1 Introduction

The importance of intellectual property for firms has increased over time, and as a result, patent litigations have become an important means of actively protecting valuable patent intellectual property and confirming firm production boundary. It is thus important to elucidate the potential broader impact of patent litigations on various corporate policies. For example, costly patent litigation hurts firms' financial health, which in turn, could deter investment activities through financial frictions Zingales (2002).[1] Patents are also an important input for producing goods that are eventually sold in product markets, and therefore, patent litigations could also have a significant impact on product market outcomes, because they could affect the level and scope of firm innovation activities.

In this paper, we use novel hand-collected *inter-firm* patent litigation data and examine its impact on financial and innovation strategies for firms operating in various product markets. Unlike non-practicing entity (NPE)-driven patent litigations (e.g., Cohen, Gurun, and Kominers (2016)), we focus on *inter-firm* patent litigations, wherein both plaintiffs and defendants are practicing entities that potentially compete in similar or different product markets. NPE patent litigations have different motives from inter-firm patent litigations; they do not cause back-to-back litigation disputes, but our inter-firm litigations do. What this implies is a much more strategic interaction between practicing entities in real product markets and their industrial-organizational dynamics, which is the main focus of our paper.

Using unique inter-firm patent litigations data, we uncover a significant interplay between intellectual property rights boundaries and product market competition. We demonstrate how innovation competition interacts with product market competition in the presence of significant litigation threats. In this regard, our study also signif-

[1]The median litigation costs and damage awards have reached $5 million and $17 million per case AIPLA (2015). These financial burdens and subsequent product market difficulties are well-described in the examples in the Appendix C.

icantly differs from those that focus on general corporate litigations such as security lawsuits (Bhagat, Brickley, and Coles (1994), Bhagat, Bizjak, and Coles (1998), Mezzanotti (2015)), in which firm and their *investors* dispute on governance, fraud, and disclosure-related issues.

We derive several underlying economics of inter-firm patent litigation, by building on the theoretical notion introduced by Lanjouw and Lerner (1997). We identify legal expense, damages awards, and the probability of winning a case as important determinants of endogenous patent litigations. We hypothesize that patent litigations decrease financial flexibility of firms since defendants are likely to bear greater financial burden of paying damages awards as well as a fixed litigation cost. We empirically confirm this intuition by documenting that defendant firms' cash level falls by $20 million after patent litigation, and that the number of firms paying dividends also decline by 5.6% post-litigation. More importantly, we find that the market share of defendant firms decreases by 4% among the five closest industry rivals. This result strengthens the product market competition consequences of patent litigation.

We further explore how litigation costs curtail innovation activities relatively more for defendant firms than plaintiffs. We hypothesize that the expected cost incurred by litigation could increase firms' hurdle rate for a positive NPV project. Consistent with this theory, we find that firm innovation activities measured by the number of patent applications over the next three-year window significantly decline by 35%. The number of citations received by defendants over the subsequent three years also significantly falls by 4%. This could be in part due to the increase in perceived costs of potential patent litigation for firms using technology related to the asserted patent, in case it is found invalid. These patentee-level findings further lead us to investigate potential industry spillover of the impact of patent litigation. We find that a greater number of firms targeted as defendants in a given industry leads to a significant reduction in *industry-wide* innovation activities measured by the number of total patent applications and citations. This result suggests that pervasive patent litigation threats

effectively curb firms' ex ante willingness to innovate through risky R&D investments.

As we emphasize our unique experimental setup–inter-term patent litigations in multiple product markets– we further delve into whether and how product market competition exacerbates our main findings. We divide our sample depending on whether plaintiffs and defendants are in the same industry or not, and examine how their product market inter-linkage plays out in patent litigation. We define intra-industry litigations as a dispute between two opposing firms in the same 2-digit SIC. We then summarize the key patent litigation determinants by intra- and inter-industry cases and generally find that greater product market overlap leads to larger damages awards, which amplify the financial damages to defendants and the firms' deterioration in subsequent innovation activities. The negative financial and innovation activities post-litigation significantly strengthen for intra-industry cases.

We further provide details of how patent litigations change the scope and context of corporate innovations. We find that firms generally pursue safer innovation products in a narrower scope. On a patent-level, firms develop more exploitative patents. On a firm-level, firms cut down on general acquisitions but increase same-industry acquisitions by 56%, which is indicative of firms focusing on their core business segment and technology. We also investigate the types of external R&D investments. The corporate venture capital (CVC) investments decrease by 10%, consistent with pursuing safer innovation strategy, as CVC investments are known as a means to explore and experiment with new technology outside of firms' existing product boundaries (Fulghieri and Seville (2009), Chemmanur, Loutskina, and Tian (2014), Ma (2017)). We also find that the breadth of business segments decline by 7.7% for defendant firms following patent litigation, suggesting that the narrower focus may have caused defendant firms to close down on too much diverse business lines, which otherwise might open up unwanted patent litigations in the future.[2]

[2]The literature considers exploratory innovation as riskier project as "exploratory innovation requires new knowledge or a departure from existing knowledge, and its payoffs take longer to realize and are of higher uncertainty." (Gao, Hsu, and Li (2018))

We finally confirm that firms' exploitative innovation strategy indeed reflects their avoidance of the higher uncertainty associated with long-term risky innovation projects (Cohen, Levin, and Mowery (1987), Nohria and Gulati (1996), Gao, Hsu, and Li (2018), Aghion, Angeletos, Banerjee, and Manova (2010)). We further provide evidence that given being involved in a patent litigation as a defendant in year t, shifting towards exploitative innovation strategy in year $t+1$ helps reduce the firm probability of being targeted as another defendant in the same year $t+1$. This result demonstrates that exploitative innovation strategy is indeed an effective way to hedge away future patent litigation risk.

Our main regression analyses adopts a difference-in-differences framework to capture the "relative" impact of patent litigation between plaintiffs and defendants. However, the types of litigant and the timing of patent litigation could arguably be endogenous, and therefore, our results could be confounded by firm-level omitted variables and potential reverse causality concerns. The weakening financial health may have attracted more patentees to target alleged infringers to take advantage of relative financial flexibility. To mitigate such potential endogeneity, we adopt an instrumental variable regression that uses an exogenous passage of TRIPS agreement between China and the US in 2001 as an instrument. TRIPS strengthened the incentive of the US firms to enforce intellectual property rights against potential entrants to the Chinese market. The passage of TRIPS agreement hence increases the likelihood of patent litigation for other US firms whose business prospects are closely related to the Chinese product markets where a focal U.S. firm operates. Using this instrument we show qualitatively consistent evidence that patent litigations induce financial constraint to defendant firms and subsequently reduce their innovation activities.

Our paper contributes to the literature on corporate innovation and product market dynamics. We expand patent litigation literature by showing important inter-firm dynamics and innovation competition among operating entities. Our paper differentiates from the NPE patent litigation studies (Cohen, Gurun, and Kominers (2016), Mezzan-

otti (2015),Appel, Farre-Mensa, and Simintzi (2018)) as we provide direct evidence of inter-firm dynamics that form innovation and product market competition, which are, by nature, absent in NPE patent litigations. Whereas the NPE litigation is largely driven by monetary gains to NPE's from suing cash rich defendants, we do not find evidence of such cash-driven motives in our inter-firm patent litigations. The diverging litigation effects between plaintiffs and defendants and stronger intra-industry litigation effects clearly differentiate the litigation motive of operating entities from that of NPE's. Building on previous studies, we do not only show the adverse effects of patent litigation, but we additionally focus on providing in-depth analyses of how affected firms' innovation strategies change in terms of both internal and external R&D efforts.

Our paper also builds on broader corporate litigation literature. Existing corporate litigation studies focus on corporate fraud (e.g., Karpoff and Lott Jr. (1993), Dyck, Morse, and Zingales (2010)), shareholder litigation (e.g., Lin, Liu, and Manso (2016)), environmental-related litigation (Karpoff, Lott, and Rankine (1999)), antitrust litigation (Bizjak and Coles (1995)) and general inter-firm litigation (Bhagat, Brickley, and Coles (1994)). Unlike corporate fraud or shareholder litigation that stem from managerial agency problem, patent litigation highlights operating risk for firms with large intellectual properties. This paper shows findings consistent with Bhagat, Brickley, and Coles (1994) that litigation leads to decline in financial flexibility. However, we provide additional important details on changes in the types, modes, and breadth of firms' innovation strategies specific to patent litigation.

Our paper also identifies the innovation competition and intellectual property rights dispute as an important determinant of industrial-organizational dynamics. As plaintiffs gain significant market shares than defendants after patent litigations, such relative innovation competition between defendants and plaintiffs would serve as an important economic determinant of product market dynamics. Researcher could further look into this novel element to improve our understanding of what constitutes various product markets- and inter-product dynamics.

The rest of the paper is organized as follows. Section 2 develops our hypotheses. Sample data, variable definitions, and summary statistics are reported in Section 3. Section 4 describes our empirical approach. Section 5 presents the main results, and Section 6 concludes.

2 Hypothesis Development

In this section, we derive our economic intuition on the inter-firm patent litigations using the theoretical setup in Lanjouw and Lerner (1997). Following their theoretical notion, we consider a plaintiff's decision of whether to file a suit against a potential infringer, i.e., a potential defendant in patent litigation. The plaintiff compares its expected payoff from going to trial to the payoff it would receive if it settles with the infringer. With the probability of winning the case (W), the damages award (J), and the fixed legal cost (L), the former payoff to the plaintiff if it goes to trial is given as:

$$Y + WJ - L, \tag{1}$$

where Y denotes the income that the plaintiff attains under the damages. Similarly, we can define the expected payoff to the defendant should it be taken to trial. Using similar parameters that are represented by lowercase letters for the defendant, y, w, j, and l, the payoff to the defendant is given as:

$$y - wj - l. \tag{2}$$

The sum of the two payoffs above, i.e., $Y + y + WJ - wj - (L + l)$, is the trial value of the two firms' litigation game. If they instead settle rather than dispute at the court, they can share $Y + y$ net of settlement cost, which we assume is negligible for simplicity.

The two firms settle only if their perceived surplus to cooperate is positive:

$$-(WJ - wj) + (L + l) \geq 0 \tag{3}$$

With the bargaining power, θ, for the plaintiff during the settlement, the plaintiff receives $\theta\left[(L + l) - (WJ - wj)\right]$. This gives the following payoff that a potential plaintiff expects from patent litigation:

$$Y + WJ - L + Max\left\{0, \theta\left[(L + l) - (WJ - wj)\right]\right\}. \tag{4}$$

Note that a potential plaintiff will go to trial only if the second Max term above becomes negative. Using this key Equation (4) in Lanjouw and Lerner (1997), we derive the following testable implications. We parameterize damages awards perceived by the plaintiff, i.e., set $J = \alpha j$, where $\alpha \gg 1$ implies that the plaintiff perceives a much higher return from the trial than the defendant. By varying key parameters of the model – the damages awards, legal costs, and the probability of winning trial – we derive comparative statics of the real consequences of patent litigation on firms.

Hypothesis 1: Patent litigation costs decrease financial flexibility.

Patent litigation is costly. According to AIPLA (2015), the median legal cost (L, l) has increased from \$4.5 million to \$5.0 million between 2005 and 2015 for firms with more than \$25 million risk. Also, the median damages award (J, j) ranges from \$2 million to \$17 million over 1997-2016, and as much as \$2.5 billion for mega-award granted in 2016 (PWC, 2017). Damages awards are not required to be reported on dockets. There are 112 cases with reported damages awards in our data. Breaking down into different types of damages awards, our data show that the lost profits range between \$2.2 million and \$57.4 million. The royalty ranges from \$88,000 to \$45.3 million.

Given this significant cost of litigation, we expect that both plaintiffs and defendants to experience financial constraints post litigation, but since defendants are accountable

for damages awards (j), if found to have infringed the patentee's technology, defendants' financial burden will be larger. It is important to note that if legal expenses (L, l) are substantially larger than the damages awards (j), cases are likely to be settled most of the time. However, in our data, the median lost profits and reasonable royalty are \$8.9 million and \$4.6 million, respectively, both of which are larger than or at least comparable to the median legal expenses of \$5 million.

Hypothesis 2: Litigation costs reduce innovation activities.

As litigation costs (l, L) increase, the threshold for taking positive NPV innovation project also rises, forcing firms to forgo some of low return innovation projects on both firm- and industry-level. This is particularly true for the defendant as it bears both the fixed legal cost (l) and the royalty payment (j).[3] Thus we predict that the number of patent applications decrease after patent litigation, particularly for defendants of the litigation. Moreover, as patent citations capture the intricate web of technology users, we expect that patent litigation decreases the number of citations received by the defendant patents. This reflects the increased perceived of cost of citing the asserted patent for citing firms for the possibility of the asserted patent resulting invalid.

Although not directly extrapolated from our model, we expect a potential industry spillover of patent litigation effect at the industry-level. We predict that the greater the number of defendants in a given year in a given industry, the larger reduction in industry-level innovation activities. This reflects our notion that pervasive patent litigation risks increase the perceived cost to bear by firms that operate in the industry. With the increasing hurdle rate for their future innovative investments, firms in the industry tend to lower their investment intensity in terms of the volume of their innovation activities.

Hypothesis 3: The decrease in financial flexibility and innovation activities is more pronounced in intra-industry case.

[3]Recall that the expected NPV conditional on a potential patent litigation is $y - wj - l$.

We divide our sample cases into intra- and inter-industry case in order to emphasize that patent litigation is closely related to industry dynamics. We categorize a case as an intra-industry case when plaintiffs and defendants share the same two-digit SIC code. By doing so, we can re-characterize the key patent litigation parameters by intra- and inter-industry cases.

Our data shows that intra-industry case plaintiffs and defendants indeed overlap to a larger degree in terms of technology and product market. The patent proximity,[4] which measures the distance between vectors of patent classes of plaintiff and defendant pair, is higher in intra-industry case (0.42) than in inter-industry case (0.31). Hoberg and Phillips (2016) measure of text-based industry classification of product market rivals also is greater for intra-industry cases. The score is 0.037 for intra-industry and 0.011 for inter-industry, which indicates that the pair of firms in intra-industry cases are closer rivals in the product market. These two measures ensure that intra-industry case litigants have greater product market overlap. Therefore, the average damages award is larger in intra-industry cases ($9.60 million) compared to inter-industry cases ($8.29 million), as damages awards account for the harm done by an infringer on sales of the product related to an asserted patent.

The summary of key parameters above by intra- and inter-industry case alludes to a greater chance of observing intra-industry case as the key parameters increase patentees' incentives to go to trial. Higher j given $\alpha > 1$ (recall $J = \alpha j$) implies more negative $\theta\left[(L + l) - (WJ - wj)\right]$. We confirm that there are greater number of intra-industry cases (441) than inter-industry cases (390) in our data. These observations lead us to expect also to find more pronounced negative effects of financial and innovation activities results for defendants in intra-industry cases. This is mainly due to larger damages awards when there is greater product market overlap as we have shown above.

[4]Technological proximity Jaffe (1986) measures closeness of any two firms' innovation activities in the technological space using patent counts in different technology classes.

Hypothesis 4: Firms choose exploitative innovation strategy after patent litigation to avoid future litigation risks.

Lerner (1995) finds that greater uncertainty about the quality of case (i.e. the perceived probability of winning the case) impedes settlement. When plaintiff and defendant disagree on the winning probability of the case (wider $W - w$), going to trial becomes more attractive to a potential plaintiff. When they both agree on who is going to win the trial (i.e.,$W \approx w$), patent litigation risk could be significantly reduced. Hence, to avoid future litigation risks, we expect firms to choose incremental patent development to stay closer to the core technology that reduces the uncertainty about the quality of cases. In other words, after patent litigation, firms will follow an exploitative innovation strategy.

We use a few proxies of narrower innovation scope. First, on a patent-level, we measure the breadth of patents using the citations. An *Exploitative* patent uses existing patents and patents cited by those to capture how narrow is the trajectory of related technologies. On a firm-level, we expect firms to focus more on *same*-industry acquisitions for external innovation. Alternatively, we can measure firms' incentives to pursue exploitative innovation projects by looking at changes in their corporate venture capital (CVC) investments. It is widely accepted that firms use CVC to search for new technologies outside of firm boundaries (Fulghieri and Seville (2009)) and to become more receptible to experimentation and exploration (Chemmanur, Loutskina, and Tian (2014), Ma (2017)). Therefore, we predict that firms trim down on CVC investments after patent litigation. The reduction of relatively distanced projects may also result in a decrease in the number of business segments.

To close the loop, we verify the following empirical regularities. We first verify that the exploitative innovation strategy effectively lowers future litigation risks, conditioning on firms leaning towards exploitative innovation projects post-litigation. In addition, we further highlight the important product market dynamics of patent liti-

gation by isolating cases that ended with verdict.[5] A dispute that reaches verdict is deemed as a case with clarifying boundaries of asserted patents by either reinforcing or invalidating a litigant's rights to use the patent in product market. Therefore, cases that end with verdict provide better opportunity to directly explore how firms readjust innovation strategy upon the court's patent boundary guidelines.

3 Data and Summary Statistics

3.1 Data Source and Sample Selection

Our sample consists of S&P 500 firms that had at least one patent litigation during our sample period between 2000 and 2006. The final sample consists of plaintiff-defendant firm(s) pairs, where at least one S&P 500 litigant firm appearing in each case. We end our sample period to 2006 due to significant structural changes in intellectual property rights after 2006. A patent dispute started by NTP Inc., a patent holding company, nearly caused the shutdown of BlackBerry wireless service, and reached a $612.5 million settlement. This successful NPE assertion, which was quite rare before 2006, gained Congress attention and media spotlight.[6] Similar abusive patent lawsuits aiming for injunction orders led to the landmark Supreme Court decision in 2006, which reduced the likelihood of obtaining an injunction and changed expected damages awards (Mezzanotti (2015)). Furthermore, there were many structural changes in product market and regulations around 2007 in the information and communication technology (ICT) sector, with the introductions of new technologies such as iPhone, cloud computing service infrastructure, and flash-based hard drive. Given these confounding factors can cause spurious relationship between patent litigation and real consequence in firms'

[5]Only about 20% of our sample cases reach verdict and others are dismissed after the cases reaching trials, more frequently so in inter-industry cases. The cases that eventually get dismissed are likely to have reached licensing agreements and thus dampen the product market outcome.

[6]See more "BlackBerry Maker Reaches Deal in Patent Dispute," The New York Times, 2006 March and the government hearing in 2006, "Patent Trolls: Fact or Fiction," 2006 June.

financials, innovation, and product market competition, our sample period is a clearer setting for examining the implications of patent litigation.

There are two main sources of data. The first is *Lex Machina*. *Lex Machina* provides patent litigations in detail starting in January, 2000. The database leverages primary data source from PACER, the USPTO, and ITC, and offers comprehensive information about each patent litigation.[7] We hand-collect information on litigants and asserted patents involved in US district court cases, damage amounts,[8] judges, courts, and final decisions. We keep cases that involve at least one S&P 500 firm in the litigation.[9] The second source of data is NBER patent database (Hall, Jaffe, and Trajtenberg, 2001). We match our sample firms to NBER's unique identifier (*pdpass*) firm identifier and obtain detailed patents owned by our sample firms. Since NBER data ends in 2006 and *Lex Machina* starts in 2000, our sample period is restricted between 2000 to 2006.

Overall, our sample data consists of 473 including never-litigated firms unique S&P 500 firms, 1,692 unique cases, and 4,121 unique firm-case observations. The number of unique firm-case observation implies that some cases involve non-S&P 500 firm as counterparty. In the next section, we describe our sample litigations in detail and characteristics of firms by plaintiff and defendant.

[7]US District Court, ITC (International Trade Commission), and PTAB (Patent Trial and Appeal Board) are three venues for patent disputes. We only include US District Court cases as the majority of patent cases are filed at the district court level. ITC cases are relatively few, where the average number of ITC cases were 12 per year between 1990-2000 and 33 cases per year between 2001-2012. ITC cases peaked in 2011 then declined again. US district court cases and ITC cases are similar. An important difference, however, is that imposing monetary damages and/or establishing a reasonable royalty is only possible through district courts. This is important for our theoretical model as damages award is an important parameter that derives intra- and inter-industry patent litigation dynamics. However, we acknowledge that omitting ITC cases may cause an overstatement of our results, as ITC cases can indicate larger stake involved through importation of infringing goods and the related entire domestic industry. PTAB was formed in 2012 as a part of America Invents Act, which falls outside of our sample period.

[8]Not all cases disclose the damage amount. We leave the unreported damages as zeroes in the data.

[9]In order to verify whether our sample patent litigation cases are part of NPE litigations, we use a list of NPEs identified from PlainSite and IPCheckups, which are used in Lerner, Speen, Baker, and Leamon (2015). We individually matched all plaintiffs in our sample and found nearly none that matched to the NPE list. This is not so surprising given NPE-led patent litigations started to grow dramatically after 2010. Another possible reason is that since the objective of NPEs centers around monetary gains, these cases may settle before reaching a trial.

3.2 Summary Statistics

3.2.1 Patent Litigation Summary

Table 1 Panel A describes our sample patent litigation cases. There are total 1,692 US District Court patent litigation cases that are associated with S&P 500 firms in our sample. We exclude 16 cases that are still on-going lawsuits without case termination date.[10] In our sample, 76% cases are initiated by S&P 500 plaintiff firms. Of these cases, only 18% of the cases reach final verdict, and around 70% of cases are dismissed after being filed. Conditional on reaching verdict, about 65% of cases are won by the plaintiffs, which suggests that firms are more likely to reach trial if there is high probability of winning ex ante.

The average length of litigation is about 2 years, and each case has on average 1.31 plaintiffs and 1.90 defendants.[11] Since there are multiple plaintiffs and defendants in a given case, theoretically, each case contains multiple plaintiff-defendant pairs. For empirical analyses, we only keep firms that are identified in Compustat, and this leaves us with unique Compustat firm pairs for each case.[12] About 60% of cases are intra-industry cases, where plaintiffs and defendants are in the same industry based on two-digit SIC. The average total damage awards in our sample is $7.3 million,[13] which is also consistent with the previously referenced number for PWC (2017). Note that damage awards are not always reported in case dockets, and we only have 112 cases

[10]The results are robust after including those on-going lawsuits.

[11]There may be plaintiff firms and/or defendant firms under joint ownership of patent rights. We estimate such possibilities using NBER's Dynamic Assignee Match file, which keeps track of unique patent-assignee pairs over time. When merging each unique patent-assignee pairs (through *pdpass*) with all patents owned by each assignee in our sample, there are only 2 instances of potential joint ownership of patent at 95 percentiles. However, we are not able to observe patent licensing agreements, which may share both risk and returns from patent rights. Without knowing details of licensing agreements of our sample firms, it is unclear how licensing agreements bias our results and in which direction.

[12]Since our sample include only litigants who can be identified in Compustat, these numbers constitute the lower bounds.

[13]In untabulated table, we also report damages from litigation, computed as a net amount. Damages paid are negative numbers and received are positive number. The average net damage amount is positive given our sample firms are more likely to be plaintiffs in sample cases, and they are also more likely to win, receiving damages from their opponent firms.

with reported damage awards. We treat the unreported damage awards as zeroes.

In the Appendix B we provide two additional analyses. The univariate analysis on comparing the characteristics of asserted patents of sample firms with those of non-asserted patents resembles closely with the existing studies on patent-level determinants of patent litigation and also helps understanding our data better. The determinants of patent litigation analysis bridges between the patent-level understanding of patent litigation with firm-level characteristics. The results show that patent-level characteristics are pronounced determinants of patent litigation, suggesting that patent litigation is driven strongly by patent characteristics yet has significant effects on firm-wide financials and innovation. These results motivate a closer examination of inter-firm patent litigation to have a better grasp on the propagation of patent-level shock to firm-level outcomes.

We acknowledge that many patent assertions can reach settlement before actual trials. Those settlements that are not observed in our litigation sample. In our litigation sample, 18% of trials end up with a verdict during our sample and about 70% of trials are dismissed. We expect that patent disputes reaching actual trials are the ones that face fiercer product market competition. Usually damage rewards are three times larger than settlement costs, and thus our litigation sample captures cases with greater economic importance.

3.2.2 Firm Characteristics Summary

Table 1 Panel B reports summary statistics of patent portfolios on firm-level. We have total 286 unique firms and 159 unique S&P 500 firms in our sample.[14] Our sample firms have mean (median) of 5,162 (2,790) patents in their portfolio and a mean (median) age of 10.32 (11.14) years-old.[15] The average number of claims on patents and

[14]The total number of observation in regression analyses is 10,099 because 1) a few firms appear multiple times in different cases and 2) we conduct our analyses over the [-3 years, +3 years] window around patent litigation over the 2000-2006 period.

[15]NBER Dynamic Assignee data keeps track of the assignee sequence on ownership of each unique patent. For the asserted patents in our sample, the average of such sequence number (1 being the first assignee and

truncation-adjusted citations received are 16.63 and 15.95, respectively. Lastly, our sample firms hold relatively more of exploratory patents that uses and are related to a wide variety of technology fields.[16]

Panel C describes financial characteristics of our sample firms. The average leverage of 0.18 is relatively large for R&D-intensive firm. However, keep in mind that our sample firms consist of S&P 500 firms, therefore the leverage ratio of 0.18 may actually be on the upper end compared to other small R&D-intensive firms. Also, note that our sample firms have relatively high average Q and are in highly competitive industries.

In order to give some reference statistics, we also report comparisons between litigated firms and never-litigated firms, using all S&P 500 firms between 2000 and 2006 in Table 2 Panel A. In terms of financials, litigated and never-litigated firms are quite different. The number of patents, however, shows stark differences. Also, liitigated firms have statistically significantly higher R&D expenses and Tobin's Q and are more profitable. These are intuitive differences because patent litigation would be common among firms actively pursuing innovation. Also, highly profitable firms have the financial ability to bear the high litigation costs as well as more likely to attract potential litigants.

4 Empirical Approach

Our main analysis approach is difference-in-difference regressions. We define our "treatment" group as defendant firms[17] and compare the *relative* changes in outcome vari-

5 being the last assignee tracked by NBER) is 1.00. This reduces the concerns with our results capturing changes in the patent-related measures, such as size of patent stock and citations, merely from patent transfers. Our results are robust restricting samples to originally assigned patents with sequence number equal to one.

[16]In untabulated summary of asserted patents only, consistent with patent litigation literature, we find that younger (7.13 years) and more valuable patents, measured by the number of claims (23.37) and citations (44.16), are more likely to be litigated. We provide patent-level regressions of determinants of patent litigation in more detail in Section 3.3.

[17]Technically both plaintiffs and defendants are "treated" as they all undergo litigation. To simplify the interpretation of coefficients, we arbitrarily designate defendants as "treatment" group. If we were to

ables two years before and after patent litigation.[18] We use difference-in-difference analysis to capture the differential impact of patent litigation on different types of litigant around the patent litigation.

$$Y_{i,j,t} = \beta_0 + \beta_1 After_{i,j,t} \times Defendant_{i,j,t} + \beta_2 After_{i,j,t} + \beta_3 Defendant_{i,j,t} + \beta' X_{i,t} + \alpha_i + \alpha_t + \varepsilon_{i,j,t}$$

where i indexes portfolio firms, j indexes litigation cases, t indexes years, $Y_{i,j,t}$ is a dependent variable. *After* is a dummy variable that equals one after litigation year, and zero before and including litigation year. *Defendant* is a dummy variable that equals one if a firm is defendant in litigation case, otherwise zero. The year fixed effects and firm fixed effects are included to remove common time trend in corporate policy and time-invariant unobservables, respectively. We cluster standard errors at case level.[19] The resulting difference-in-difference coefficient captures the changes in defendant firm outcome variables relative to the changes in plaintiff firm outcome variables, post-treatment.

We acknowledge that our "treatment" is non-random (also discussed in Section 2.2 Determinants of Patent Litigation), and also have shown that the defendant firms are somewhat different from the plaintiff firms from Panel B of Table 2. The non-random treatment and the endogenous timing of patent litigation can cause several limitations in drawing causal inference. For example, firms with strong innovation outcome may attract more asserted claims because rival firms using similar technology may wait un-

designate plaintiffs as treatment group, the magnitude of coefficients would remain the same, except they would carry opposite signs. Since our sample data consists of firms with at least one patent litigation, the difference-in-difference coefficients can be interpreted in exactly the opposite way with defining plaintiff firms as a treatment group.

[18]For robustness, we also use different windows for treatment period. The results are robust.

[19]In our diff-in-diff regressions, we cluster the standard errors at the case level because firm observations (both defendant and plaintiff) are related across year within a certain case. However, since some litigation cases might even affect other cases within a year or same firm across year, we consider clustering at the firm level, the same level as the included fixed effect, and double-clustering at the firm and case level. Our results do not change.

til the profits from the allegedly infringing patent build up to maximize the expected profit from patent litigation. The unobservable drivers of decision to initiate patent litigation that are correlated with firms' financial health, innovation strategy, or product market position would cause differential outcome even without patent litigation. Given these limitations, we try to provide comparisons of pre-litigation trends in the set of outcome variables to ensure that the defendant and plaintiff firms have similar trends in observable dimensions prior to litigation to understand the direction of any possible bias on the difference-in-difference estimate.

5 Results

5.1 Financial and Innovation Outcomes

5.1.1 Financial Outcome

In this section, we present firm-level financial and innovation activities as consequences of patent litigation. Again, the main coefficients of interests describe the additional changes in the outcome variables of defendant firms relative to plaintiff firms. In Table 3 columns (1) and (2) of Panel A, we find that defendant firms' cash level declines sharply by 2 percentage point, or by 9.5% of unconditional mean value of cash to asset ratio, and the number of defendant firms paying dividend declines by 5 percentage points, or by 7.8%. The results confirm that defendant firms experience mounting financial constraints as they go through costly patent litigation. Panel B traces treatment effect over time to show that the observed litigation effects are not driven by pre-existing trends. The coefficients prior to the litigation year t are close to zero and statistically not significant. The treatment effect of patent litigation appears only after the litigation year t and the coefficients post-litigation become large and statistically significant. Panel B results ensure, at least, that there are no apparent reverse-causality or significant pre-trends between plaintiffs and defendants.

In columns (3)-(4) of Panel A, we also find an increase in leverage by 26% and a decrease in asset growth 53%. We hypothesized that defendant firms' leverage would decrease as a result of diminished value of patents as collateral (Mann (2018)) as a medium of financing for innovation. However we find that the leverage actually increases possibly due to shrinking asset size. This is likely to be associated with firms' exploitive innovation strategy by cutting down on investments and business segments remotely related to firms' core technologies. Also, it is important to make a note of $After$ term, which estimates the average changes in the outcome variables over time for plaintiffs. The coefficients on $After$ in columns (1)-(3) in Panel A are indistinguishable from zero, which means that litigation has almost no effect on *plaintiff* firms' cash, dividend, and leverage. In contrast, strong negative and statistically significant effect is found on defendant firms' cash, dividend, and leverage. The contrast in asset growth between plaintiffs and defendants is even more pronounced, where it increases for plaintiff firms after patent litigation and relatively decreases for defendant firms. This divergent effects allude to potential product market competition consequences of patent litigation we explore in depth in market share analyses.

In Table 4, we further focus on the product market competition aspect of patent litigation. We compute market shares using Hoberg and Phillips (2016) text-based industry classification (TNIC) in columns (1)-(4). TNIC database provides cosine similarity score of a pair of firms based on text parsing of business descriptions from 10-K annual filings. Based on this score, we restrict the number of closest industry rivals to 5, 10, 25, and 100 firms when computing market shares. This exercise allows us to emphasize the importance of product market overlap in patent litigation, as we find stronger negative market share effect when the market share is computed using closer product market competitors with high similarity score based on business descriptions. We find that defendant firm market shares decrease by 5 percentage points after patent litigation accounting for a nearly 10% decrease in the unconditional market shares (48%) in column (1). This result is strongest in column (1) using the 5-closest

rivals then weakens monotonically as we broaden the composition of rival firms from column (2) to (4),[20] where low similarity score firms are added in each step. Column (5) computes market shares using *all* firms in the same 3-digit SIC. The market share effect is negative but negligible in magnitude.

The market share results in Table 4 underscore the fact that patent litigation has important product market competition consequences. In other words, patent litigation has greater impact on firms with greater product market overlap, which increases potential damages rewards if patent dispute arises between firms that depend on end-products that make use of similar patented technology. It is also highly likely that the financial damages we find in Table 3 reinforce the shrinkage of defendant firm market shares by limiting financial strengths to survive product market competition.

We briefly comment about the magnitude of our finding before discussing about potential selection issues. The decrease in cash translates to $108 million. The most relevant study to ours is Bhagat, Brickley, and Coles (1994), which finds that firm values of the plaintiff and defendant jointly drop by about 1%, or $20 million, after upon the announcement of inter-firm litigation related to corporate control, breach of contract, patent infringement, antitrust, and others between 1981 and 1983. The authors also find that patent infringement-specific lawsuits result in decrease of firm value by 1.89% ($80 million) for defendants, 0.09% ($3.5 million) for plaintiffs, and 3.13% for pairs. Compared to these, our financial results, although not directly comparable, may seem large. However, given that our sample firm market equity is ten-times larger, the magnitude of changes in our result seems reasonable, particularly as we focus on the S&P 500 firms.

We acknowledge that the baseline regression may suffer from endogeneity. First, one may be concerned that financially weaker firms tend to be attacked by rivals. This is unlikely because defendants that are unable to raise capital to finance litigation

[20]The average and median similarity scores monotonically decrease from 0.11 to 0.07 as we use broader pool of rivals, where higher score means closer rival. The changes in similarity score is marginal after 100 rivals.

would be forced to settle the dispute regardless of the ultimate merit of the case. This means that firms with deteriorating pre-treatment financial condition is *less* likely to show up in our sample. Second, firms with higher chance of intellectual property (IP) legal dispute may be more likely to protect their risk through IP insurance, which reimburses the litigation expenses either to enforce IP against infringers or defend against charges of infringing other companies' IP rights. However, this endogenous selection would likely bias our results toward finding no effect of the treatment and thus it is unlikely to drive our results.

5.1.2 Innovation Activities

We further explore how firms' innovation activity changes. The financial costs of patent litigation limit firms' ability to take on all positive NPV projects, which then slows down innovation activities. The results using a sample of 11,370 firm-year observations for 1,692 litigation cases are reported in Table 5. The dependent variables are the logarithm of one plus the number of patent applications in a given year. We use the same regression specification as those used in Table 3. In particular, we control for year and firm fixed effects since the innovation activities can be influenced by the time trend and firm-specific characteristics. We measure innovation activity by the number of application because the effects measured by the number of granted patents show up with some time lags.

In Table 5, column (1) and (2) in Panel A show that defendants' number of patent applications declines by $52.1\%(=e^{0.42}-1)$, and the number of citations also declines by 3%.[21] The decrease in citations is indicative of citing firms' fear of finding the asserted patents invalid, which would increase patent litigation risks and reduce the citing firms' expected profit.[22] To check if the patent application, citations, and patent grants have

[21] We find similar results on firm-level analysis in Appendix Table A3.

[22] In untabulated cross-sectional results, we find that the litigation effect is stronger if asserted patent in patent litigation case has more citations. This supports our hypothesis that the adverse litigation impact is larger for greater potential damages awards, which can be inferred from the importance of the asserted

delayed responses, we run the regressions again by focusing on the effects in the first, second, and third year after litigation individually in each columns of Table A4. Our results are consistent with the main regression results.

It appears that patent litigation does not only affect firms' in-house R&D but also external acquisitions of technology. The results are presented in columns (3) and (4). We find defendant firms' number and size of acquisitions fall by 10% and 58.4%, respectively.[23] Again, it is important to note that the reduction in the number and size of acquisitions is related to firms' post-litigation innovation strategies to pursue exploitive innovation projects that we discuss in Section 5.4. later.[24]

The citation result hints at potential spillover effects of patent litigation within industries, as patents are intricate web of related technology users. We exclude litigated firms to examine firm-year level spillover effects on never-litigated industry peers. Panel A in Table 6 presents how patent litigation has spillover effects on never-litigated firms during our sample period of 2000-2006 in the same industry. Excluding the litigated firms from this analysis ensures that what we find represents industry externality, as the litigation effects remain strong after removing firms directly involved in litigation. A 1% increase in the number of patent litigation in a given industry lowers the industry-level innovation productivity by 0.13% and patent quality by 0.03%. Similarly, Panel B shows that 1% increase in the number of patent litigation defendants reduces industry-wide patent productivity and quality by 0.14% and 0.4%, respectively. The coefficients almost doubles when using the average number of litigation or defendant cases over the last three years for both litigation intensity (Panel A) and defendant risk (Panel B). These results ensure that we are not capturing any spurious industry effects in a

patent measured by citations.

[23]The declining acquisition results are reflective of the example of Johnson & Johnson's and Boston Scientific case in the Appendix C, where after settling a series of patent disputes in losses, Boston Scientific experienced financial difficulties that led to fewer acquisitions.

[24]Bena and Li (2014) provide evidence that combining innovation capabilities by patent-mergers is important driver of corporate acquisitions. The results convey how firms use patent mergers as means to rely on technological synergies for corporate innovation.

given year by using contemporaneous measures of litigation. This negative externality can be socially inefficient because it may cause a holdup problem where excessive IP rights lead rival firms to underinvestment in innovation and hurt consumers (Galetovic, Haber, and Levine (2015)).

5.1.3 Additional Robustness Tests

In this section, we briefly report additional robustness tests to deal with a few concerns with difference-in-difference specification with control variables and potential bias due to multiple litigation treatments.

We avoid including controls that may also be affected by patent litigation in our main regressions. Including them will cause our estimates to be biased and inconsistent. However, we report regressions that include a few controls in the Appendix Table A5, Table A6, and Table A7 as a reference. The regression results remain almost the same, and the controls do not seem to make the results inconsistent.

Second, our patent litigation data contains firms that appear multiple times during our sample period, some even during the same year both as plaintiff and defendant in different cases.[25] In order to mitigate the conflicting effects from sequential litigation, we only use a subsample of firms' first cases and rerun the baseline regressions. The results in Appendix Table A8 shows that our results become sharper. More importantly, Table A9 uses only firms that are free of conflicting litigant types during our sample period. We find that the results using only these subsample of firms strengthen, capturing a cleaner plaintiff-defendant nature of patent litigation. Overall, the results in this section show that patent litigation has economically significant financial impact on defendant firms, and thus reduce litigant firms' incentives to innovate.

[25]In our full sample data of tracking both plaintiff and defendants from 1,692 cases over the 11-years span (3-years before and after the litigation sample from 2000-2006), we find that the mean (median) number of multiple treatment is 1.83 (0). Therefore, although there are a few firms that experience multiple patent litigation in a given year, our main results are not driven by these extreme cases.

5.2 Matching and Instrumental Variable Approach

The observable level differences between defendant and plaintiff firms are not problematic for consistency of our regression coefficient because the level differences between defendant and plaintiff firms are fully accounted for by the treatment indicator. However, to provide robustness of our previous results that these results are not driven by the observable differences, we use propensity score matching and re-estimate our difference-in-difference regressions for robustness.

5.2.1 Propensity Score Matching Regressions

We first estimate propensity scores using a probit regression, where the outcome variable is equal to one in the year a firm is involved in patent litigation as a defendant and zero otherwise. We use all the S&P 500 sample firms that had at least one patent litigation for the period of 2000-2006, but exclude sample firms that show up both as plaintiff and defendant in separate patent litigation cases in the same year. To calculate the propensity score, we use variables including firm-level patent portfolio characteristics (Number of Patent, Number of Claims, Assigned Number, Originality, Adjusted Citation) and financial characteristics (Size, R&D, Profitability, Tangibility, Market/Book ratio, Cash Flow Volatility, Market Competition). It is important to note that we also use the pre-litigation period growth rate of the outcome variables to ensure that we take into account the parallel trend assumption. We then match one controlled firm that involved in litigation as a plaintiff for each treated firm based on the predicted probability of being a defendant. After the propensity score matching, the difference in average propensity score between the treated and control groups decreases significantly from 12.3% to 4.8%.

The results using a propensity score matching sample are reported in Table 7. The results are qualitatively consistent with Table 3 and Table 5. Both the Panel A and Panel B show that the financial and innovation activity results remain robust although

the number of observation decreases due to matching. The similar matching coefficients ensure that the matched covariates above did not cause the differential trends in each of the outcome variables in Table 3 and in Table 5.

5.2.2 Instrumental Variable Regressions

In this section, we attempt to further sharpen our tests by addressing the endogeneity by exploiting an exogenous shock on the timing and probability of becoming a patent litigation defendant. China's World Trade Organization (WTO) accession in 2001 did not only mark a milestone in the country's integration into the global economy but also overhaul China's patent law to commit to complying with the requirements of Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement (Hu and Jefferson (2009), USITC (2010), USITC (2011)). The goal of TRIPS Agreement was to reduce distortions and impediments to international trade, promote effective and adequate protection of intellectual property rights by setting the minimum standards for protecting intellectual property rights (IPR) and also laying out general principles applicable to IPR enforcement procedures.[26]

The passage of TRIPS Agreement in China provides us with an identification setting to instrument the timing and the probability of becoming a defendant in patent litigation for US domestic firms. The passage of TRIPS Agreement increased competition among the firms in the US as better IP rights protection and enforcement in China attract greater market interests and revenue opportunities in the Chinese market. The impact of TRIPS Agreement in China was a significant event for US firms as China had developed into the second-larges US trading partner. Besides, Delgado, Kyle, and McGahan (2010) finds that the implementation of TRIPS led to an increase in trade in IP-dependent products compared with other sectors, isolating shocks most relevant to IP-intensive, particularly patent, industries and firms in terms of better profit pro-

[26]See details of provisions and background of initial establishment of TRIPS Agreement in 1995 at the following WTO website: https://www.wto.org/english/tratop_e/trips_e/intel2_e.htm.

tection with the implementation of the TRIPS Agreement.

For example, IP infringement and counterfeits in China prior to TRIPS Agreement had frequently undermined the profitability of US firms (USITC (2010)). This was a problem particularly for semiconductor firms that underwent the dot-com boom in the late 1990s and subsequent periods of strong semiconductor demand (SIA (2013)). Two of our sample cases illustrate the increased potential incentives of competing US firms to strengthen IPR domestically against each other for greater potential in Chinese market. The first case involves two of leading semiconductors–Cirrus Logic Inc. and NVIDIA. Cirrus Logic Inc already had strong presence in the Chinese market and had plans to exploit China's accession to the WTO as an opportunity for further expansion in the Chinese market, prior to the patent dispute with NVIDIA in 2003.[27] The second patent dispute ensued in late 2001 between Micron Technology and SanDisk in the midst of Micron Technology's establishment in Chinese market.[28] The two firms were close rivals in the industry,[29] where both firms design, develop, manufacture, and market semiconductor memory products.

We instrument the incidence of a sample firm becoming a patent litigation defendant with an indicator for whether a given industry had any firms with exposures to Chinese market, as measured by sales in China greater than zero.[30] We further restrict our sample period to year 2001 so that we concentrate on cases that are most likely affected by the shock, yet draw the implication of patent litigation from the cross-sectional difference between patent litigation triggered by TRIPS Agreement with "control" patent litigation that occurred independent of incentives to protect sales against potential

[27] See https://www.eetimes.com/document.asp?doc_id=1130398; https://www.businesswire.com/news/home/20030626005761/en/Cirrus-Logic-ChipPAC-Enter-Strategic-Alliance

[28] See http://investors.micron.com/releasedetail.cfm?releaseid=569943; https://www.eetimes.com/document.asp?doc_id=1267705

[29] SanDisk had explicitly named Micron Technology as primary competitor in its 10-K annual report.

[30] We obtain regional sales distribution data for S&P500 sample firms from Factset database.

entrants to the Chinese market.

$$\mathbb{1}(Defendant)_{2001,i} = \alpha + \beta \times \textit{China TRIPS Exposure}_i + \epsilon_i,$$

where the *Defendant* indicator variable that is equal to one if a sample firm is sued as defendant in 2001 and zero otherwise, and *China TRIPS Exposure* is also an indicator variable that is equal to one if a sample firm resides in the same 3-digit SIC industry with at least one peer firm with sales in China in 2001.

More specifically, the first-stage cross-sectional regression identifies firms that were not only more likely to become patent litigation defendant immediately following the passage of TRIPS agreement but also increasingly so due to the sales exposure in China due to securing product market competition in China against domestic US firms given their current exposures in the Chinese market. We are effectively comparing these firms to "control" firms that were not affected either because of misalignment in timing of patent litigation or absent exposures to Chinese market at the time. The first-stage result is reported in the top line of Panel A Table 8. The coefficient on *China TRIPS Exposure* is positive (0.03) and significant at 1% level.

The first-stage result shows that our instrument satisfies relevance condition, such that the partial correlation between the instrument and the endogenous variable is not zero. In addition, the *F*-statistic for the null that the coefficient on *China TRIPS Exposure* is equal to zero is 19.79, which exceeds both the rule of thumb for strong instruments of 10 and the 15% critical threshold value of 8.96 from Stock and Yogo (2005). These tests ensure that weak instrument is not an issue.

Another important identification assumption in instrumental variable regression is that the TRIPS shock influences the financial and innovation outcome only through changing the probability of becoming patent litigation defendant upon strengthening IPR in China. It is important to note that our setting relies only on the increases in the likelihood litigation incidence, for already established China exposure of US firms

based on their sales in China *prior* to the TRIPS Agreement. Also, if the strengthening Chinese IPR were to affect US firm financials and innovation outcomes directly, it would do so by *improving* financials from greater revenue potential and not worsening financials, which is what we find.

The second-stage regression results using TRIPS as an instrument variable are reported in Panel B and Panel C of Table 8. Since we now have cross-sectional set up, to be consistent with the difference-in-difference interpretation, we use change variables as the dependent variables. The IV coefficients capture changes in the financial and innovation outcome variables for defendant firms that driven only by the patent litigation affected by TRIPS Agreement. The results are strengthened, partly due to local treatment effect, and qualitatively consistent with main difference-in-difference results. We find that defendant firms still experience weakened patent outcomes, take on less innovative projects and acquisitions, which implies losing competitive position in the product market.

5.3 Intra- and inter-industry Patent Litigation

The important driver of patent litigation is to protect the boundary of a firm's intellectual boundary, which also determines the competitiveness of the firm's position in the product market. In this section, we emphasize how product market relevance plays an important role in the interactions of litigants in patent litigation. To do so, we categorize cases into intra- and inter-industry. A case is categorized as intra(inter)-industry if plaintiffs and defendants share the same (different) 2-digit SIC.

In our data, about 60% of our sample cases (502 out of 838 cases) are categorized as intra-industry litigation, where the top three industries in this category are Drugs (SIC 283), Electronic Components and Accessories (SIC 367), and Computer and Office Equipments (SIC 357). The top three industries in inter-industry cases are similar, but in the reverse order. This is consistent with earlier studies that identifies these

industries as most-litigated industries for patent enforcements. However, in addition to the existing understanding patent litigation in these industries, we shed new lights on how product market interaction of opposing litigants matter for differential outcome on the litigants depending on the degree of product market overlap.

As we discussed in the hypothesis section, we expect that the firms involved in intra-industry litigation to act more fiercely as the product market competition also hinges on the outcome of the patent litigation when the two opposing firms operate in similar industry and business lines. On the other hand, inter-industry litigation is likely to involve new competition arising from entrance of a technology user from another industry. These entrant firms from other industries may unintentionally encroach upon the boundaries of patents of incumbent for the lack of understanding of established boundaries of technology and product market competition. Therefore, whereas the inter-industry litigation may happen inadvertently, the intra-industry litigation is driven by the key litigation parameters, which we discussed in the hypothesis development section in the direction, in the direction of more frequent litigation in intra-industry firm interactions.

In an untabulated univariate analyses, we verify that both the technological proximity[31] and industry-relatedness are greater for intra-industry cases. The distance between vectors of two firms' technology classes is 0.42 for intra-industry cases and 0.31 for inter-industry case, where the higher the score translates into greater technology overlap between two firms' patent portfolios. The text-based industry classification of product market rivals is also higher for intra-industry cases, 0.037, compared to 0.011 for inter-industry cases. The text-based industry classification is based on the match of product description from firms' 10-K, which suits well with our purpose of capturing the product market overlap. The greater product market overlap alludes to greater impact of damages awards and patent litigation consequences for defendants

[31]We calculate technological proximity following Jaffe (1986) to measure closeness of any two firms' innovation activities in the technological space using patent counts in different technology classes.

in intra-industry cases.

Consistent with our predictions, Table 9 Panel A shows that most of patent litigation effects come from intra-industry cases. As we described in the hypothesis development section, intra-industry case litigants indeed have greater product market overlap, as measured by technology proximity and text-based industry classification rival scores, and the greater product market overlap predicts more pronounced patent litigation effects for intra-industry cases due to larger litigation costs exacerbating financing constraints and thus even lower innovation activities. Panel B shows the same analyses for inter-industry cases only. The interaction coefficients are mostly indistinguishable from zero, supporting the evidence that the competition among innovation firms in the same industry seems to strongly drive the negative financial and innovation effects of patent litigation.

5.4 Innovation Strategy

This section provides substantial details of how firms change their investments and innovation strategy following patent litigation with variety of proxies for the scope of innovation. First, we quantitatively capture the changes in firms' innovation strategies following Gao, Hsu, and Li (2018) measures of innovation. A patent is categorized as exploitative if 80% or more of its citations are based on a firm's existing patents and the citations made by those patents, whereas a patent is categorized as exploratory if 80% more more of its citations are based on new knowledge outside of a firm's existing patents or the citations made by those patents. Then we scale the total number of exploitative/exploratory patents over year t-2 to year t by the total number of patent application over the same period, which gives us continuous time-varying measure of innovation strategy. Table 10 columns (1) and (2) show that defendant firm patents become more exploitative.

Columns (3)-(5) presents narrower scope of innovation projects in terms of innova-

tion done outside the firm's boundary. In relation to cutting down on acquisitions in columns (3) and (4) in Table 5, column (3) in Table 10 shows that defendant firms appear to trim down less-related industry acquisitions and focus more on same-industry acquisitions, which is indicative of technologically-driven acquisitions suggested by Bena and Li (2014). More interestingly, we find firms invest 10.5% less in corporate venture capital (CVC).[32] Innovative firms often use CVC as means to be more open to experimentation and exploration (Fulghieri and Seville (2009)) and to undertake R&D investments outside of firms' boundaries to exploit new technologies (Chemmanur, Loutskina, and Tian (2014), Ma (2017)).[33] Therefore, the decrease in the number of CVC investment captures defendant firms' reduction of scope of innovation that increases potential probability of future patent litigation. We also find that defendant firms reduce the number of business segments after litigation. This is consistent with the negative asset growths shown in Table 3 as defendant firm's cutting down on less related business segments both inside and outside the firm.[34]

Lastly, we provide evidence that the exploitative innovation strategy indeed seems to hedge some of the future patent litigation risks. Table 11 tests whether pursuing exploitative innovation strategy in the year following patent litigation for a defendant reduce the probability of being accused as an infringer in the near future. The result shows that defendant firms that narrow down the scope of innovation in the year following patent litigation becomes defendant in future patent litigation less frequently. Appendix Table A11 in the appendix reinforces the product market relevance of post-

[32]We obtain Corporate VC fund- and portfolio firm-specific information from Thomson Reuters' VentureXpert database for the period 1995-2010. VentureXpert, which has been used extensively in the prior literature (Chemmanur, Loutskina, and Tian (2014), Bernstein, Giroud, and Townsend (2015)), provides detailed firm-specific funding information. We calculate the CVC investment variable that captures the total number/investment amount of CVC on entrepreneurial firms at the firm-year level.

[33]In 2014, CVC investors participated in 656 deals totaling $12.31 billion. For example, *Intel Capital* invested 1100 start-up companies, and 189 of these portfolio firms went public and 258 of them are acquired. *Dow Venture* extends to agriculture, consumer and life-style, energy, infrastructure and transportation through CVC and *Samsung Venture* extensively invested in clean-tech and medical-tech.

[34]We also report regression that include a set of controls in Appendix Table A10. The regression results do not change.

litigation innovation strategy by isolating cases that reach verdict from the court. These cases are opportunities to explore the direct impact of enforcement of patent boundaries on product market competition through the "j(damages awards)-effect" from the negative remedies, reinforcing our base model described in the hypothesis section. We find that the exploitative innovation strategy results strengthen.

6 Conclusion

In this paper, we examine the real consequences of patent litigation on corporate financial flexibility, innovation output, and innovation strategy. We consider patent litigation as a form of product market competition. Hence, we emphasize the product market relevance in understanding the effects of patent litigation.

To derive our predictions on the impact of patent litigation, we borrow the stylized model of patent enforcement from Lanjouw and Lerner (1997). The model allows us to focus our analyses around the key parameters that determine the patentee's decision to go to trial against an infringer. We are able to build our hypotheses on the comparative statics on the key patent litigation parameters that are observable in our hand-collected data.

We show that patent litigation weakens firms' financial health, particularly more for defendants who need to bear the burden of damages awards. We also find that such deterioration in financial health reduces firms' innovation output. More importantly, we show that the intra-industry litigation that involves litigants with substantial overlap in the product market has more pronounced effects. Additionally, we find evidence that firms choose more exploitative innovation strategies to avoid future patent litigation risks by reducing the uncertainty about the quality of potential cases.

Overall, using our novel hand-collected patent litigation data, we highlight the essence of patent litigation as innovation competition for firms in innovation-intensive industries and further extend the existing literature by providing detailed analyses of subsequent changes in firms' investment and innovation types.

References

Aghion, Philippe, George-Marios Angeletos, Abhijit Banerjee, and Kalina Manova, 2010, Volatility and growth: Credit constraints and the composition of investment, *Journal of Monetary Economics* 57, 246–265.

AIPLA, 2015, Report of the economic survey, *American Intellectual Property Law Association*.

Allison, John, Mark Lemley, and Joshua Walker, 2009, Extreme value or trolls on top? the characteristics of the most-litigated patents, *University of Pennsylvania Law Review* 158, 1–37.

Appel, Ian, Joan Farre-Mensa, and Elena Simintzi, 2018, Patent trolls and small business employment, *Unpublished working paper, Harvard Busines School*.

Bena, Jan., and Kai Li, 2014, Corporate innovations and mergers and acquisitions, *Journal of Finance* 69, 1923–1960.

Bernstein, Shai, Xavier Giroud, and Richard Townsend, 2015, The impact of venture capital monitoring, *Journal of Finance* 71, 1591–1622.

Bhagat, Sanjai, John Bizjak, and Jeffrey Coles, 1998, Shareholder wealth implications of corporate lawsuits, *Financial Management* 27, 5–27.

Bhagat, Sanjai, James Brickley, and Jeffrey Coles, 1994, The costs of inefficient bargaining and financial distress, *Journal of Financial Economics* 35, 221–247.

Bizjak, John, and Jeffrey Coles, 1995, The effect of private antitrust litigation on the stock-market valuation of the firm, *American Economic Review* 85, 436–461.

Chemmanur, Thomas, Elena Loutskina, and Xuan Tian, 2014, Corporate venture capital, value creation, and innovation, *Review of Financial Studies* 27, 2434–2473.

Cohen, Lauren, Umit Gurun, and Scott Kominers, 2016, Patent trolls: Evidence from targeted firms, *Unpublished working paper, Harvard Business School*.

Cohen, Wesley M, Richard C Levin, and David C Mowery, 1987, Firm size and r&d intensity: A re-examination, *Journal of Industrial Economics* 35, 543–65.

Delgado, Mercedes, Margaret Kyle, and Anita McGahan, 2010, The influence of trips on global trade in pharmaceuticals, 1995-2006, *NBER Working paper*.

Dyck, Alexander, Adair Morse, and Luigi Zingales, 2010, Who blows the whistle on corporate fraud?, *Journal of Finance* 65, 2213–2253.

Fulghieri, Paolo, and Merih Seville, 2009, Organization and financing of innovation, and the choice between corporate and independent venture capital, *Journal of Financial and Quantitative Analysis* 44, 1291–1321.

Galetovic, Alexander, Stephen Haber, and Ross Levine, 2015, An empirical examination of patent holdup, *Journal of Competition Law and Economics* 11, 549–578.

Gao, Huasheng, Po-Hsuan Hsu, and Kai Li, 2018, Innovation strategy of private firms, *Journal of Financial and Quantitative Analysis* 53, 1–32.

Hall, Bronwyn, Adam Jaffe, and Manuel Trajtenberg, 2001, The nber patent citations data file: Lessons, insights and methodological tools, *NBER Working Paper*.

Hoberg, Gerard, and Gordon Phillips, 2016, Text-based network industries and endogenous product differentiation, *Journal of Political Economy* 124, 1423–1465.

Hu, Albert, and Gary Jefferson, 2009, A great wall of patents: What is behind china's recent patent explosion?, *Journal of Development Economics* 90, 57–68.

Jaffe, Adam B., 1986, Technological opportunity and spillovers of r&d: Evidence from firms' patents, profits, and market value, *American Economic Review* 76, 984–1001.

Karpoff, Jonathan, John Lott, and Graeme Rankine, 1999, Environmental violations, legal penalties, and reputation costs, *John M. Olin Law and Economics Working Paper*.

Karpoff, Jonathan, and John Lott Jr., 1993, The reputational penalty frims bear from committing criminal fraud, *Journal of Law and Economics* 26, 757–802.

Lanjouw, Jean, and Josh Lerner, 1997, The enforcement of intellectual property rights: A survey of the empirical literature, *NBER working paper*.

Lanjouw, Jean, and Mark Schankerman, 2004, Protecting intellectual property rights: Are small firms handicapped?, *Journal of Law and Economics* 47, 45–74.

Lerner, Josh, 1995, The importance of trade secrecy: Evidence from civil litigation, *Unpublished working paper, Harvard Business School*.

——— , Andrew Speen, Mark Baker, and Ann Leamon, 2015, Financial patent quality: Finance patents after *state street*, *HBS Working Paper* pp. 1–55.

Lin, Chen, Sibo Liu, and Gustavo Manso, 2016, Shareholder litigation and corporate innovation, *Working paper, Hong Kong University*.

Ma, Song, 2017, The life cycle of corporate venture capital, *Unpublished working paper, Yale School of Management*.

Mann, William, 2018, Creditor rights and innovation: Evidence from patent collateral, *Journal of Financial Economics*.

Mezzanotti, Filippo, 2015, Roadblock to innovation: The role of patent litigation on corporate r&d, *Unpublished working paper, Northwestern University*.

Nohria, Nitin, and Ranjay Gulati, 1996, Is slack good or bad for innovation?, *Academy of Management Journal* 39, 1245–1264.

PWC, 2017, 2017 patent litigation study, *PWC Forensic Services*.

SIA, 2013, Winning the battle against counterfeit semiconductor products, *Semiconductor Industry Association Anti-Counterfeiting Task Force Report*.

Stock, James, and Motohiro Yogo, 2005, Testing for Weak Instrument in Linear IV Regression. In D. W. K. Andrews and J.H. Stock (eds.), *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg* pp. pp. 80–108. Cambridge, UK: Cambridge University Press.

USITC, 2010, China: Intellectual property infringement, indigenous innovation policies, and frameworks for measuring the effects on the u.s. economy part 1, *United States International Trade Commission Report*.

——— , 2011, China: Intellectual property infringement, indigenous innovation policies, and frameworks for measuring the effects on the u.s. economy part 2, *United States International Trade Commission Report*.

Zingales, Luigi, 2002, Survival of the fittest or the fattest? exit and financing in the trucking industry, *Journal of Finance* 53, 905–938.

Table 1: Summary Statistics

The table presents summary statistics for patent litigation cases in the U.S. for the period of 2000-2006. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. Panel A describes the patent litigation case characteristics in our sample. *Defendant* is an indicator that takes a value of one if a S&P 500 firm is defendant in litigation case, otherwise zero. Panel B is a summary of firm-year patent portfolio summary. Panel C reports summary statistics for firm-year financial and innovation characteristics. All variable definitions are in Appendix C.

	Mean	Std.dev	Min	Med	Max	Obs.
Panel A: Litigation Summary						
Case with Verdict	0.17	0.38	0.00	0.00	1.00	1,692
Defendant (indicator)	0.24	0.43	0.00	0.00	1.00	1,692
Intra-industry Case	0.60	0.49	0.00	1.00	1.00	838
Length of Litigation	1.98	2.11	0.00	1.00	13.00	1,692
Net Total Damage	0.48	4.89	-1.76	0.00	101.23	1,692
Number of Defendants	1.90	2.69	1.00	1.00	59.00	1,692
Number of Plaintiffs	1.31	0.65	1.00	1.00	5.00	1,692
Plaintiff (indicator)	0.76	0.43	0.00	1.00	1.00	1,692
Win case (conditional)	0.64	0.48	0.00	1.00	1.00	294
Panel B: Patent Summary						
Assignee Sequence Number	1.00	0.01	1.00	1.00	1.06	11,370
Exploitative t+1	0.16	0.16	0.00	0.12	1.00	9,500
Exploratory t+1	0.71	0.20	0.00	0.75	1.00	9,500
Log(1+Average Number of Defendant Cases in Industry in Past 3 years)	0.44	0.93	0.00	0.00	3.74	1,649
Log(1+Average Number of Litigations in Industry in Past 3 years)	0.62	1.15	0.00	0.00	4.39	1,649
Log(1+Number of Citations)	2.89	0.44	1.32	2.85	4.73	11,370
Log(1+Number of Citations) (Peer)	2.64	0.89	0.00	2.59	6.63	1,649
Log(1+Number of Defendant Cases in Industry)	0.49	1.02	0.00	0.00	4.03	1,649
Log(1+Number of Litigations in Industry)	0.68	1.26	0.00	0.00	4.78	1,649
Log(1+Number of Patent Application)	3.06	2.39	0.00	3.37	8.32	11,370
Log(1+Number of Patent Application) (Peer)	0.87	1.40	0.00	0.00	6.32	1,649
Number of Patents	4978	6725	3.00	2739	45215	11,370
Patent Age	10.38	4.25	0.35	11.14	23.40	11,370
Panel C: Financial and Investment Summary						
Assets growth	0.10	0.34	-0.71	0.05	6.99	11,370
Cash	0.18	0.16	0.00	0.13	0.88	11,370
CF Volatility	0.02	0.03	0.00	0.02	0.29	11,370
Dividend	0.71	0.45	0.00	1.00	1.00	11,370
Leverage	0.18	0.14	0.00	0.16	1.39	11,370
Log(1+Average Acquisition Size)	1.42	2.65	0.00	0.00	11.40	11,370
Log(1+Number of CVC Deal)	0.58	0.99	0.00	0.00	5.38	11,370
Log(1+Number of Total Acquisition)	0.23	0.43	0.00	0.00	2.48	11,370
Market Share With All Rivals	0.13	0.16	0.00	0.06	1.00	11,370
Market Share With Closest 5 Rivals	0.43	0.25	0.00	0.42	1.00	11,370
Market Share With Closest 10 Rivals	0.32	0.24	0.00	0.24	1.00	11,370
Market Share With Closest 25 Rivals	0.23	0.22	0.00	0.15	1.00	11,370
Market Share With Closest 100 Rivals	0.19	0.21	0.00	0.10	1.00	11,370
Number of Segments	4.84	2.71	1.00	5.00	17.00	10,360
Profitability	0.15	0.08	-0.22	0.14	0.48	11,370
R&D Expense	0.07	0.05	0.00	0.06	0.60	11,164
Same Industry Acquisition	0.08	0.36	0.00	0.00	6.00	11,370
Size	9.54	1.23	5.29	9.53	13.78	11,370
Tangibility	0.83	0.15	0.16	0.87	1.00	10,760
Tobin's Q	2.24	2.07	0.08	1.65	48.69	11,280
1 - HHI	0.87	0.11	0.01	0.89	0.97	11,370

Table 2: Univariate Analysis

The table presents summary statistics for the firms that have patent litigation records vs. never-litigated (Panel A) during the sample period of 2000-2006, and pre-treatment characteristics for the firms that are plaintiff vs. defendant (Panel B) in our sample patent litigation cases. In *Panel A*, the sample consists of 4,121 firm-year observations of all S&P 500 firms during the period of 2000-2006. In Panel B, the sample consists of 6,531 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms during the pre-treatment period. All variable definitions are in Appendix. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Comparison between Litigated and Never-litigated Firms

	Litigated		Never-litigated		
	Mean	Median	Mean	Median	Mean Diff
Assets growth	0.12	0.06	0.14	0.05	-0.02
Cash	0.17	0.11	0.12	0.06	0.05***
Dividend	0.71	1.00	0.69	1.00	0.02
Exploitive	0.14	0.08	0.07	0.00	0.07***
Explorative	0.75	0.80	0.87	0.97	-0.12***
Leverage	0.21	0.21	0.26	0.25	-0.04***
Log(1+Average Acquisition Size)	1.34	0.00	0.79	0.00	0.55***
Log(1+Number of CVC Deal)	0.41	0.00	0.08	0.00	0.33***
Log(1+Number of Citations)	2.91	2.82	2.61	2.55	0.30***
Log(1+Number of Patent Application)	2.68	2.83	0.93	0.00	1.75***
Log(1+Number of Total Acquisition)	0.21	0.00	0.11	0.00	0.10***
Market Share With Closest 10 Rivals	0.30	0.24	0.23	0.17	0.08***
Number of Segments	4.34	4.00	3.41	3.00	0.93***
Same Industry Acquisition	0.09	0.00	0.06	0.00	0.03**
Observations	1,290		2,831		

Panel B: Pre-treatment Comparison between Plaintiff and Defendant

	Plaintiff		Defendant		
	Mean	Median	Mean	Median	Mean Diff
Assets growth	0.11	0.06	0.13	0.06	-0.02
Cash	0.16	0.12	0.21	0.14	-0.05***
Dividend	0.72	1.00	0.64	1.00	0.08***
Exploitive	0.15	0.12	0.11	0.10	0.04***
Explorative	0.73	0.75	0.79	0.81	-0.06***
Leverage	0.19	0.17	0.15	0.11	0.03***
Log(1+Average Acquisition Size)	1.30	0.00	1.76	0.00	-0.46***
Log(1+Number of CVC Deal)	0.53	0.00	0.71	0.00	-0.18***
Log(1+Number of Citations)	2.90	2.79	3.06	3.06	-0.16***
Log(1+Number of Patent Application)	3.92	4.29	4.72	4.88	-0.80***
Log(1+Number of Total Acquisition)	0.21	0.00	0.30	0.00	-0.09***
Market Share With Closest 10 Rivals	0.31	0.24	0.38	0.32	-0.07***
Number of Segments	4.56	4.00	5.62	5.00	-1.05***
Same Industry Acquisition	0.07	0.00	0.11	0.00	-0.03***
Observations	4,913		1,618		

Table 3: The Effects of Patent Litigation: Financial Outcomes

The table examines the effects of patent litigation on corporate financial outcomes. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. For each case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(4), the dependent variables are corporate financial policy: total cash scaled by total assets (*Cash*), dividend payer indicator (*Dividend (indicator)*), book value of total debt scaled by total assets (*Leverage*), and assets growth rate (*Asset Growth*). In Panel A, we present results from difference-in-difference analysis. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. In Panel B, we report the dynamics of the litigation effects. The variable $t-1$ year is an indicator variable equal to one if the observation is recorded in the year preceding the litigation. $t-3$, $t-2$, $t-1$, $t+1$, $t+2$, $t+3$ year are indicator variables defined analogously. All individual time and defendant indicators are suppressed for brevity. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Diff-in-Diff Analysis on Financial Policies

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset Growth
After X Defendant	-0.02***	-0.05***	0.04***	-0.07***
	(-3.63)	(-3.69)	(3.11)	(-5.10)
Defendant	0.01***	0.01	-0.02***	0.03***
	(2.88)	(1.46)	(-3.37)	(3.52)
After	0.00**	-0.00	-0.00	0.03***
	(2.36)	(-0.19)	(-1.00)	(3.95)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11,370	11,370	11,370	11,370
Adjusted R^2	0.864	0.863	0.672	0.158

Panel B: Dynamic Effects on Financial Policies

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset Growth
t-3 year X Defendant	0.01	0.00	-0.01	0.03
	(0.89)	(0.15)	(-1.41)	(1.18)
t-2 year X Defendant	0.00	0.03***	-0.00	0.13***
	(0.88)	(2.99)	(-0.46)	(3.48)
t-1 year X Defendant	0.00	0.01	-0.00	-0.01
	(0.48)	(0.77)	(-1.28)	(-0.42)
t+1 year X Defendant	-0.01***	-0.05***	0.04***	-0.05***
	(-2.91)	(-3.19)	(3.08)	(-3.03)
t+2 year X Defendant	-0.02***	-0.04**	0.03***	0.00
	(-3.49)	(-2.39)	(2.58)	(0.20)
t+3 year X Defendant	-0.01	-0.03*	0.03***	-0.05***
	(-1.63)	(-1.71)	(2.93)	(-2.78)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11,370	11,370	11,370	11,370
Adjusted R^2	0.864	0.863	0.672	0.161

Table 4: The Effects of Patent Litigation: Product Market Outcome

The table examines the effects of patent litigation on product market outcomes. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. For each litigation case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(4), the dependent variables are market shares among the closest 5, 10, 25, and 100 industry rivals, respectively, calculated using Hoberg and Phillips (2016) text-based industry classification (TNIC). In column (5), the dependent variable is market shares using all firms in the same 3-digit SIC. In Panel A, we present results from difference-in-difference analysis. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. In Panel B, we report the dynamics of the litigation effects. The variable $t-1$ year is an indicator variable equal to one if the observation is recorded in the year preceding the litigation. $t-3$, $t-2$, $t-1$, $t+1$, $t+2$, $t+3$ year are indicator variables defined analogously. All individual time and defendant indicators are suppressed for brevity. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Diff-in-Diff Analysis on Market Share

	(1) With Closest 5 Rivals	(2) With Closest 10 Rivals	(3) With Closest 25 Rivals	(4) With Closest 100 Rivals	(5) With All Rivals (3-digit SIC)
After X Defendant	-0.05***	-0.04***	-0.03***	-0.01**	-0.003**
	(-6.45)	(-5.92)	(-4.68)	(-2.48)	(-2.26)
Defendant	0.02***	0.02***	0.02***	0.01***	0.003***
	(5.29)	(5.35)	(5.09)	(3.20)	(3.21)
After	0.01	0.01**	0.01***	0.00	0.004***
	(1.46)	(1.98)	(3.89)	(1.02)	(5.21)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	11,370	11,370	11,370	11,370	11,370
Adjusted R^2	0.624	0.706	0.729	0.729	0.978

Panel B: Dynamic Effects on Market Share

	(1) With Closest 5 Rivals	(2) With Closest 10 Rivals	(3) With Closest 25 Rivals	(4) With Closest 100 Rivals	(5) With All Rivals (3-digit SIC)
t-3 year X Defendant	-0.02	-0.02	-0.00	-0.00	-0.002
	(-1.40)	(-1.64)	(-0.48)	(-0.10)	(-0.83)
t-2 year X Defendant	0.02*	0.05***	0.04***	0.03***	0.00
	(1.85)	(4.67)	(3.96)	(3.48)	(0.29)
t-1 year X Defendant	0.01	0.02**	0.01*	0.01*	-0.001
	(0.96)	(2.39)	(1.80)	(1.93)	(-0.75)
t+1 year X Defendant	-0.03***	-0.02***	-0.02***	-0.01	-0.000
	(-2.99)	(-2.88)	(-2.97)	(-1.39)	(-0.20)
t+2 year X Defendant	-0.04***	-0.03***	-0.02*	-0.00	-0.003**
	(-3.77)	(-3.01)	(-1.79)	(-0.15)	(-2.02)
t+3 year X Defendant	-0.07***	-0.04***	-0.02*	-0.00	-0.009***
	(-5.58)	(-3.50)	(-1.88)	(-0.03)	(-4.59)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	11,370	11,370	11,370	11,370	11,370
Adjusted R^2	0.625	0.707	0.730	0.729	0.978

Table 5: The Effects of Patent Litigation: Innovation Outcomes

The table examines the effects of patent litigation on corporate innovation outcomes. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. For each litigation case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(4), the dependent variables are corporate innovation outcomes: the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*), the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*), the logarithm of one plus number of acquisitions (*Log(1+Number of Total Acquisitions)*), and the logarithm of one plus average transaction size of acquisitions (*Log (1+Average Acquisition Size)*) at a certain year. In Panel A, we present results from difference-in-difference analysis. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. In Panel B, we report the dynamics of the litigation effects. The variable $t-1$ year is an indicator variable equal to one if the observation is recorded in the year preceding the litigation. $t-3$, $t-2$, $t-1$, $t+2$, $t+3$ year are indicator variables defined analogously. All individual time and defendant indicators are suppressed for brevity. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Diff-in-Diff Analysis on Innovation Outcome

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
After X Defendant	-0.42***	-0.03***	-0.10***	-0.46***
	(-7.70)	(-4.52)	(-4.55)	(-4.00)
Defendant	0.17***	0.01	0.06***	0.32***
	(7.35)	(1.34)	(5.06)	(5.46)
After	0.19***	0.01***	0.01	0.00
	(7.92)	(3.22)	(0.74)	(0.02)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11,370	11,370	11,370	11,370
Adjusted R^2	0.924	0.955	0.355	0.326

Panel B: Dynamic Effects on Innovation Outcome

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
t-3 year X Defendant	0.17***	0.04***	0.00	0.22
	(3.50)	(5.01)	(0.00)	(1.07)
t-2 year X Defendant	0.20***	0.04***	0.01	-0.06
	(4.85)	(5.98)	(0.21)	(-0.33)
t-1 year X Defendant	0.18***	0.02***	-0.03	-0.34*
	(5.79)	(5.40)	(-0.83)	(-1.77)
t+1 year X Defendant	-0.22***	-0.01*	-0.12***	-0.46**
	(-6.03)	(-1.79)	(-3.89)	(-2.40)
t+2 year X Defendant	-0.27***	-0.01*	-0.06*	-0.36*
	(-5.22)	(-1.87)	(-1.91)	(-1.86)
t+3 year X Defendant	-0.36***	-0.01*	-0.13***	-0.70***
	(-5.40)	(-1.91)	(-4.01)	(-3.40)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11,370	11,370	11,370	11,370
Adjusted R^2	0.924	0.955	0.356	0.328

Table 6: Patent Litigation and Industry Outcome

The table examines the effect of patent litigation on industry-level corporate innovation performance. The sample comprises of all S&P 500 firms for the period of 2000-2006. We include only rival firms that never experience any litigations during our sample period. In Panel A, we examine the effect of industry-level patent litigation intensity on innovation outcome, and in Panel B, we focus on the defendant cases. In columns (1)-(2), the dependent variable is the logarithm of one plus number of patent applications at a certain year ((*Log(1+Number of Patent Application)*). In columns (3)-(4), the dependent variable is the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*) *Log(1+Number of Litigations in Industry)* is the logarithm of one plus total number of litigation cases in a 3-digit SIC industry in year $t-1$. *Log(1+Average Number of Litigations in Industry in Past 3 years* is the logarithm of one plus total number of litigation cases in a 3-digit SIC industry within $t-1$ to $t-3$ year. *Log(1+Number of Defendant Cases in Industry)* is the log of one plus total number of defendant cases in a 3-digit SIC industry in year $t-1$. *Log(1+Average Number of Defendant Cases in Industry in Past 3 years)* is the logarithm of one plus total number of defendant cases in a 3-digit SIC industry within $t-1$ to $t-3$ year. Firm and year fixed effects are included. *t-statistics* (in parenthesis) are robust. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Industry-level Litigation Intensity and Effects on Peer Firm

	Log(1+Number of Patent Application)		Log(1+Number of Citations)	
	(1)	(2)	(3)	(4)
Log(1+Number of Litigations in Industry)	-0.13*** (-3.28)		-0.03** (-2.01)	
Log(1+Average Number of Litigations in Industry in Past 3 years)		-0.27*** (-4.75)		-0.06** (-2.29)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,627	1,627	1,627	1,627
Adjusted R^2	0.759	0.767	0.963	0.964

Panel B: Industry-level Defendant Risk and Effects on Peer Firm

	Log(1+Number of Patent Application)		Log(1+Number of Citations)	
	(1)	(2)	(3)	(4)
Log(1+Number of Defendant Cases in Industry)	-0.14*** (-2.97)		-0.04** (-2.17)	
Log(1+Average Number of Defendant Cases in Industry in Past 3 years)		-0.29*** (-4.73)		-0.08** (-2.40)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,627	1,627	1,627	1,627
Adjusted R^2	0.758	0.766	0.963	0.965

Table 7: The Effects of Patent Litigation: Propensity Matching Analysis

The table examines the effects of patent litigation on corporate financial, product market and innovation outcomes using propensity score matching. The sample comprises of 5,023 firm-year observations for 788 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. We match the control (plaintiff) case based on predicted probability of becoming defendant. We use firm-year patent portfolio characteristics and the same set of control variables in Table A2, including size, R&D expense, profitability, tangibility, Tobin's Q, cash flow volatility and industry HHI based on 3-digit SIC, as matching variables. In columns (1)-(4) of Panel A, the dependent variables are corporate financial policy: total cash scaled by total assets (*Cash*), dividend payer indicator (*Dividend (indicator)*), book value of total debt scaled by total assets (*Leverage*), and assets growth rate (*Asset Growth*). In column (5) of Panel A, the dependent variable is market share among the closest 10 industry rivals calculated using Hoberg and Phillips (2016) text-based industry classification (TNIC). In columns (1)-(4) of Panel B, the dependent variables are corporate innovation outcomes: the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*), the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*), the logarithm of one plus number of acquisitions (*Log(1+Number of Total Acquisitions)*), and the logarithm of one plus average transaction size of acquisitions (*Log (1+Average Acquisition Size)*) at a certain year. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Propensity Score Matching Analysis on Financial Outcome and Market Share

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset growth	(5) Market Share
After X Defendant	-0.01	-0.06***	0.04***	-0.08***	-0.05***
	(-0.89)	(-2.96)	(2.76)	(-4.49)	(-5.44)
Defendant	0.01***	0.00	-0.02***	0.05***	0.02***
	(2.94)	(0.12)	(-3.55)	(3.13)	(3.58)
After	0.00	0.00	0.00	0.05***	0.02***
	(0.65)	(0.35)	(0.20)	(3.49)	(3.02)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	5,023	5,023	5,023	5,023	4,997
Adjusted R^2	0.873	0.838	0.636	0.168	0.763

Panel B: Propensity Score Matching Analysis on Innovation Outcome

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
After X Defendant	-0.20***	-0.03***	-0.16***	-0.76***
	(-2.87)	(-2.79)	(-6.58)	(-5.76)
Defendant	0.09***	0.00	0.08***	0.43***
	(2.63)	(0.30)	(5.84)	(5.74)
After	0.21***	0.01	0.08***	0.45***
	(4.69)	(1.40)	(5.70)	(5.03)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	5,023	5,023	5,023	5,023
Adjusted R^2	0.934	0.955	0.397	0.351

Table 8: The Effects of Patent Litigation: IV approach

The table examines the effects of patent litigation on corporate financial, product market and innovation outcomes using instrument variable approach. We use China's TRIPS compliance in 2001 as an instrument and apply a diff-in-diff estimation. The indicator variable *China TRIPS Exposure* takes the value of one for firms in industries that have revenues from China before 2001, affected by TRIPS with the passage of the Agreement in 2001, and zero otherwise. The sample comprises of 1,677 litigation cases that S&P 500 firm associated for the period of 2000-2002. In Panel A, the first-stage regression estimates the probability of becoming a defendant as a function of sales exposure to China and the passage of TRIPS in 2001. In Panel B and C, the second-stage regression presents corporate financial, product market and innovation outcomes as a function of instrumented probability of being a defendant. The dependent variables are identical to those in Table 7 and defined as the difference between the value of $t-1$ and $t+1$ year around China's TRIPS participation. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: First Stage Regression

First stage	Defendant
China TRIPS Exposure	0.03***
	(4.45)
F-stat	19.79
Adjusted R^2	0.012

Panel B: Instrument Variable Analysis on Financial Policies and Market Share

Second stage	(1) △ Cash	(2) △ Dividend	(3) △ Leverage	(4) △ Assets growth	(5) △ Market Share
Defendant	-0.34**	-4.83***	1.54***	-13.32***	-3.20***
	(-2.19)	(-3.94)	(4.09)	(-3.79)	(-4.15)
Observations	1,677	1,677	1,677	1,677	1,642

Panel C: Instrument Variable Analysis on Innovation Outcome

Second stage	(1) △ Log(1+Number of Patent Application)	(2) △ Log(1+Number of Citations)	(3) △ Log(1+Number of Total Acquisitions)	(4) △ Log(1+Average Acquisition Size)
Defendant	-7.64***	-2.10***	-2.02**	-8.73*
	(-3.83)	(-4.30)	(-2.39)	(-1.81)
Observations	1,677	1,677	1,677	1,677

Table 9: The Effects of Patent Litigation on Financial Policies and Innovation: Intra- vs. Inter-industry

The table examines the effects of patent litigation on corporate financial, product market and innovation outcomes. We use sub-sample where cases are between intra-industry rivals in Panel A and inter-industry firms in Panel B based on 2-digit SIC code. The sample comprises of 5,708 firm-year observations for 838 litigation cases (502 intra-industry and 336 inter-industry cases) that are associated with S&P 500 firms for the period of 2000-2006. For each litigation case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(4), the dependent variables are corporate financial policy: total cash scaled by total assets (*Cash*), dividend payer indicator (*Dividend (indicator)*), book value of total debt scaled by total assets (*Leverage*), and assets growth rate (*Asset Growth*). In column (5), the dependent variable is market share among the closest 10 industry rivals calculated using Hoberg and Phillips (2016) text-based industry classification (TNIC). In columns (6)-(7), the dependent variables are corporate innovation outcomes: the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*), the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*). *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Intra-Case Cases

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset growth	(5) Market Share	(6) Log(1+Number of Patent Application)	(7) Log(1+Number of Citations)
After X Defendant	-0.05***	-0.14***	0.11***	-0.08**	-0.05***	-0.47***	-0.08***
	(-5.46)	(-4.22)	(3.53)	(-2.24)	(-4.45)	(-4.58)	(-4.79)
Defendant	0.02***	0.05***	-0.04***	0.03	0.03***	0.25***	0.01
	(3.21)	(2.80)	(-3.23)	(0.86)	(3.80)	(4.99)	(0.82)
After	0.02***	-0.01	-0.00	0.05***	0.02**	0.26***	0.03***
	(4.71)	(-1.27)	(-0.36)	(2.90)	(2.10)	(5.89)	(3.84)
Year and Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,413	3,413	3,413	3,413	3,413	3,413	3,413
Adjusted R^2	0.860	0.799	0.535	0.166	0.707	0.936	0.943

Panel B: Inter-Case Cases

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset growth	(5) Market Share	(6) Log(1+Number of Patent Application)	(7) Log(1+Number of Citations)
After X Defendant	-0.00	-0.01	-0.01	-0.03*	-0.02	-0.14	-0.02
	(-0.30)	(-0.28)	(-0.46)	(-1.86)	(-1.61)	(-1.06)	(-1.19)
Defendant	0.00	0.01	0.00	0.01	0.01	0.09*	0.01*
	(0.27)	(0.52)	(0.30)	(1.55)	(0.92)	(1.69)	(1.77)
After	0.00	0.01	0.01	0.02**	-0.01	0.02	-0.00
	(0.97)	(0.87)	(1.59)	(2.41)	(-0.89)	(0.44)	(-0.05)
Year and Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,295	2,295	2,295	2,295	2,295	2,295	2, 295
Adjusted R^2	0.887	0.902	0.722	0.257	0.711	0.916	0.968

Table 10: The Effects of Patent Litigation: Innovation Strategy

The table examines the effects of patent litigation on corporate innovation strategy. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. For each litigation case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(5), the dependent variables are corporate innovation strategy: the exploitive innovation measure (*Exploitative*), the explorative innovation measure (*Exploratory*), the indicator that equals one if a defendant firm acquires a target in the same industry based on 4-digit SIC (*Same Industry Acquisition*), the logarithm of one plus number of corporate venture capital (CVC) investment initiation (*Log(1+Number of CVC Deal)*), and the number of business segments (*Number of Segments*). *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1) Exploitative	(2) Exploratory	(3) Same Industry Acquisition	(4) Log(1+Number of CVC Deal)	(5) Number of Segments
After X Defendant	0.04***	-0.03***	0.06***	-0.10***	-0.36***
	(4.69)	(-3.59)	(3.04)	(-3.95)	(-4.30)
Defendant	-0.01***	0.01***	-0.02*	0.03**	0.33***
	(-4.33)	(2.67)	(-1.75)	(1.99)	(6.97)
After	-0.01***	0.01*	-0.02**	0.00	0.18***
	(-3.01)	(1.95)	(-2.16)	(0.08)	(4.58)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	9,500	9,500	11,370	11,370	10,360
Adjusted R^2	0.539	0.677	0.315	0.847	0.818

Table 11: The Hedging Effects of Innovation Strategy on Patent Litigation

The table examines the effects of corporate innovation strategy on future patent litigation. We test whether exploitive innovation strategy after a litigation in year t affects the likelihood of litigation and being a defendant in year t+1. The sample comprises of all S&P 500 firms that had at least one patent litigation for the period of 2000-2006. In columns (1)-(4), the dependent variables are the logarithm of one plus number of defendant cases in year t+1 (*Log(1+Number of Defendant Cases in t+1)*), the logarithm of one plus total number of defendant cases from t+1 to t+3 year (*Log(1+Total number of Defendant Cases within 3 years)*), an indicator variable that equals one if firm is a defendant in any litigation case in year t+1 (*Defendant in t+1 (indicator)*), an indicator variable that equals one if firm is a defendant in any litigation case within t+1 to t+3 year (*Defendant within 3 years (indicator)*). *Exploitative t+1* is the firm-level patent portfolio's percentage of a patent's citations made by the patentee firm's existing patents and the citations made by those patents in year t+1. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for firm-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1) Log(1+Number of Defendant Cases in t+1)	(2) Log(1+Total Number of Defendant Cases within 3 years)	(3) Defendant in t+1 (indicator)	(4) Defendant within 3 years (indicator)
Exploitative t+1 X Defendant	-0.93*	-1.33***	-0.60**	-0.71***
	(-1.92)	(-3.51)	(-2.00)	(-2.81)
Exploitative t+1	-0.25	-0.35	-0.23	-0.20
	(-1.18)	(-1.24)	(-1.47)	(-1.00)
Defendant	-0.07	-0.27***	-0.05	-0.14***
	(-0.63)	(-3.76)	(-0.76)	(-2.67)
Size	0.02	-0.12	0.03	-0.08
	(0.22)	(-0.90)	(0.50)	(-0.82)
R&D Expense	-0.30	-0.02	-0.21	0.00
	(-0.67)	(-0.03)	(-0.66)	(0.00)
Profitability	0.40	0.70	0.27	0.33
	(1.06)	(1.04)	(1.26)	(0.87)
Tangibility	-0.04	-0.17	-0.01	-0.18
	(-0.12)	(-0.37)	(-0.03)	(-0.52)
Tobin's Q	0.00	-0.00	0.00*	-0.00
	(1.52)	(-0.30)	(1.69)	(-0.01)
CF Vol	0.39	0.65	0.26	0.27
	(1.24)	(1.06)	(1.41)	(0.94)
1 - HHI	0.36	0.52	0.80	0.90
	(0.41)	(0.40)	(1.28)	(1.10)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	756	756	756	756
Adjusted R^2	0.207	0.645	0.163	0.530

Table A1: Comparison between asserted and not-asserted patents

The table presents patent-level summary statistics for all patents held by our sample firms. The asserted patents are patents that are involved in patent litigation in our sample cases. The non-asserted patents are patents that are held by our sample firms but are not involved in sample patent litigation cases during our sample period. Of 1,692 cases in our data, there were 1,078 unique patents identified, which means there are number of patents are are involved in multiple cases in a given year. *Patent Age* is measured from the grant year. *Backward Citations* is the count of citations made on existing patents by a patent under consideration. The rest of variables follow definitions in Appendix. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Asserted		Not asserted		
	Mean	Median	Mean	Median	Mean Difference
Patent Age	8.16	7.00	11.08	9.00	-2.92***
Number of Claims	23.90	18.00	16.50	14.00	7.40***
Citations	41.72	23.49	16.19	8.25	25.54***
Backward Citations	16.83	10.00	9.78	6.00	7.05***
Observations	480,844		1,078		

Table A2: Firm-level Determinant of Patent Litigation

The table examines the effects of corporate innovation strategy on future patent litigation. We test whether exploitive innovation strategy after a litigation in year t affects the likelihood of litigation and being a defendant in year $t+1$. The sample comprises of 1,740 firm-year observations for 457 unique S&P 500 firms for the period of 2000-2006. In columns (1)-(2), the dependent variable is an indicator variable that equals to one if the firm is involved in any litigation in a given year (*Litigation*). In columns (3)-(4), the dependent is an indicator variable that equals to one if the firm is involved in any litigation as a defendant in a certain year (*Defendant*). In columns (5)-(6), the dependent is an indicator variable that equals to one if the firm is involved in a litigation as a plaintiff in a certain year (*Plaintiff*). Firm, industry, and year fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for 3-digit SIC industry clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	Litigation		Defendant		Plaintiff	
	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.02	0.03	0.04***	0.02	0.00	0.01
	(0.84)	(0.97)	(2.70)	(0.63)	(0.19)	(0.24)
Cash	-0.14*	-0.12	-0.04	0.16	-0.14*	-0.27
	(-1.73)	(-0.73)	(-0.78)	(1.15)	(-1.95)	(-1.37)
Leverage	-0.07	-0.02	-0.08	-0.09	-0.12*	-0.08
	(-0.84)	(-0.15)	(-0.99)	(-1.02)	(-1.74)	(-0.59)
R&D Expense	-0.18	-0.24	-0.00	0.04	-0.05	-0.28
	(-0.54)	(-1.02)	(-0.01)	(0.22)	(-0.23)	(-1.36)
Profitability	-0.08	-0.16	0.00	-0.18	-0.11	-0.13
	(-0.50)	(-0.76)	(0.04)	(-1.07)	(-0.88)	(-0.68)
Tangibility	-0.07	0.02	-0.02	-0.11	-0.04	0.14
	(-0.58)	(0.14)	(-0.18)	(-1.33)	(-0.45)	(1.25)
Tobin's Q	0.01	0.02***	0.00	0.01**	0.01	0.01
	(0.89)	(2.98)	(0.03)	(2.17)	(0.94)	(1.44)
CF Vol	0.01	-0.35	0.19	-0.14	-0.07	-0.12
	(0.08)	(-1.56)	(1.38)	(-0.58)	(-0.72)	(-1.01)
Dividend (indicator)	0.05*	-0.03	0.04	0.01	0.02	-0.00
	(1.91)	(-0.71)	(1.48)	(0.19)	(0.86)	(-0.01)
1 - HHI	-0.42	-0.30	0.10	0.20	-0.44	-0.41
	(-1.04)	(-0.68)	(0.42)	(0.76)	(-1.38)	(-1.15)
Market Share	0.07	0.07	0.01	-0.04	0.03	0.10
	(0.77)	(0.71)	(0.20)	(-0.48)	(0.38)	(1.22)
Log(1+Number of Patent)	0.05***	-0.01	0.02***	-0.03	0.05***	0.02
	(5.43)	(-0.39)	(2.76)	(-1.30)	(4.52)	(0.72)
Log(1+Number of Citations)	0.03	-0.06	0.00	-0.06	0.04**	-0.01
	(0.90)	(-1.14)	(0.15)	(-1.22)	(2.39)	(-0.27)
Log(1+Number of Citing)	0.06**	0.12	0.03	-0.02	0.02	0.14**
	(2.02)	(1.40)	(0.68)	(-0.28)	(0.74)	(2.29)
Portfolio Average Originality	-0.02	-0.32	-0.10	0.02	0.10	-0.38***
	(-0.11)	(-1.50)	(-0.61)	(0.14)	(1.07)	(-2.94)
Log(Assignee Sequence Number)	-0.83	3.36	0.73	4.33*	-1.45	-0.98
	(-0.42)	(1.20)	(0.63)	(1.91)	(-1.16)	(-1.07)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	No	Yes	No	Yes	Yes
Firm Fixed Effects	No	Yes	No	Yes	No	Yes
Observations	1,740	1,740	1,740	1,740	1,740	1,740
Adjusted R^2	0.188	0.308	0.084	0.211	0.157	0.262

Table A3: Patent Litigation and Firm-level Analysis

The table examines the effect of patent litigation on firm-level corporate innovation performance. The sample comprises of all S&P 500 firms for the period of 2000-2006. In Panel A, we examine the effect of patent litigation intensity on innovation outcome, and in Panel B, we focus on the defendant cases. In columns (1)-(2), the dependent variable is the logarithm of one plus number of patent applications at a certain year ((*Log(1+Number of Patent Application)*). In columns (3)-(4), the dependent variable is the logarithm of one plus adjusted citation (Log(1+Number of Citations)) *Log(1+Number of Litigations in Industry* is the logarithm of one plus total number of litigation cases in a 3-digit SIC industry in a certain year. *Log(1+Average Number of Litigations in Last 3 years* is the logarithm of one plus total number of litigation cases in a 3-digit SIC industry in last three years. *Log(1+Number of Defendant Cases in Industry* is the log of one plus total number of defendant cases in a 3-digit SIC industry in a certain year. *Log(1+Average Number of Defendant Cases in Last 3 years* is the logarithm of one plus total number of defendant cases in a 3-digit SIC industry in the last three years. Firm and year fixed effects are included. *t-statistics* (in parenthesis) are robust. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Firm-level Litigation Intensity

	Log(1+Number of Patent Application)		Log(1+Number of Citations)	
	(1)	(2)	(3)	(4)
Log(1+Number of Litigations)	-0.08**		-0.01**	
	(-2.16)		(-2.45)	
Log(1+Average Number of Litigations in Last 3 years)		-0.28**		-0.02*
		(-2.38)		(-1.72)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	2,652	1,861	2,652	1,861
Adjusted R^2	0.827	0.788	0.961	0.974

Panel B: Firm-level Defendant Risk

	Log(1+Number of Patent Application)		Log(1+Number of Citations)	
	(1)	(2)	(3)	(4)
Log(1+Number of Defendant Cases)	-0.10*		-0.01**	
	(-1.71)		(-2.18)	
Log(1+Average Number of Defendant Cases in Last 3 years)		-0.27**		-0.01
		(-2.52)		(-1.36)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	2,652	1,861	2,652	1,861
Adjusted R^2	0.827	0.788	0.961	0.974

Table A4: The Effects of Patent Litigation: Innovation Strategy by Year

The table examines the effects of patent litigation on corporate innovation outcomes. We present results from difference-in-difference analysis with the dependent variables in $t+1$, $t+2$, and $t+3$ year after litigation. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that S&P 500 firm associated for the period of 2000-2006. For each litigation case, we restrict the sample period from t-3 to t+3 year around the litigation filing date. In columns (1)-(3), the dependent variable is the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*). In columns (4)-(6), the dependent variable is the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*). In columns (7)-(9), the dependent variable is the logarithm of one plus number of patent granted at a certain year (*Log(1+Number of Patent Grant)*). *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	Log(1+Number of Patent Application)			Log(1+Number of Citations)			Log(1+Number of Patent Grant)		
	(1) t+1	(2) t+2	(3) t+3	(4) t+1	(5) t+2	(6) t+3	(7) t+1	(8) t+2	(9) t+3
After X Defendant	-0.40***	-0.37***	-0.26***	-0.03***	-0.02***	-0.01*	-0.38***	-0.45***	-0.40***
	(-6.84)	(-6.26)	(-4.52)	(-4.10)	(-3.14)	(-1.73)	(-6.88)	(-7.59)	(-7.11)
Defendant	0.14***	0.12***	0.07**	0.00	-0.00	-0.00	0.17***	0.19***	0.15***
	(5.25)	(3.92)	(2.24)	(0.76)	(-0.04)	(-0.80)	(6.63)	(6.61)	(4.98)
After	0.18***	0.11***	0.08***	0.01***	0.01**	0.00	0.19***	0.15***	0.11***
	(6.40)	(4.01)	(2.92)	(2.91)	(2.36)	(1.62)	(7.33)	(5.45)	(3.89)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,260	11,129	10,651	11,260	11,129	10,651	11,260	11,129	10,651
Adjusted R^2	0.914	0.905	0.893	0.957	0.963	0.971	0.928	0.928	0.927

Table A5: The Effects of Patent Litigation: Financial Outcomes

The table examines the effects of patent litigation on corporate financial outcomes. We present results from difference-in-difference analysis with control variables. The sample comprises of 10,060 firm-year observations for 1,692 litigation cases that S&P 500 firm associated for the period of 2000-2006. For each litigation case, we restrict the sample period from t-3 to t+3 year around the litigation filing date. In columns (1)-(4), the dependent variables are corporate financial policy: total cash scaled by total assets (*Cash*), dividend payer indicator (*Dividend (indicator)*), book value of total debt scaled by total assets (*Leverage*), and assets growth rate (*Asset Growth*). *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset Growth
After X Defendant	-0.01***	-0.03**	0.03***	-0.07***
	(-3.00)	(-2.17)	(2.69)	(-5.56)
Defendant	0.01***	0.00	-0.01***	0.05***
	(2.97)	(0.02)	(-2.90)	(6.81)
After	0.00*	-0.00	0.00	0.02***
	(1.71)	(-0.44)	(0.51)	(3.30)
Size	-0.01	0.09***	-0.05***	-0.27***
	(-1.64)	(4.87)	(-4.15)	(-9.35)
R&D Expense	-0.28***	0.45***	0.31***	0.84***
	(-5.09)	(5.00)	(4.05)	(7.41)
Profitability	-0.05*	0.15	0.07	-0.38***
	(-1.96)	(1.60)	(1.00)	(-3.27)
Tangibility	0.15***	0.07	-0.07***	0.74***
	(8.52)	(1.47)	(-2.72)	(11.48)
Tobin's Q	-0.00***	0.00***	-0.00***	0.10***
	(-4.21)	(3.72)	(-4.12)	(10.31)
CF Vol	0.18***	0.46***	0.17	-0.97***
	(5.11)	(4.55)	(1.13)	(-6.76)
1 - HHI	-0.08	0.05	0.32***	-0.09
	(-1.26)	(0.33)	(2.88)	(-0.41)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	10,060	10,060	10,060	10,060
Adjusted R^2	0.879	0.889	0.682	0.530

Table A6: The Effects of Patent Litigation: Product Market Outcome

The table examines the effects of patent litigation on product market outcomes. We present results from difference-in-difference analysis with control variables. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that are associated with S&P 500 firms for the period of 2000-2006. For each litigation case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(4), the dependent variables are market shares among the closest 5, 10, 25, and 100 industry rivals, respectively, calculated using Hoberg and Phillips (2016) text-based industry classification (TNIC). In column (5), the dependent variable is market shares using all firms in the same 3-digit SIC. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1) With Closest 5 Rivals	(2) With Closest 10 Rivals	(3) With Closest 25 Rivals	(4) With Closest 100 Rivals	(5) With All Rivals (3-digit SIC)
After X Defendant	-0.05***	-0.03***	-0.03***	-0.01**	0.00**
	(-6.58)	(-5.20)	(-4.46)	(-2.34)	(2.46)
Defendant	0.02***	0.01***	0.01***	0.01***	-0.00
	(5.30)	(3.87)	(4.37)	(2.64)	(-1.42)
After	0.00	0.00	0.01***	0.00	0.00***
	(0.88)	(1.15)	(2.99)	(0.79)	(3.07)
Size	0.05***	0.09***	0.07***	0.04***	0.04***
	(4.59)	(9.03)	(8.95)	(7.17)	(13.75)
R&D Expense	-0.07	0.04	-0.04	-0.10***	0.04***
	(-1.19)	(0.63)	(-0.98)	(-3.48)	(3.68)
Profitability	0.42***	0.03	0.06**	0.12***	0.07***
	(7.60)	(0.84)	(2.30)	(5.23)	(8.66)
Tangibility	-0.06*	-0.09***	-0.03	-0.09***	-0.02***
	(-1.79)	(-3.28)	(-1.25)	(-4.41)	(-3.03)
Tobin's Q	0.00	0.00***	0.00***	0.00***	0.00***
	(1.58)	(3.57)	(4.19)	(5.26)	(4.56)
CF Vol	-0.04	-0.40***	-0.20**	-0.02	0.04***
	(-0.53)	(-5.06)	(-2.49)	(-0.42)	(4.20)
1 - HHI	0.12	-0.05	-0.03	-0.16*	-0.62***
	(0.94)	(-0.55)	(-0.30)	(-1.78)	(-11.63)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	10,060	10,060	10,060	10,060	10,060
Adjusted R^2	0.646	0.730	0.751	0.749	0.986

Table A7: The Effects of Patent Litigation: Innovation Outcomes

The table examines the effects of patent litigation on corporate innovation outcomes. We present results from difference-in-difference analysis with control variables. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that S&P 500 firm associated for the period of 2000-2006. For each litigation case, we restrict the sample period from $t-3$ to $t+3$ year around the litigation filing date. In columns (1)-(4), the dependent variables are corporate innovation outcomes: the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*), the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*), the logarithm of one plus number of acquisitions (*Log(1+Number of Total Acquisitions)*), and the logarithm of one plus average transaction size of acquisitions (*Log (1+Average Acquisition Size)*) at a certain year. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
After X Defendant	-0.34***	-0.03***	-0.10***	-0.40***
	(-6.52)	(-5.19)	(-4.60)	(-3.60)
Defendant	0.15***	0.01**	0.05***	0.28***
	(6.52)	(2.48)	(4.62)	(4.66)
After	0.19***	0.01***	0.00	-0.06
	(7.98)	(2.97)	(0.10)	(-1.08)
Size	0.43***	-0.11***	0.17***	1.04***
	(7.44)	(-8.49)	(8.23)	(7.55)
R&D Expense	2.25***	0.06	-1.12***	-7.12***
	(4.63)	(1.33)	(-5.36)	(-6.90)
Profitability	-0.29	-0.37***	0.55***	3.28***
	(-1.31)	(-6.48)	(6.79)	(7.11)
Tangibility	1.37***	-0.09**	0.75***	5.72***
	(7.98)	(-2.55)	(12.25)	(14.18)
Tobin's Q	-0.00	0.01***	0.01**	-0.02
	(-0.52)	(8.81)	(2.57)	(-1.38)
CF Vol	0.47	0.51**	0.78***	3.03**
	(0.73)	(2.38)	(2.69)	(2.27)
1 - HHI	-5.63***	-0.36***	0.79***	2.18
	(-8.01)	(-4.04)	(3.73)	(1.35)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	10,061	10,061	10,061	10,061
Adjusted R^2	0.928	0.966	0.394	0.370

Table A8: The Effects of Patent Litigation: First Litigation Case

The table examines the effects of patent litigation on corporate financial, product market and innovation outcomes. We restrict our sample to the first litigation cases (505 cases) for each firm during our sample period of 2000-2006. In columns (1)-(4) of Panel A, the dependent variables are corporate financial policy: total cash scaled by total assets (*Cash*), dividend payer indicator (*Dividend (indicator)*), book value of total debt scaled by total assets (*Leverage*), and assets growth rate (*Asset Growth*). In column (5) of Panel A, the dependent variable is market share among the closest 10 industry rivals calculated using Hoberg and Phillips (2016) text-based industry classification (TNIC). In columns (1)-(4)of Panel B, the dependent variables are corporate innovation outcomes: the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*), the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*), the logarithm of one plus number of acquisitions (*Log(1+Number of Acquisitions)*), and the logarithm of one plus average transaction size of acquisitions (*Log (1+Average Acquisition Size)*) at a certain year. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: First Litigation Effect on Financial Outcome

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset growth	(5) Market Share
After X Defendant	-0.04***	-0.02	0.14***	-0.11***	-0.01***
	(-4.71)	(-0.69)	(4.03)	(-3.56)	(-2.85)
Defendant	0.02***	0.01	-0.06***	0.04***	0.00***
	(4.68)	(0.69)	(-4.01)	(3.35)	(2.84)
After	0.01**	0.04***	0.01	0.07***	0.01***
	(2.30)	(3.19)	(0.86)	(2.93)	(6.59)
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	3,456	3,456	3,456	3,456	3,456
Adjusted R^2	0.910	0.874	0.626	0.207	0.986

Panel B: First Litigation Effect on Innovation Outcome

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
After X Defendant	-0.33***	-0.01	-0.13***	-0.89***
	(-4.23)	(-0.56)	(-3.54)	(-4.45)
Defendant	0.14***	0.00	0.05***	0.37***
	(4.19)	(0.56)	(3.53)	(4.43)
After	0.08**	0.00	0.07***	0.45***
	(2.45)	(0.45)	(2.88)	(3.07)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	3,456	3,456	3,456	3,456
Adjusted R^2	0.940	0.968	0.417	0.344

Table A9: The Effects of Patent Litigation: Excluding observation with both defendant and plaintiff cases

The table examines the effects of patent litigation on corporate financial, product market and innovation outcomes. We restrict our sample by excluding the observations where a firm experience both defendant and plaintiff cases in a certain year. In columns (1)-(4) of Panel A, the dependent variables are corporate financial policy: total cash scaled by total assets (*Cash*), dividend payer indicator (*Dividend (indicator)*), book value of total debt scaled by total assets (*Leverage*), and assets growth rate (*Asset Growth*). In column (5) of Panel A, the dependent variable is market share among the closest 10 industry rivals calculated using Hoberg and Phillips (2016) text-based industry classification (TNIC). In columns (1)-(4)of Panel B, the dependent variables are corporate innovation outcomes: the logarithm of one plus number of patent applications at a certain year (*Log(1+Number of Patent Application)*), the logarithm of one plus adjusted citation (*Log(1+Number of Citations)*), the logarithm of one plus number of acquisitions (*Log(1+Number of Acquisitions)*), and the logarithm of one plus average transaction size of acquisitions (*Log (1+Average Acquisition Size)*) at a certain year. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Litigation Effect on Financial Outcome

	(1) Cash	(2) Dividend Dummy	(3) Leverage	(4) Asset growth	(5) Market Share
After X Defendant	-0.04***	-0.08***	-0.00	-0.12***	-0.07***
	(-5.25)	(-3.34)	(-0.48)	(-5.27)	(-5.76)
Defendant	0.02***	0.01	-0.00	0.08***	0.04***
	(3.89)	(0.97)	(-0.37)	(4.55)	(5.18)
After	0.01***	0.01*	-0.00	0.04***	0.01*
	(2.75)	(1.82)	(-1.44)	(4.32)	(1.84)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	6,621	6,621	6,621	6,621	6,621
Adjusted R^2	0.868	0.790	0.738	0.140	0.709

Panel B: Litigation Effect on Innovation Outcome

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
After X Defendant	-0.70***	-0.08***	-0.05	-0.34**
	(-8.85)	(-6.30)	(-1.42)	(-2.05)
Defendant	0.41***	0.02**	0.05***	0.38***
	(7.29)	(1.99)	(3.38)	(3.95)
After	0.32***	0.01**	0.04***	0.23***
	(9.32)	(2.45)	(3.81)	(3.05)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	6,621	6,621	6,621	6,621
Adjusted R^2	0.920	0.958	0.367	0.315

Table A10: The Effects of Patent Litigation: Innovation Strategy

The table examines the effects of patent litigation on corporate innovation strategy. We present results from difference-in-difference analysis with control variables. The sample comprises of 11,370 firm-year observations for 1,692 litigation cases that S&P 500 firm associated for the period of 2000-2006. For each litigation case, we restrict the sample period from t-3 to t+3 year around the litigation filing date. In columns (1)-(5), the dependent variables are corporate innovation strategy: the exploitive innovation measure (*Exploitative*), the explorative innovation measure (*Exploratory*), the indicator that equals one if a defendant firm acquires a target in the same industry based on 4-digit SIC (*Same Industry Acquisition*), the logarithm of one plus number of corporate venture capital (CVC) investment initiation (*Log(1+Number of CVC Deal)*), and the number of business segments (*Number of Segments*). *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1) Exploitative t+1	(2) Exploratory t+1	(3) Same Industry Acquisition	(4) Log(1+Number of CVC Deal)	(5) Number of Segments
After X Defendant	0.04***	-0.03***	0.06***	-0.10***	-0.33***
	(5.36)	(-3.90)	(3.27)	(-3.82)	(-4.39)
Defendant	-0.02***	0.01***	-0.02**	0.03**	0.32***
	(-5.38)	(3.25)	(-2.22)	(1.98)	(7.07)
After	-0.01***	0.01**	-0.02***	0.01	0.22***
	(-3.67)	(2.11)	(-2.93)	(0.61)	(6.12)
Size	-0.01	0.03**	0.03	0.07***	0.43***
	(-0.85)	(1.97)	(1.46)	(2.86)	(4.47)
R&D Expense	-0.33***	0.23***	-0.45***	1.09***	3.92***
	(-4.59)	(2.66)	(-3.38)	(6.17)	(5.29)
Profitability	0.25***	0.04	0.62***	-0.46***	-2.90***
	(4.88)	(0.98)	(4.13)	(-5.55)	(-7.48)
Tangibility	-0.17***	0.15***	0.27***	0.68***	0.57*
	(-5.70)	(4.30)	(4.94)	(5.62)	(1.80)
Tobin's Q	-0.00	0.00**	0.05***	0.01	0.01
	(-1.59)	(2.52)	(4.59)	(1.51)	(0.62)
CF Vol	0.11*	-0.03	-0.03	-0.27**	-1.61***
	(1.94)	(-0.53)	(-0.28)	(-1.98)	(-3.33)
1 - HHI	-0.49***	-0.33**	0.29	1.32***	5.91***
	(-3.31)	(-2.23)	(1.53)	(3.80)	(5.73)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	8,303	8,303	10,060	10,060	9,180
Adjusted R^2	0.554	0.692	0.437	0.870	0.837

Table A11: The Effects of Patent Litigation: Case with Verdict

The table examines the effects of patent litigation on corporate financial and innovation outcomes. The sample comprises of 8,192 firm-year observations for 1,692 litigation cases that S&P 500 firm associated for the period of 2000-2006. The dependent variables are identical to those in Table A9. *Negative Remedy* is an indicator that equals one if litigation case reaches to a verdict reporting a remedy for defendant including preliminary injunction, permanent injunction, no invalidity, or infringement. *After* is an indicator that equals one after litigation year, and zero before and including litigation year. *Defendant* is an indicator that equals one if firm is one of defendants in litigation case, otherwise zero. Year and firm fixed effects are included. *t-statistics* (in parenthesis) are robust and adjusted for case-level clustering. ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: Diff-in-Diff Analysis on Financial Outcome

	(1) Cash	(2) Dividend (indicator)	(3) Leverage	(4) Asset growth	(5) Market Share
Defendant X After X Negative Remedy	-0.01	-0.04*	-0.07**	-0.12	-0.15***
	(-1.39)	(-1.67)	(-2.50)	(-1.62)	(-4.62)
After X Negative Remedy	0.00	0.05***	0.00	0.01	0.02***
	(0.49)	(3.70)	(0.88)	(0.45)	(3.12)
Defendant X Negative Remedy	0.03**	0.03	0.04**	0.06	0.10***
	(2.19)	(1.60)	(1.97)	(0.86)	(3.52)
After X Defendant	-0.02***	-0.05***	0.04***	-0.06***	-0.04***
	(-3.35)	(-3.16)	(3.14)	(-3.64)	(-6.63)
Defendant	0.00	0.01	-0.02***	0.02**	0.02***
	(1.50)	(0.60)	(-3.51)	(2.07)	(5.01)
After	0.00*	-0.01*	-0.01**	0.03***	0.01**
	(1.93)	(-1.70)	(-2.31)	(3.38)	(2.06)
Negative Remedy	-0.00	-0.03**	0.01*	-0.02	-0.00
	(-0.84)	(-2.25)	(1.74)	(-1.49)	(-0.02)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	8,192	8,192	8,192	8,192	8,192
Adjusted R^2	0.881	0.865	0.687	0.183	0.745

Panel B: Diff-in-Diff Analysis on Innovation Outcome

	(1) Log(1+Number of Patent Application)	(2) Log(1+Number of Citations)	(3) Log(1+Number of Total Acquisitions)	(4) Log(1+Average Acquisition Size)
Defendant X After X Negative Remedy	-0.44***	0.00	-0.21**	-0.93**
	(-2.82)	(0.10)	(-2.24)	(-1.98)
After X Negative Remedy	0.36***	0.01	0.06***	0.45***
	(7.71)	(1.08)	(2.62)	(2.69)
Defendant X Negative Remedy	0.22**	-0.07*	0.11*	0.35
	(2.50)	(-1.96)	(1.79)	(1.38)
After X Defendant	-0.31***	-0.03***	-0.07***	-0.18
	(-8.96)	(-4.25)	(-3.52)	(-1.54)
Defendant	0.10***	0.00	0.04***	0.11
	(4.87)	(0.34)	(2.63)	(1.30)
After	0.10***	0.01**	0.00	-0.07
	(5.20)	(2.10)	(0.11)	(-0.94)
Negative Remedy	-0.20***	-0.03***	-0.03	-0.24*
	(-5.57)	(-3.02)	(-1.52)	(-1.68)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	8,192	8,192	8,192	8,192
Adjusted R^2	0.933	0.962	0.369	0.341

B Determinants of Patent Litigation

As we emphasized in the introduction, patent litigation is likely to affect firms' innovation strategies and product market competitions, beyond the individual patent characteristics. The goal of this paper is to capture such firm-level characteristics and interactions of firms in the product market together which lead to patent litigation. Earlier studies of patent litigation has focused and identified the patent-level determinants of patent litigation. Before we present our main firm-level analyses, we briefly describe the determinants of patent litigation and ensure that our data exhibits similar characteristics to earlier small sample patent litigation studies.

In Appendix Table A1, we first run patent-level univariate analysis comparing patent characteristics of asserted patents in our sample patent litigation cases and those that are not. Consistent with previous studies, we find that asserted patents tend to be younger, have more claims, and are cited more frequently than patents that are not involved in litigation during the sample period, all with statistical significance. In other words, our data shows that firms' technologically important and valuable patents tend to get involved in patent litigation, highlighting the importance of studying the consequence of patent litigation for intellectual property intensive firms.

In Appendix Table A2, we report firm-level regressions of probability of patent litigation using firms' financials, and innovation characteristics. The results are not as pronounced as patent-level characteristics. Columns (2) and (4) show that firms with high Tobin's q tend to be in litigation, particularly as defendants, more often on average. This result is consistent with more valuable patents tend to get involved in patent litigation (Lanjouw and Schankerman 2004, Allison, Lemley, and Walker 2009) as firms with high Tobin's q tend to have better innovation investment opportunities. It also appears that firms with relatively high cash-to-assets ratio are less likely to be in patent litigation. The cash result, however, does not necessarily mean that inter-firm litigation are absent cash motives as firms can still be cash rich in absolute amount but only take only small proportion of total assets.

C Case Examples

Symbol Technologies v. Proxim

In December 2001, Symbol Technologies filed suit against Proxim for patent infringement. Symbol Technologies and Proxim were direct competitors wireless networking equipment for Wi-Fi and broadband wireless networks industry. The asserted patents in the litigation entailed a power saving feature in wireless local area network ("WLAN") communication protocols. During the trial, the jury found that Proxim's OpenAir products and 802.11 products infringed Symbol's patents. Around the time when Symbol's patents were granted between 1991 and 1995, Proxim began selling the OpenAir products under the RangeLAN2 name in 1994. Symbol's infringement expert had performed infringement analysis for the OpenAir products, but without joining Proxim's Wireless LAN Interoperability Forum, could not further determine direct infringement without Proxim's protocol and source code.

As a defense against patent infringement suit, Proxim contended that it is entitled to the defense of laches, arguing Symbol Technologies sustained both economic and evidentiary prejudice as a result of Symbol's unreasonable delay in bringing suit. However, Proxim failed to bring evidence that demonstrates Symbol had actual knowledge of Proxim's infringing activities and that Symbol Technologies failed on duty to inquire. As a result, in lieu of permanent injunction, Symbol Technologies was awarded a six percent royalty on sales of infringing products by Proxim in amount of $22,865,477 and damages in amount of $3,052,192, adding to approximately $26 million.

After the ordering of royalty and damages in July 2004, Proxim shortly announced that it plans to pay Symbol $22.75 million over the next two and a half years, starting with the quarter that ended September 30th. In a quarterly SEC filing in 2004, Proxim noted that "...we may be subject to significant and immediate liabilities in connection with our patent litigation case with Symbol Technologies, Inc. ("Symbol") which exceed our current cash resources." Proxim also warned that a large patent award to Symbol combined with difficulties in refinancing its Bridge Notes could force the company to "seek protection under applicable bankruptcy laws." Proxim was eventually acquired in 2005 by Terabeam Inc.[35]

Johnson & Johnson v. Boston Scientific

Johnson & Johnson and Boston Scientific's long history of myriad patent disputes date back to 2003. The asserted patent technology is used in making coronary artery stents. The market for coronary artery stents has grown into a $6.5 billion worldwide business in which profit margins can near 80 percent. Boston Scientific enjoyed a huge success, generating $2 billion sales, from Taxus stent introduced in the stents market dominated by the market pioneer, Cypher by Johnson & Johnson. Quickly, Boston Scientific became Johnson & Johnson's biggest rival in the stents market.

However, by 2005, a series of courtroom battles with Johnson & Johnson raised concerns by the stock market of Boston Scientific's ability to enhance Taxus line for

[35]See following sources for further information on Proxim's patent litigation news reports. https://www.law360.com/telecom/articles/2166/proxim-pays-23m-to-settle-symbol-s-wlan-patent-suit; http://query.nytimes.com/gst/fullpage.html?res=940DE5DD1E30F936A2575AC0A9629C8B63&mcubz=0; http://www.proxim.com/about-us/investor-information/investor-faqs

further sales and casted doubt on the company's financial health from continuing legal expenses. The media and market analysts particularly expressed concerns with Johnson & Johnson's potential strategy of using appeals and cases to drag on the patent dispute given its size and financial flexibility to hurt Boston Scientific financially even more than by collecting royalties. In 2006, Johnson & Johnson acquires Conor Medsystems that uses paclitaxel, the drug that stent patent litigation centers on. The market viewed that Johnson & Johnson's deep pockets and long experience with stent litigation could strengthen Conor's legal position, and Boston Scientific's shares fell on the news of Johnson's and Johnson's acquisition of Conor.

The final blow on Boston Scientific came in 2010. Since 2003, Boston Scientific settled 17 lawsuits with Johnson & Johnson, and it finally settled on the on going patent litigation on stent by paying Johnson & Johnson $1.7 billion, which is the largest sum ever paid to resolve patent litigation over medical device. Even though Ray Elliot, president and chief executive of Boston Scientific, assured the market of Boston Scientific's resilience and ability to manage the payments with some financial flexibility, the market and industry analysts suggested that the settlement's size would sharply curtail the company's ability to make major acquisitions in the near future or force the company to undergo layoffs. Consistent with the market's view, Boston Sceintific announced layoff plans during the same month, apparently due to large impairment charges and legal bills including payments to Johnson & Johnson.[36]

[36]See following sources for further information on Johnson & Johnson and Boston Scientific patent disputes.
http://query.nytimes.com/gst/fullpage.html?res=990CEED9173EF93AA3575BC0A9639C8B63&pagewanted=all&pagewanted=print; http://www.nytimes.com/2006/11/18/business/18stent.html;
http://www.nytimes.com/2007/10/04/business/04patent.html;
http://www.nytimes.com/2010/02/02/business/02device.html;
http://www.massdevice.com/update-boston-scientific-lay-1300-q4-2009-sales-rise-losses-narrow/.

D Variable Definition

Variable Name	Definition
After	An indicator that equals one after litigation year, and zero before and including litigation year.
Asset Growth	The annual change in total assets
Cash	Cash and cash equivalent scaled by total assets
CF Vol	Earning volatility in last 3 years
Defendant	An indicator that equals one if firm is one of defendants in litigation case, otherwise zero.
Defendant in $t+1$	An indicator that equals one if a sample firm is litigated as defendant in the year after the sample litigation year, and zero otherwise.
Defendant within 3 years	An indicator that equals one if a sample firm is litigated as defendant in the next three years after the sample litigation year, and zero otherwise.
Dividend (indicator)	An indicator that equals one if a firm pays dividend in a certain year.
Exploitative	A percentage of a patent's citations made by the patentee firm's existing patents and the citations made by those patents (Gao, Hsu, and Li (2018)).
Exploratory	A percentage of a patent's citations made *not* by the patentee firm's existing patents or the citations made by those patents (Gao, Hsu, and Li (2018)).
Inter-industry Case	An indicator that equals one if plaintiff and defendant are *not* in the same industry (2-digit SIC), and zero otherwise.
Intra-industry Case	An indicator that equals one if plaintiff and defendant are in the same industry (2-digit SIC), and zero otherwise.
Leverage	Book value of total debt divided by book assets
Log(1+Average Acquisition Size)	Logarithm of 1 plus the total dollar value of acquisition deals divided by the number of deals in a year.
Log(1+Average Deal Size)	Logarithm of average transaction size of acquisitions at a certain year
Log(1+Number of Total Acquisitions)	Logarithm of one plus number of acquisitions
Log(1+Number of Citations)	Logarithm of one plus NBER truncation-adjusted citations (in a given 3-digit SIC industry-year in the industry-level analysis).
Log(1+Number of CVC Deal)	Logarithm of 1 plus the number of new CVC deal initiations.
Log(1+Number of Defendant Cases in $t+1$)	Logarithm of 1 plus the number of cases in which a sample firm is litigated again as defendant in the year after the sample litigation year.
Log(1+Number of Litigation in Industry)	Logarithm of one plus the total number of patent litigation cases in a 3-digit SIC industry in year $t-1$.
Log(1+Average Number of Litigations in Industry in Past 3 years)	Logarithm of one plus the average of the number of S&P 500 firm defendant cases in a 3-digit SIC industry in the past 3 years.
Log(1+Number of Patent Application)	Logarithm of one plus number of patent applications in a given year (or in a given 3-digit SIC industry-year in the industry-level analysis).

Variable Name (contd.)	Definition (contd.)
Log(1+Number of Segments)	Logarithm of 1 plus the number of business segments.
Log(1+Number of Total Acquisitions)	Logarithm of 1 plus the number of acquisitions made in a year (both public and private acquisitions).
Log(1+Total Number of Defendant Cases within 3 years)	Logarithm of 1 plus the total number of cases in which a sample firm is litigated as defendant in the next three years after the sample litigation year.
Market Share	Market share computed with Hoberg and Phillips (2016) text-based industry classification. The number of rivals indicate N closest competitors based on score variable that measures closeness of any two firm's product descriptions from annual statements.
Plaintiff	An indicator that equals one if a S&P 500 firm in a given case is plaintiff and zero otherwise.
Total damage	The sum of lost profits, royalty, and other administrative payments.
Profitability	Operating income before depreciation and amortization scaled by total assets
R&D Expense	R&D expenditures (zero if missing) scaled by total assets
Same Industry Acquisition	An indicator that equals one if the acquirer and target firm are from the same industry (4-digit SIC).
Size	Logarithm of total assets
Tangibility	Tangible assets scaled by total assets
Tobin's Q	(Total assets - book value of equity + market value of equity) divided by total assets
1-HHI	Herfindahl index of three-digit SIC industry measured at the end of fiscal year