equipment	-0.495***	-0.504***	_	-0.476***
	(0.153)	(0.150)		(0.116)
Electronic and other electrical equipment and components	-0.908***	-0.935***	_	-0.875***
	(0.111)	(0.105)		(0.087)
Measuring, analyzing, and controlling instruments	-0.643***	-0.665***	_	-0.597***
	(0.107)	(0.139)		(0.096)
Communication	-1.054***	-1.096***	_	-0.974***
	(0.318)	(0.284)		(0.221)
Business services	0.163*	0.217**	_	0.158**
	(0.099)	(0.093)		(0.074)
Constant	-3.379***	-3.009***	_	-3.615***
	(0.262)	(0.268)		(0.215)
Observations (NxT)	7,147	7,147	3,676	7,147
Number of firms (N)	1,912	1,912	836	1,912
Goodness of fit-Wald test (χ^2)	1,196.1***	1,069.8***	114.34***	3,076.9***
Wald test: Means fixed effects (χ^2)	–	–	–	65.49***
Exponentiated coefficient estimate (e^b)	1.474***	1.294**	1.217**	1.222***
	(0.137)	(0.101)	(0.101)	(0.087)

Notes: (i) pooled Poisson model with clustered standard errors at the firm level in column one, random-effects Poisson model with bootstrapped standard errors in column two, fixed-effects Poisson model with adjusted robust standard errors in column three and Generalized Estimating Equation (GEE) model with Correlated-Random-Effects (CRE) and robust standard errors in column four. (ii) Time-fixed effects included in all the models. (iii) Exponentiated coefficient estimates at the bottom of the table obtained from the Delta Method (iv) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5. Results for the Poisson regression estimation with an endogenous binary-treatment variable

Independent variables	Strategic alliance formation model	PAE-litigation status model
PAE litigation	1.584***	_
	(0.162)	
R&D intensity	0.777**	0.376
	(0.350)	(0.680)
R&D intensity squared	1.052***	0.342
	(0.366)	(0.683)
Stock of patent applications (log value)	-0.733**	-0.679
	(0.323)	(0.949)
Firm size (log value)	0.150***	0.108***
	(0.029)	(0.028)
Firm size squared (log value)	0.184***	0.329**
	(0.068)	(0.131)
Fixed asset share	-0.739**	-0.864**
	(0.290)	(0.387)
U.S. company	0.658***	0.163
	(0.111)	(0.121)
Industrial-commercial machinery and computer equipment	-0.643***	0.953***
	(0.153)	(0.202)
Electronic and other electrical equipment and components	-1.017***	0.730***
	(0.106)	(0.163)
Measuring, analyzing, and controlling instruments	-0.629***	0.019
	(0.113)	(0.182)
Communication	-1.062***	0.960***
	(0.289)	(0.246)
Business services	0.083	0.781***
	(0.098)	(0.160)
Lag PAE litigation	_	0.760***
		(0.131)
Lag Strategic Alliances	_	0.119***
		(0.024)
Cash flow (log value)	_	0.044
		(0.037)
Constant	-3.751***	-5.128***
	(0.261)	(0.685)
Observations (NxT)	7,089	
Number of firms (N)	1,909	
Goodness of fit-Wald test (χ^2)	3,183.15***	
Wald test of independent equations	21.86**	

Notes: (i) Estimations correspond to a Poisson model with endogenous binary-variable. (ii) Results for the propensity of strategic alliances formation in column one, and results for the probability of being litigated by PAEs in column two. (iii) Time-fixed effects included in all the models. (iv) Robust standard error in parathesis, clustered at the firm-level. (v) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6. Estimating results from linear panel regressions on the firms' operating expenses

Independent variables	Random effects	Fixed effects
PAE litigation = 0 x WC	0.001**	0.001***
	(0.000)	(0.000)
PAE litigation = 1x WC	0.152**	0.125**
	(0.068)	(0.062)
PAE litigation	-0.064**	-0.078***
	(0.026)	(0.025)
Debt ratio	-0.010***	-0.009***
	(0.003)	(0.003)
Firm size (log values)	0.655***	0.467***
	(0.019)	(0.035)
Fixed asset share	-1.162***	-0.911***
	(0.178)	(0.186)
Stock of patent applications (log values)	0.176***	0.047***
	(0.012)	(0.014)
U.S. company	0.161**	_
	(0.069)	
Industrial and commercial machinery and computer equipment	-0.611***	_
	(0.085)	
Electronic and other electrical equipment and components	-0.648***	_
	(0.064)	
Measuring, analyzing, and controlling instruments	-0.638***	_
	(0.059)	
Communication	0.683***	_
	(0.187)	
Business services	-0.533***	_
	(0.058)	
Constant	0.392***	1.310***
	(0.136)	(0.212)
Observations (NxT)	6,057	6,057
Number of firms (N)	1,698	1,698
R squared	0.865	0.865
Goodness of fit-F-test	_ -	302.58***

Notes: (i) The dependent variable is the firms' operating expenditures. (ii) Time fixed-effect included. (iii) Standard errors clustered at the firm-level within parentheses. (iv) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7. Results from Ordinary Least Square (OLS) regressions of the individual average treatment effect of PAE litigation on alliance formation against liquidity and litigation costs

	OLS					
Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
WC	-1.220***	-1.018***	-0.919***	-1.043***	-1.064***	-0.916***
	(0.316)	(0.291)	(0.266)	(0.286)	(0.305)	(0.283)
Days in litigation (log value)	–	0.237	–	–	–	–
		(0.145)				
Number of dockets (log value)	–	–	0.259**	–	–	–
			(0.105)			
Patents in suit (log value)	–	–	–	0.382**	–	–
				(0.191)		
Accused products (log value)	–	–	–	–	0.250*	–
					(0.140)	
Litigation cost index	–	–	–	–		0.251**
						(0.116)
Constant	1.255	-0.253	0.674	0.907	1.272	-0.253
	(0.957)	(1.028)	(0.980)	(0.931)	(0.893)	(1.028)
Control variables	Y	Y	Y	Y	Y	Y
Year-fixed effects	Y	Y	Y	Y	Y	Y
Industry-fixed effects	Y	Y	Y	Y	Y	Y
Observations	182	182	182	182	182	182
R-squared	0.133	0.153	0.165	0.157	0.158	0.170
Goodness of fit-F-test	2.88***	2.65**	2.85***	3.39***	3.04***	3.02**

Notes: (i) The dependent variable measures the individual average treatment effect associated with the PAE litigation, calculated as explained in the main text. (ii) Covariates are measured with one lag with respect to the individual treatment effect. (iii) Control variables include the following financial ratios: Profitability (ratio total revenues to total assets), operating efficiency (ratio earning before interests and taxes to total assets), equity (ratio market value to total liability), total asset turnover (ratio sales to total assets). (iv) Robust standard error within parenthesis. (iv) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Figure 1. Average of strategic alliance formation rate across PAE-litigation status

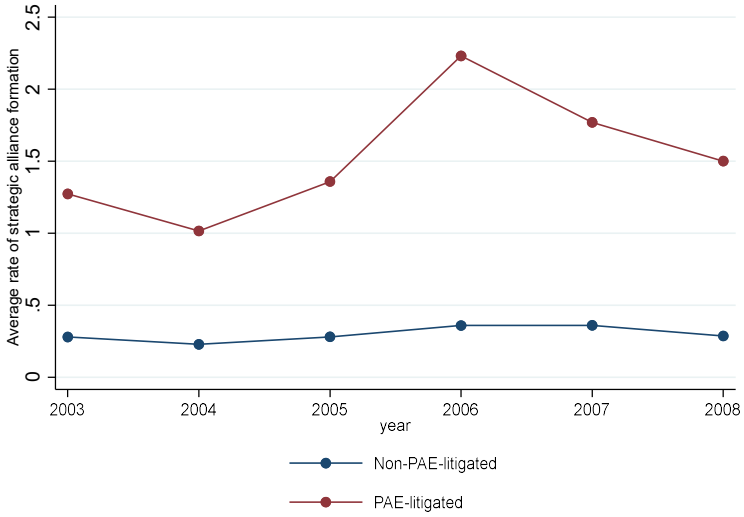
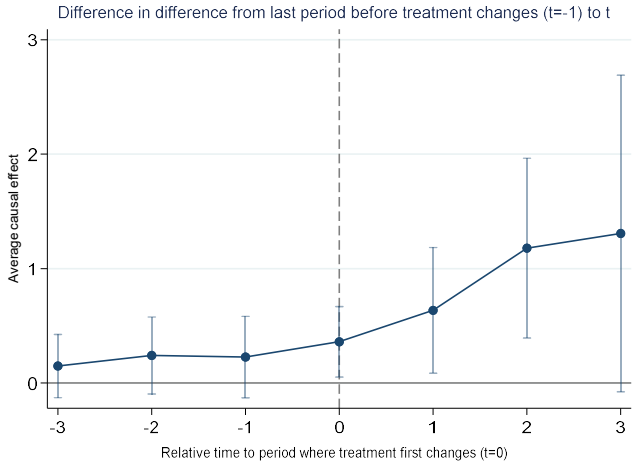


Figure 2. Dynamic effects: de Chaisemartin and D'Haultfoeuille's estimator (2022)



APPENDIX

Appendix A1: Data assembly

The process of data assembly for the analysis entails several sequential steps. Initially, Compustat firms were linked to CorpWatch, utilizing CIK numbers to facilitate the identification of Compustat firms' subsidiaries. The selection process involves considering the hierarchical structure of corporations, thereby enabling the retrieval of both primary subsidiaries directly associated with Compustat firms and those indirectly linked through intermediary subsidiaries. This matching yields a comprehensive database delineating the corporate structure of each Compustat company, comprising a compilation of corporate entities alongside their affiliated business names. The list identifies public and private subsidiaries affiliated with Compustat firms, which is critical to retrieving more comprehensive data on each Compustat corporation's litigations, alliance formation, and patent activities.

Next, a name-matching methodology, as delineated by Raffo and Lhuillery (2009), is employed to match our databases. Standardization and disambiguation of company names across datasets follow the guidelines stipulated by the NBER patent data project[20]. This standardization process involves, for instance, uniform capitalization and consistent terminology selection, such as harmonizing designations like "Limited" and "Ltd". Employing the Levenshtein distance as the basis for matching and a vectorial decomposition of corporate name strings into character sequences ("tokens") is undertaken, as outlined by Galasso et al. (2013). This procedure generates a similarity score for each pair of company names subject to the merger process, with perfect matches denoted by a similarity score of 1.

In the subsequent phase, the compiled list of Compustat corporate entities and their respective affiliates matches our litigation data, which documents defendants involved in both PAE and non-PAE litigations. This matching results in the identification of 2,324 perfectly matched pairs. For cases with Levenshtein's distances falling within the range of 0.8 to 1, we retrieved 242 additional pairs discerned through an extensive manual review. This matched dataset is denoted as DATA 1.

Continuing the matching procedure, DATA 1 is merged with alliance data, encompassing entities engaged in strategic alliances, according to SDC information. Repeating the same matching procedure, 2,462 perfect matches are reached, supplemented by 225 pairs identified through manual review from pairs with Levenshtein's distances falling between 0.8 and 1. This matched dataset is denoted as DATA 2.

Finally, DATA 2 is merged with patent data, capturing entities reporting patent activity in accordance with PATSTAT. This step identifies 5,591 perfect matches in conjunction with 1,052 pairs identified through manual review. This dataset is denoted as DATA 3. Table A1 summarizes the matching results.

Table A1 Match results

	Number of pairs retrieved	% of pairs retrieved
DATA 1: Compustat/CorpWatch and RPX data		
Perfect matches	2,324	90.57
Manually matched	242	9.43
DATA 2: DATA 1 and SDC data		
Perfect matches	2,237	90.86
Manually matched	225	9.14
DATA 3: DATA 2 and patent data		
Perfect matches	5,591	84.16
Manually matched	1,052	15.84

[20] Retrieving from: https://sites.google.com/site/patentdataproject/Home

Table A2 Results for Poisson model estimations of non-PAE litigation status on the firms' number of announced strategic alliances

Independent variables	(1) Poisson pooled data	(2) Poisson random effects	(3) Poisson fixed effects	(4) Poisson GEE with CRE
PAE litigation	0.060	0.054	0.013	0.016
	(0.087)	(0.065)	(0.065)	(0.054)
R&D intensity	1.552***	0.433	-1.019***	-1.021***
	(0.518)	(0.279)	(0.336)	(0.394)
R&D intensity squared	-1.159**	-0.306	0.241**	0.202
	(0.522)	(0.218)	(0.112)	(0.215)
Stock of patent applications (log value)	0.173***	0.199***	0.124*	0.087**
	(0.036)	(0.031)	(0.073)	(0.039)
Firm size (log values)	0.040	0.046	-0.230	-0.119
	(0.067)	(0.070)	(0.203)	(0.157)
Firm size squared (log value)	0.019***	0.015***	0.029*	0.018
	(0.005)	(0.006)	(0.017)	(0.013)
Fixed asset share	-0.815**	-0.625**	0.067	0.199
	(0.357)	(0.284)	(0.543)	(0.447)
U.S. company	0.794***	0.633***		0.789***
	(0.135)	(0.134)		(0.081)
Industrial-commercial machinery and computer equipment	-0.402**	-0.472***	_	-0.320***
	(0.158)	(0.148)		(0.114)
Electronic and other electrical equipment and components	-0.829***	-0.911***	_	-0.740***
	(0.114)	(0.105)		(0.086)
Measuring, analyzing, and controlling instruments	-0.623***	-0.664***	_	-0.564***
	(0.107)	(0.140)		(0.096)
Communication	-0.950***	-1.058***	_	-0.799***
	(0.324)	(0.283)		(0.223)
Business services	0.259**	0.247***	_	0.320***
	(0.104)	(0.094)		(0.073)
Constant	-3.351***	-2.989***	_	-3.555***
	(0.266)	(0.266)		(0.213)
Observations (NxT)	7,147	7,147	3,676	7,147
Number of firms (N)	1,912	1,912	836	1,912
Goodness of fit-Wald test (χ^2)	974.03***	986.25***	109.02***	2,904.79***
Wald test: Means fixed effects (χ^2)	–	–	–	56.11***
Exponentiated coefficient estimate (e^b)	1.062***	1.055**	1.013**	1.016***
	(0.092)	(0.069)	(0.066)	(0.055)

Notes: (i) pooled Poisson model with clustered standard errors at the firm level in column one, random-effects Poisson model with bootstrapped standard errors in column two, fixed-effects Poisson model with adjusted robust standard errors in column three and Generalized Estimating Equation (GEE) model with Correlated-Random-Effects (CRE) and robust standard errors in column four. (ii) Time-fixed effects included in all the models. (iii) Exponentiated coefficient estimates at the bottom of the table obtained from the Delta Method (iv) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A3. Results for a GEE Poisson model with CRE on the firms' number of announced strategic alliances, controlling for distinct value creation mechanisms

Independent variables	(5)	(6)	(7)
	Poisson GEE with CRE		
PAE litigation	0.235***	0.236***	0.228***
	(0.085)	(0.085)	(0.085)
Tobin's q (log value)	0.176***	0.184***	0.181***
	(0.047)	(0.047)	(0.047)
Granted patent claims	–	0.050**	–
		(0.020)	
Family patent forward citations	–	–	0.021
			(0.021)
Observations (NxT)	6,020	6,020	6,020
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Control variables	Yes	Yes	Yes
Means fixed effects	Yes	Yes	Yes
Exponentiated coefficient estimate (e^b)	1.264***	1.266***	1.256***
	(0.107)	(0.107)	(0.106)

Notes: (i) Robust standard errors in parenthesis. (ii) Exponentiated coefficient estimates at the bottom of the table obtained from the Delta Method. (iii) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A4. Results for the diff-and-diff analysis: Instantaneous and dynamic effects

Time elapsed since the treatment	de Chaisemartin and D'Haultfoeuille
-3	0.148
	(0.141)
-2	0.240
	(0.172)
-1	0.226
	(0.181)
0	0.360**
	(0.157)
1	0.635**
	(0.280)
2	1.179***
	(0.401)
3	1.307*
	(0.706)

Notes: (i) Control variables include the set described in the main text, adding the lag value of the variable *Strategic Alliances*. (ii) Industry-fixed effects are included. (iii) Standard errors are clustered at the firm level. (iv) The PAE litigation impact at time zero corresponds to the instantaneous effect. (v) Statistical significance levels labeled as follow: **** p<0.01, ** p<0.05, * p<0.1.*

Table A5. Results for the diff-and-diff analysis: Aggregated effect

Independent variables	de Chaisemartin and D'Haultfoeuille
PAE litigation	0.632***
	(0.209)
Observations (NxT)	6,902
R^2	0.685
Firm-fixed effects	Yes
Time-fixed effects	Yes
Control variables	Yes

Notes: (i) Control variables include the set described in the main text, adding the lag value of the variable Strategic Alliances. (ii) Industry-fixed effects included in the models. (iii) Clustered standard errors at the firm level are reported both cases. (iv) Statistical significance levels labeled as follow: **** p<0.01, ** p<0.05, * p<0.1.*

Table A6 Results for the propensity score matching model

Independent variables	Probit model
Lag of PAE litigation	0.866***
	(0.131)
Lag of Strategic alliances	0.068**
	(0.027)
R&D intensity	-0.018
	(0.545)
R&D intensity squared	-0.152
	(0.587)
Stock of patent applications (log values)	0.123***
	(0.030)
Firm size (log values)	0.267**
	(0.123)
Firm size squared (log values)	-0.008
	(0.008)
Cash flow (log value)	0.040
	(0.038)
Fixed asset share	-0.805**
	(0.405)
U.S. company	0.179
	(0.128)
Industrial and commercial machinery and computer equipment	1.044***
	(0.214)
Electronic and other electrical equipment and components	0.828***
	(0.181)
Measuring, analyzing, and controlling instruments	0.088
	(0.207)
Communication	1.004***
	(0.266)
Business services	0.926***
	(0.174)
Constant	-5.146***
	(0.669)
Observations (NxT)	7,089
Number of firms (N)	1,909
Goodness of fit-Wald test (χ^2)	554.62***
Pseudo-R^2	0.346

Notes: (i) Pooled Probit model used for the propensity score estimation. (ii) The dependent variable is a dummy indicating whether the firm is sued by an PAE at time t. (iii) Time-fixed included. (iv) Standard errors clustered at the firm-level within parentheses. (v) Statistical significance levels labeled as follow: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A7a. Mean-comparison between litigated and non-litigated companies before the matching

Observables	Treated group	Control group	Differences
Covariates			
Lag of PAE litigation	0.313	0.020	0.292***
Lag of Strategic alliance	1.930	0.357	1.573***
R&D intensity	0.167	0.259	-0.092***
R&D intensity square	0.042	0.142	-0.100***
Firm size (log values)	8.685	5.560	3.125***
Firm size squared (log values)	79.639	35.816	43.823***
Stock of patent applications (log values)	4.650	1.880	2.770***
Cash flow (log values)	19.669	16.504	3.165***
Fixed asset share	0.142	0.124	0.018***
U.S. company	0.811	0.843	-0.032***
Industrial and commercial machinery and computer equipment	0.169	0.045	0.124***
Electronic and other electrical equipment and components	0.350	0.204	0.146***
Measuring, analyzing, and controlling instruments	0.045	0.157	-0.112***
Communication	0.041	0.026	0.015
Business services	0.346	0.233	0.113***
Outcome			
Strategic alliances	1.601	0.343	1.258***

Notes: (i) The pre-matching pseudo-R-squared equal to 0.352. (ii) Statistical significance levels labeled as follow: *** *p<0.01,* ** *p<0.05,* * *p<0.1*.

Table A7b. Mean-comparison between litigated and non-litigated companies after the matching

Observables	Treated group	Control group	Differences
Covariates			
Lag of PAE litigation	0.231	0.223	0.008
Lag of Strategic alliance	1.165	0.980	0.185
R&D intensity	0.168	0.161	0.006
R&D intensity square	0.044	0.044	0.000
Firm size (log values)	8.418	8.454	-0.036
Firm size squared (log values)	74.844	75.276	-0.432
Stock of patent applications (log values)	4.205	4.238	-0.033
Cash flow (log values)	19.373	19.337	0.036
Fixed asset share	0.144	0.142	0.002
U.S. company	0.792	0.805	-0.012
Industrial and commercial machinery and computer equipment	0.132	0.146	-0.014
Electronic and other electrical equipment and components	0.368	0.346	0.022
Measuring, analyzing, and controlling instruments	0.052	0.049	0.003
Communication	0.047	0.053	-0.006
Business services	0.354	0.359	-0.005
Outcome			
Strategic alliances	1.028	0.691	0.337**

Notes: (i) Matching carried out using the nearest-neighbor criterion (ii) One neighbor used in the matching with a caliper of 0.005. (iii) On support, we have 6,216 untreated and 212 treated companies. (iv) Abadie-Imbens standard error used in the standard error estimation (Abadie and Imbens, 2011). (v) The post-matching pseudo-R-squared equal to 0.006. (vi) Statistical significance levels labeled as follow: *** *p<0.01,* ** *p<0.05,* * *p<0.1*.