Patent trolling and leverage

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Abstract

I show that the exposure to patent litigation affects capital structure decisions through the financial distress channel. My identification exploits a 2017 U.S. Supreme Court decision limiting patent troll's ability to seek favorable venue outside a defendant's incorporating state. Following the decision, firms incorporated in states with strong anti-patent troll laws lever up. Treatment effects are stronger for high-tech firms that are premier targets of patent trolls. The effects are stronger for firms with higher probability of financial distress, higher conditional distress cost, and lower non-debt tax shields. The results are driven by firms with zero patents and firms with no history of pledging patents as collateral to raise debt. Finally, I show that the effects of my novel natural experiment are stronger than the impacts of the enactment of state anti-troll laws.

"The great emphasis on bankruptcy costs in recent discussions of optimal capital structure policy seems to me to have been misplaced....the supposed trade-off between tax gains and bankruptcy costs looks suspiciously like the recipe for the fabled horse-and-rabbit stew—one horse and one rabbit."

Miller (1977)

"I know of no study clearly demonstrating that a firm's tax status has predictable, material effects on its debt policy. I think the wait for such a study will be protracted."

Myers (1984)

I. Introduction

How does the threat of patent trolls, more formally referred to as Non-Practicing Entities (NPEs), affects firm capital structure decisions? NPEs acquire patents not to use them in production, but rather to sue and claim licensing fees from accused patent infringers. By 2015, 11.25% of all publicly traded firms were sued by an NPE (Cohen, Gurun, and Kominers, 2019). Defending such a lawsuit costs millions of dollars and could bankrupt a small company.[1] Continued legislative activity in Congress and across the states to stop frivolous patent litigation in recent years make it clear that patent trolling is a growing problem. While it is well recognized that patent trolls have a negative impact on targeted firms, it is less clear how the exposure to patent trolls relates to firm financing decisions.

From the perspective of the tax-bankruptcy cost trade-off theory of debt (e.g., Myers, 1984), lower exposure to frivolous patent litigation could lead to higher optimal debt ratios by decreasing a firm's risk of financial distress as well as the losses in the event of distress. The main challenge in the empirical identification of static trade-off theory is distinguishing the impact of financial distress cost from other factors that otherwise impact financial policy, such as unobservable growth opportunities. Litigations are particularly interesting in this context because they can place a firm in financial distress without placing it in economic distress (Bhagat, Brickley, and Coles, 1994). The cost of litigation can be viewed as a monetary damage representing an off-balance-sheet liability for a defendant firm and can thus isolate the effect of financial distress.

[1] https://www.nytimes.com/2013/10/18/business/extracting-a-toll-from-a-patent-troll.html

Consider what happens when a firm suddenly has more protection against NPE litigation. The decrease in negative future shock leads to a decrease in likelihood of distress. As a result, its marginal benefit of debt now exceeds the marginal cost of debt, so shareholders are better off if leverage increases. My economic hypothesis is that firms increase their leverage when their exposure to NPE litigation decrease. I hypothesize that expected cost of financial distress and the tax benefit of debt are the two frictions that provide an economic channel for such leverage increase. More specifically, firms that would benefit more from debt and firms experiencing greater reduction in distress cost ex-ante increase leverage more.

To study the causal effect of litigation risk from patent trolls, I use a setting new to the literature where a recent U.S. Supreme Court ruling changes the dynamics of patent litigation and unintentionally reduces the exposure to patent trolls for a subset of U.S. firms. This decision had heterogeneous effects across firms, depending on whether they were incorporated in states with anti-troll laws.

Thirty-three states have passed anti-troll laws to prohibit bad-faith patent infringement claims from NPEs before 2017. However, there are inherent limits to state actions. State discrepancies in anti-troll laws could lead to "forum shopping" by patent trolls in which they strategically choose to have their case heard in the venue where the state has weak or no anti-troll laws. In fact, 86% of 2015 patent cases were brought outside of the defendant's home district (Chien and Risch, 2016). Before May 2017, federal statutes covering judiciary procedure state that patent infringement lawsuits are to be held in the district court where the defendant did business, e.g., where it sold its products. This broad definition effectively allowed patent trolls to file lawsuit in nearly any district court of their choosing, regardless of where the defendant is incorporated.

In May 2017, the Supreme Court of the United States ruled in TC Heartland LLC v. Kraft Foods Group Brands LLC (hereinafter referred to as TC Heartland) that patent litigation cases must be heard in the state in which the defendant is incorporated, shutting down "forum shopping" for patent trolls. Because TC Heartland limits the venue in patent-infringement lawsuits to incorporation state, the decision represented a relative strengthening of anti-troll protection for firms incorporated in anti-troll states. My identification strategy is a difference-in-difference that compares the evolution of leverage of firms incorporated in states with anti-troll laws to firms incorporated in other states without anti-troll laws around the date of the Supreme Court decision.

This unique experiment allows me to identify the effect of prohibiting frivolous litigation from patent trolls. Anti-troll laws provide protection against two different legal tactics from patent trolls: sending demand letters and filing lawsuit. First, a patent troll often sends demand letters to businesses, claiming that they are infringing on patents. The demand letter often seek license payments and threaten further legal action that would cost the target firm far more to defend than to pay the license fees. Second, a patent troll also employ a "big fish" strategy, by directly filing lawsuit against a target firm and scaring the defendant into settlement. Studies using the adoption of the state anti-troll laws (e.g., Appel, Farre-Mensa, and Simintzi, 2019) likely identify the effect of prohibiting frivolous demand letters. The effect of prohibiting frivolous litigation, however, are unlikely to manifest at the time of adoption because of troll's ability to forum shop.

I first show that the TC Heartland decision lead to a significant increase in leverage for firms incorporated in states with anti-troll laws relative to firms incorporated in states without such laws. This increase is driven by high-tech firms, the premier target of NPEs. Figure 1 shows the number of patent litigation from July 2015 to June 2019 by industry and plaintiff entity type. More than 90% of patent troll cases are targeting high-tech firms. I find that treated high-tech firms exhibited a 3.8% increase in book leverage and a 4.5% increase in market leverage relative to untreated high-tech firms. On the contrary, this leverage increase effect is much smaller for firms in other industries.

To explore the underlying economic channel, I analyze the impact of the cost and benefit of debt on the leverage responses. First of all, the effects of the natural experiment are stronger for firms that are ex-ante closer to financial distress. Using Altman's Z score (Altman, 1968), Ohlson's O score (Ohlson, 1980), and size (Titman and Wessels, 1988) to proxy for probability of going bankrupt (e.g., Altman, 1968; MacKie-Mason, 1990; Serfling, 2016), I show that firms with higher likelihood of financial distress prior to treatment exhibited 7% to 9% more increase in book leverage and 5% to 7% more increase in market leverage post TC Heartland. Because the exposure to litigation liability does not affect the probability of distress for firms far away from distress as much as it affects firms closer to distress, the same exposure should be expected to increase the expected cost of financial distress more for the later firms.

After showing the heterogeneous treatment effect in probability of distress, I move on to analyze the impact of the second component in the expected cost of financial distress—conditional cost of financial distress. Widely accepted measures for conditional distress cost such as product uniqueness (Titman and Wessels, 1988) and the Tobin's Q (John, 1993; Rajan and Zingales, 1995) also predict firms' leverage responses to the natural experiment. I find that the effect of TC Heartland is more pronounced for firms with higher conditional financial distress costs. All of the heterogeneity in treatment effects lend support to the hypothesis that exposure to patent trolling affects firm leverage decisions through the expected financial distress cost channel.

After investigating the impact of distress cost, I focus on the other side of the classic trade-off: the tax benefit of debt. I find that protected firms with higher tax benefit of debt increase leverage more compared with protected firms with lower benefit. Specifically, firms with lower non-debt tax shields relative to their taxable income and thus higher tax benefit of increasing debt exhibit 6.7% more increase in book leverage and 4.9% more increase in market leverage post TC-Heartland.

If patent trolls target financially unhealthy firms more, the difference in treatment effect between high and low distress cost firms may be attributed to difference in treatment intensity. To rule out this alternative explanation, I first match my high-tech sample firms to a hand-collected dataset covering 8,095 patent infringement lawsuits filed by NPEs in district court from 2015 to 2019. I then show that the high and low distress cost firms experienced similar decline in number of times sued by NPEs after TC Heartland. Furthermore, I show that NPE litigation does not affect the distress probability of financially healthy firms ex-post.

To further understand the increase in firm leverage after TC Heartland, I focus on the net leverage effect of debt and equity issues and retirements. I find that protected firms deliberately increase firm leverage after TC Heartland through the combined effects of net debt issuances and net equity payouts. I also find that the higher net inflow from financing activities in protected firms post TC Heartland is not driven by increase in investment in these firms, which only accounts for a fraction of their positive financing deficit. Finally, I find no change in investment trend for firms with different distress cost. These findings are inconsistent with an alternative channel where the leverage changes in protected firms are driven by changes in investment after TC Heartland.

Another competing channel is the patent collateral channel—TC Heartland may increase the collateral value of the patents owned by protected firms, therefore increasing their debt capacity. In order to understand this channel, I combine my main dataset from Compustat with patent application, assignment, and pledging data, and test for heterogeneity of treatment effect in firms' patenting and patent pledging history. Contrary to what the patent collateral channel predicts, I find that the effects of the natural experiment are driven by firms with zero patents and firms with no history of pledging patents as collateral to raise debt.

Lastly, I compare the effect of TC Heartland on leverage to the effect of the initial enactment of anti-troll laws on leverage. I did not find a significant effect from the enactment of anti-troll laws on leverage as I find from the TC Heartland decision. One possible interpretation is that the patent troll's ability to choose venue before TC Heartland weakened anti-troll protection for firms incorporated in anti-troll states. The anti-troll laws may be effective in reducing frivolous lawsuits filed in states that passed the laws, but they are less effective in granting protection for firms incorporated in those states. This paper provides the first analysis of the TC Heartland decision as a natural experiment. The law literature has studied the effect of TC Heartland on shifting the choice of venue in patent litigation (e.g. Eldar and Sukhatme, 2018), and has focused on the shift from one specific venue that is plaintiff-friendly, the Eastern District of Texas, to other district courts. My paper is the first to document the impact of TC Heartland on anti-troll regulations, which have received considerable attention in the literature recently given the impact of patent trolls.

II. Related literature

My paper is related to the growing literature that studies the economic consequences of NPEs. Cohen et al. (2019) find that firms reduce their innovative activity after settling with NPEs or losing to them in court. Appel et al. (2019) study the effects of state anti-troll laws. They show that the law improved high-tech startups' ability to create jobs, innovate, and raise venture capital funding, but they do not study the effects of anti-troll laws on firm leverage as I do in this paper. In addition, because the firms' ability to raise debt could affect their innovative investment, one implication of my findings is that some of the results in these papers could be related to the effects of NPEs litigation on firms' financing decision. My paper also contributes to this literature by documenting the significant implications of TC Heartland for NPE litigation.

My paper also broadly contributes to a long lasting debate. While the tradeoff between the tax benefit of debt and the cost of financial distress has been a cornerstone of the capital structure research, its empirical relevance continues to be debated since at least Miller (1977). Opinions in the literature range from that tax benefits are irrelevant to debt policy to that bankruptcy costs appear to be too small to offset the large tax benefits of debt. The capital structure literature tests this tradeoff by running cross-sectional regressions of leverage on a set of widely accepted variables that proxy for the cost and benefit of debt (Harris and Raviv, 1991; Myers, 2003; Frank and Goyal, 2008). Early cross-sectional studies identifies a negative correlation between a firm's leverage and proxies for its expected cost of financial distress (Titman and Wessels, 1988; Rajan and Zingales, 1995; Frank and Goyal, 2008).

The literature also find firms that would benefit more from the debt tax shield have higher leverage. MacKie-Mason (1990) and Graham (1996a) find a positive correlation between a firm's leverage and its estimated or simulated marginal tax rate. Theories predict negative relationship between non-debt tax shield because it is a substitute for debt tax shield (DeAngelo and Masulis, 1980; Bradley, Jarrell, and Kim, 1984). However, empirical studies focusing on cross-sectional variation in leverage find mixed results. Bradley et al. (1984) find positive relationship between non-debt tax shield and leverage. Titman and Wessels (1988) fail to identify a statistically significant relationship between the two variables. Blouin, Core, and Guay (2010) find firms that appear underlevered have a significantly larger amount of non-debt tax shield. These papers study the variation in leverage across firms, while my study focus on the within-firm variation overtime. As pointed out by Welch (2004) and Graham and Leary (2011), within-firm variation is important Standard variables best explain leverage variation across industries, but struggle to explain variation within firms.

A shortcoming of the cross-sectional approach is that measures of the cost and benefit of debt may correlate with other observed as well as unobserved firm characteristics. For example, the documented positive relationship between marginal tax rate and leverage is confounded by profitability, since high profitability puts firms into a high tax bracket. Additionally, high tax rate can also correlate with low distress cost through the effects of profitability and firm size. The second drawback of this approach is that it is difficult to disentangle the causal effect. To illustrate, the literature established size as a robust predictor for cross-sectional variation in leverage. However, little is known about the causality behind this relationship, because size is correlated with different factors such as default risk, agency costs, tax rates, and access to financial markets. Finally, since all the measures of the cost and benefit of debt are likely affected by a firm's debt policy, cross-sectional relationships are vulnerable to reverse causality. As a result, the debate on whether tax benefits and distress costs are first-order determinants of capital structure choices is far from being settled despite a vast literature.

I contribute to this debate by studying the leverage responses by firms experiencing an exogenous decrease in their likelihood of financial distress and analyzing the heterogeneity in those responses depending on firms' expected cost of financial distress and tax benefit of increasing debt ex-ante.

More recent literature on capital structure have focused on using natural experiments to show how firm leverage responds to exogenous changes in distress cost and tax benefits of debt. Several studies focus on tax shocks. Givoly, Hayn, Ofer, and Sarig (1992) report that firms reduced their debt following the tax cuts introduced by the Tax Reform Act of 1986. Calomiris and Hubbard (1993) show that firms increased their debt after Undistributed Profits Tax was introduced. Heider and Ljungqvist (2015) find that firms increase leverage following increase in state tax rate. Other studies focus on shocks to probability of distress. Blanchard, Lopez-de Silanes, and Shleifer (1994) find that firms increased their long-term debt following cash windfalls in the form of a won or settled lawsuit. Giroud, Mueller, Stomper, and Westerkamp (2012) use snow falls as a distress cost shifter to show that debt overhang impairs firm performance.

My paper differ by focusing on the heterogeneity in leverage responses depending on the cross-sectional differences in the cost and benefit of debt. Therefore, I emphasis expected cost of financial distress and the tax benefit of debt as frictions that provides an economic channel for increase in leverage following a distress cost shifter.

My paper is related to the literature on litigation risk and firm financing decisions. This literature focuses on the effects after litigation (Hutton, Peterson, Smith, et al., 2014; Yuan and Zhang, 2015), while my paper shows that the exposure to patent litigation affects firm financing decisions. Malm and Krolikowski (2017) find that an increase in litigation risk is associated with a significant decrease in total debt. They use firms' litigation histories to proxy for litigation risk. It is difficult, however, to make causal inference about litigation risk with their cross-sectional tests. My study is distinct, in that I document a causal relationship between litigation risk and debt ratios in a different setting.

My study contributes to the literature in finance and economic studying the negative effects of lawsuits on firm. Several papers have analyzed the negative stock-market reactions to interfirm litigation through the channel of increased costs of financial distress imposed on the defendant. Cutler, Poterba, and Summers (1988) study the Pennzoil and Texaco lawsuit and find the filing of the lawsuit significantly reduced the wealth of the defendant, Texaco. They attribute the loss mainly to an increase in the costs of financial distress for Texaco. Nevertheless, their study is based on one lawsuit and is not related to patent infringement. Bhagat et al. (1994) study the announcement returns for 43 defendants of patent infringement lawsuits and report significant negative cumulative abnormal returns. They show that that costs of financial distress are an important determinant of defendant stock returns around lawsuit filings. Bizjak and Coles (1995) and Bhagat, Bizjak, and Coles (1998) also find that the losses in value to defendant in litigation are attributable to an increased likelihood of financial distress.

My study also contributes to the literature on financing for innovation. A theme in this literature is that innovative firms is more dependent on equity than debt financing (e.g., Brown, Fazzari, and Petersen, 2009; Brown, Martinsson, and Petersen, 2013). The interpretation has been that debt is not suited to finance investments that are risky and intangible. My results are consistent with this view, suggesting that litigation risk is an important factor contributing to innovative firms'reluctance to use debt.

III. Theoretical link between the exposure to NPE litigation and capital structure

Why do patent trolls affect a firm's optimal leverage? First, from the perspective of the tax-bankruptcy cost trade-off theory (e.g., Kraus and Litzenberger, 1973; Myers, 1984), lower exposure to frivolous patent litigation could lead to higher optimal leverage ratios by decreasing a firm's likelihood of financial distress induced by patent litigation. The firm can therefore take more debt to capture the tax benefits. In the classic trade-off theory, the firm is portrayed as balancing the value of interest tax shields against the expected cost of financial distress, which is equal to the probability of financial distress times the cost in the event of distress. The expected cost of financial distress for firms that are likely targets of patent trolls are lower with anti-troll protection, because such protection reduces the probability of financial distress induced by defending patent litigation. The present value of tax shields increases in debt, whereas the expected costs of financial distress decreases with debt. The firms are supposed to substitute debt for equity, or equity for debt, until the value of the levered firm is maximized. Thus the optimal leverage of a firm protected by the anti-troll law should be higher than that of an unprotected firm. Consider what happens after the treated firms are granted more protection against NPE litigation post TC Heartland. Their marginal benefit of debt now exceeds the marginal cost of debt, and so they should offset the shock by moving toward the higher optimal leverage.

The exposure to patent trolls not only reduces cash flow, but also increases the volatility of cash flows and thus increases the probability of financial distress. Graham and Harvey (2002) survey chief financial officers and present evidence that "a large number of CFOs (48%) said that earnings volatility was an important consideration in making debt decisions, which is consistent with the trade-off theory's prediction that companies use less debt when the probability of bankruptcy is higher."

This distress cost channel is pertinent to NPE litigation. Specifically, the primary targets of these litigations are growing high-tech firms (e.g. Feng and Jaravel, 2016; Cohen et al., 2019). Higher information asymmetry in these firms makes it difficult for claimants to recontract in distress, increasing the cost in such event (e.g., Harris and Raviv, 1991; Bhagat et al., 1994).

As discussed before, more protection against NPE litigation leads to a decrease in future negative shocks to cash flow. For protected firms, the mean of their expected cash flow should increase and the volatility decrease. Because the marginal cost of debt function is decreasing in the probability of distress, the protection ultimately represents a decrease in marginal cost of debt. My economic hypothesis is that firms increase their leverage when their exposure to NPE litigation decrease. I hypothesize that expected cost of financial distress and the tax benefit of debt are the two frictions that provide an economic channel for such leverage increase. More specifically, firms that would benefit more from debt and firms experiencing greater reduction in distress cost ex-ante increase leverage more.

From the perspective of the agency theory, lower *expected* monetary damage from litigation can be viewed as higher *expected* free cash flow. Hence lower exposure to NPE litigation could lead to higher optimal leverage, for firms benefit from the discipline that debt provides in reducing agency cost of free cash flow (Jensen, 1986). From the perspective of pecking order theory, more internal cash available following lower likelihood of litigation could lead to lower leverage. In this context, pecking order theory and trade-off theory predicts opposite leverage responses from the protected firms.

Second, exposure to patent troll indirectly affects a firm's optimal leverage through the firm's innovation input. Cohen et al. (2019) find that NPE litigation has a negative impact on innovation at targeted firms. This observation suggests that lower risk of such litigation could increase firms' incentive to pursue risky and innovative investments. Innovation is considered risky because of the high probability of failure and some chance of large upside returns. Increase in risky innovative investment may lead to higher cost of financial distress and lower optimal leverage. Besides, Myers (1977) argues that research and development (R&D) create assets that can be viewed as call options. Because the future value of this option depends on managerial discretion, the agency theory predicts an inverse relationship between R&D and leverage ratios. Furthermore, Bradley et al. (1984) argue that investments in R&D generate non-debt tax shields that are expected to be inversely related to leverage ratios. Ultimately, because financing decisions are made jointly with investment decisions, the effect of lower litigation risk on leverage through innovation is ambiguous. A likely prediction, however, is that firms respond to lower litigation risk by increasing both leverage and risky investment.

Third, exposure to patent troll indirectly affects a firm's optimal leverage through the firm's innovation output. Lower risk of frivolous patent litigation could increase firms' incentive to produce innovative products that might expose it to NPE lawsuits. This increase in incentive to develop new technologies should be expected to increase firms' innovative activities and patenting (Appel et al., 2019). The increase in patenting could in turn lead to increase in leverage by increasing firms' ability to use patents as collateral for loans. Hochberg, Serrano, and Ziedonis (2018) and Mann (2018) find that patents are pledged as collateral to raise significant debt financing. This patent collateral effect is strengthened by firms' decreased cost of financial distress, as the decreased risk makes lending to a firm more attractive. The patent collateral channel is consistent with the literature examining the determinants of capital structure decisions (e.g. Titman and Wessels, 1988; Rajan and Zingales, 1995). Collateral is one of the reliable factors established in this literature that are positively related to leverage.

Why does the likelihood of being sued by patent trolls affect a firm's choice between debt and equity? Lower likelihood of litigation and lower expected monetary damage from defending litigation represent an increase in a firm's equity value, which decrease the market leverage. If the previous leverage is optimal, the firm needs to adjust by increase its debt or repurchase equity after the likelihood of litigation reduces.

The source of external financing for new innovative investment could also affect a firm's debt and equity. On the one hand, the pecking order theory of debt is generally interpreted as predicting increase in leverage as firm increase investment, because firms prefer debt financing to equity financing. On the other hand, if new investment is financed by equity rather than debt, higher innovative investment translates to lower leverage ratios. Indeed, Brown et al. (2009) and Brown et al. (2013) show that small and innovative firms rely on equity financing for innovative investment, because these firms are likely credit constrained. The need for external financial, however, is unclear following a decrease in patent troll activities. Affected firms have stronger incentive to invest in innovation but they also have more internal cash to invest, because of the decreased cost of defending patent litigation. Ultimately, the firm's choice between equity and debt is determined by its optimal leverage. As noted by Hovakimian, Opler, and Titman (2001),"when firms adjust their capital structures, they tend to move toward a target debt ratio that is consistent with theories based on tradeoffs between the costs and benefits of debt."

Finally, critics of legislative activities aiming at patent trolls worry that such attempts may make it harder for firms to enforce patent rights. The empirical literature on intellectual property right (IPR) protection has established that a decrease in IPR protection could lead to lower innovation. This dark side of decreasing NPE litigation could thus affect a firm's leverage through its innovation activities. This is a secondary channel and is not important for my main results because IPR protection does not affect treated firms and untreated firms differently.

Because financing and investment are jointly determined, the effect of lower NPE litigation risk on leverage through innovative investment is likely second-order and ambiguous. On the contrary, lower NPE litigation risk should have first-order effects on leverage by directly reducing a firm's probability of financial distress and the distress cost.

What is special about litigation brought by patent trolls that is different from other litigation? Low-quality security class action lawsuits is another type of lawsuit targeting innovative firms. As noted by Kempf and Spalt (2019), the standard narrative in the literature studying class action lawsuits and target firms is that innovative firms are more susceptible to low-quality litigation because of their more volatile stock prices. Innovative firms are not the only set of firms that frequently experience large stock drops. Any firm can be the target of low-quality security class action lawsuits. The link between NPE lawsuits and innovative firms are more straight forward because patent trolls specifically target innovative high-tech firms (Feng and Jaravel, 2016). If high-tech firms are the only firms affected by the court decision, it is likely that the effect comes from patent trolls.

Overall, my economic hypothesis is that the lower likelihood of being sued by patent trolls affect debt policy by decreasing the likelihood of financial distress. Furthermore, I hypothesize that expected cost of financial distress and the tax benefit of debt are the two frictions that provide an economic channel for such leverage increase.

IV. Institutional background

A. Anti-troll laws

To illustrate how the U.S. Supreme Court decision in TC Heartland affected two sets of firms differently in terms of patent-litigation protection, I begin by describing state anti-troll laws.

Patent troll had an advantage in litigation for at least three nonmutually exclusive reasons. One, it is expensive to defend against patent lawsuits. Using cumulative abnormal returns for defendants in NPE lawsuits, Bessen and Meurer (2012) show that the mean annual cost of litigation for an alleged infringer is estimated to be \$14.9 million for large firms. Because of the high cost of defending against a patent infringement lawsuit, defendants may settle for a smaller amount even if they consider the lawsuits frivolous.[2] Patent troll is a bigger problem in the United States compared with the most of the world. The United States generally adopt the American rule for attorney fees, under which each party is responsible for paying its attorney, win or lose.[3] The English rule, which is applicable in most of the world, deters frivolous patent litigation by requiring the losing party to pay the winner's attorney fees (Chen, 2013).

Two, there was an asymmetrical proof of burden in patent litigation. A patent troll needs to prove infringement by only a "preponderance of evidence." The most effective defense for a defendant, on the other hand, required a "clear and convincing evidence" which is a higher standard.[4] Three, there were no downside risks to patent trolls in lawsuits. The Non-manufacturing status of NPEs has a strategic advantage, in that the target infringer cannot counter-sue for infringement. In litigation between firms who use patents, the defendant can use its own patent as a basis to file a counterclaim for infringement. This counter-suing treat to discourage patent litigation does not work against patent trolls because they do not produce any products.

The state anti-troll laws created downside risks for patent trolls. The "Bad Faith Assertions of Patent Infringement" statute passed in Vermont in May 2013 was the first state statute outlawing acts of frivolous patent enforcement. Although most aspects of patent law are considered a federal matter, studies have shown that the state anti-troll laws will likely survive federal preemption and will thus be effective in punishing frivolous and bad-faith patent litigations (Thoman, 2014; Todd, 2016).

The Vermont's statute has served as a model for other states. 33 states passed anti-troll laws at the time of the Supreme Court decision in TC Heartland. The core provision of the Vermont statute states: "A person shall not make a bad faith assertion of patent infringement." The statute then lists several factors that courts may consider as evidence that an assertion of patent infringement has been made in bad faith. The factors include that the claim lacks the required patent information,

[2] Source: https://www.natlawreview.com/article/patent-trolls-can-you-sue-them-suing-or-threatening-to-sue-you

[3] The U.S. Supreme Court's decision in Octane Fitness, LLC v. ICON Health & Fitness, Inc. in 2014 increased a litigant's chances of winning attorney fees in a frivolous patent litigation (Jiam, 2015)

[4] Under the preponderance standard, the burden of proof is met when the party with the burden convinces the fact finder that there is a greater than 50% chance that the claim is true. "Clear and convincing" means that the evidence is highly and substantially more likely to be true than untrue; the fact finder must be convinced that the contention is highly probable. Source: https://www.law.cornell.edu/wex/clear_and_convincing_evidence

the demand letter requested an unreasonable license fee, and the patent holder has previously filed or threatened to file similar patent infringement lawsuits and those threats were found by a court to be meritless. This last factor considering history of patent trolling behavior can be useful to identify NPEs. If those elements are met and there is sufficient evidence to prove that the patent holder acted in bad faith, the Vermont statute empowers the state attorney general to initiate legal actions against abusive NPEs. The statute also creates a private right of action for the target of a bad faith assertion of patent infringement. In that private action, a plaintiff may obtain equitable relief, damages, costs and attorneys' fees, and "exemplary damages" of $50,000 or three times the total damages, costs, and fees, whichever is greater.

Notably, legal activities that can expose a patent troll to liability under the anti-troll laws include both filing infringement litigation in court and sending demand letters to accused infringers. Some of the laws directly define an assertion to include both filing lawsuits and sending demand letters (e.g. Idaho). Others did not include litigation in the definition of assertion but define a target as a person receiving demand letters or "against whom a lawsuit has been filed alleging patent infringement" (e.g. Vermont). Studies using the adoption of anti-troll laws (e.g. Appel et al., 2019) likely identifies the effect of prohibiting frivolous demand letters. The effect of prohibiting frivolous litigation, however, are unlikely to manifest at the time of adoption, because of patent troll's ability to forum shop.

B. U.S. Supreme Court decision as a source of variation in protection under anti-troll laws

This section briefly describes the TC Heartland case and explains why the protection from frivolous patent litigation is stronger for firms in anti-troll states after the U.S. Supreme Court decision.

Kraft Food Group Brands LLC sued TC Heartland LLC, incorporated and headquartered in Indiana, for patent infringement in the United States District Court for the District of Delaware, arguing that the defendants shipped infringing products into Delaware. The defendants argued that the venue, the location for trial of the case, is not proper. The District Court, and subsequently the United States Court of Appeals for the Federal Circuit, rejected TC Heartland's argument. Finally, the U.S. Supreme Court reviewed the case and overturned the decisions by the lower courts. It ruled in May 2017 that patent infringement cases were to be tried in the state within which the defendant was incorporated.

Because TC Heartland limits the venue in patent-infringement lawsuits to incorporation state, the decision represented a relative strengthening of anti-troll protection for firms incorporated in anti-troll states. The previous section introduced that the most effective enforcement granted by the anti-troll laws is the cause of action against the patent troll. However, it is harder to countersue the patent troll if it brings lawsuits outside of the defendant's home district. Specifically, the level of protection granted by anti-troll laws to the defendant depends on the venue state, not on defendant's state of incorporation.

For example, Vermont enacted the anti-troll law in 2013, and New York has no such law. Before

TC Heartland, a patent troll could file a frivolous patent infringement lawsuit against a Vermont company in New York federal district court, arguing that the Vermont company has sold products in New York state. The Vermont company will not be protected by the anti-troll laws as it would be if the case is filed in a Vermont court. First, the Vermont state law does not give the Vermont company a cause of action to file counterclaim against the plaintiff in New York state. Second, even if the law grants cause of action to counter-sue the troll in Vermont, Vermont district court is unlikely to have personal jurisdiction over the troll. In order for the Vermont district court to have authority over the subject matter of the counter-sue case, the patent troll's conduct must create a substantial connection with the forum state. This connection is known as minimum contact. [5] The non-practicing status of NPEs ensure that the NPEs are unlikely to have minimum contact with the Vermont state if they are not registered in Vermont. The only previous "contact" between the troll and Vermont is that the troll sued a Vermont company in New York, which does not establish minimum contact with Vermont.

After TC Heartland, patent trolls no longer have the option to file lawsuits against a firm incorporated in anti-troll states in chosen venue to avoid punishment from anti-troll laws. Therefore, limiting the venue to state of incorporation decreased the exposure to patent litigation from NPEs for firms incorporated in anti-troll states.

The law literature has particularly focused on the shift of patent litigation from the Eastern District of Texas to other district courts after TC Heartland. Approximately 30% of patent-infringement cases in the United States between 2014 and 2016 were heard in the Eastern District of Texas, where the district court are found relatively plaintiff-friendly (Love and Yoon, 2017). In addition to being plaintiff-friendly, Texas, although having passed an anti-troll law, has relatively weak protection against trolls compared with other states like Vermont (Weidman, 2017). Texas law has more narrow definition of bad faith and has limited private cause of action. My study does not focus on the effect of troll's ability to file lawsuits in Texas. My study instead focuses on the larger decrease in exposure to patent litigation from NPEs for firms incorporated in states with anti-troll laws relative to firms incorporated in other states.

Strengthening protection granted by anti-troll laws for a subset of firms is an unintended consequence of TC Heartland. The Supreme Court's decision in TC Heartland is primarily based on the ordinary meaning of the legal text, where no consideration is given to broader context such as the implication for patent policy and state anti-troll laws (Bone, 2017). The key to this natural experiment is that the assignment to treatment is based on the existing anti-troll law status. Firms incorporated in 33 states with anti-patent troll laws received treatment after the Supreme Court decision, other firms did not. A violation of the identification assumption would need a confounding events that occur coincidentally with TC Heartland *and* hit the firms in those 33 specific states

[5]The minimum contact refers to the relationship between the defendant, the forum, and the lawsuit. To establish jurisdiction in the forum state, the defendant must have sufficient minimum contact with the forum state. Minimum contacts must be with the forum state, not just with a firm that reside in the forum state. Source: https://www.lexisnexis.com/legalnewsroom/corporate/b/business/posts/to-establish-personal-jurisdiction-minimum-contacts-must-be-with-forum-state-not-just-its-resident

after TC Heartland.

V. Data and natural experiment

A. Data

The main sample includes 61,159 firm-quarters for industrial firms from the third quarter of 2015 to the second quarter of 2019 (16-quarter window around the U.S. Supreme Court decision). I drop all financial firms (Standard Industrial Classification (SIC) 6000-6999) and utilities (SIC 4900-4999). I also remove any observations with zero, negative or missing total asset (Compustat item ATQ) and any observations with missing incorporation state (item INCORP). I calculate total debt as the sum of long-term debt (item DLTTQ) and debt in current liabilities (item DLCQ). For market leverage, I divide total debt by the sum of long-term debt and market value of equity (items PRCCQ*CSHOQ). I replace missing market value of equity with zero. Following (Mann, 2018), I replace missing value of total debt with zero and trim the debt to asset ratio at zero and one. Finally, all financial variables from Compustat are winsorized at both the upper and lower one percent tails. The main results are replicated and reported in Appendix D when the data are not winsorized.

Table I shows the summary statistics for treated and control firms before and after TC Heartland. Panel A reports the full sample and Panel B reports the high-tech sample that are the premier target of patent trolls. The first two columns compare the sample means and the next two columns presents the differences of the sample means between treated and control firms and the t tests of the differences. Column 5 reports the difference-in-difference estimators. The are computed by subtracting the difference in the *After* panel by the corresponding difference in the *Before* panel. Column 6 reports the t statistics of the difference-in-difference estimators. They are computed by estimating a standard difference-in-difference model.

To further investigate the connections between TC Heartland and NPE litigations, I scrapped a list of 8,095 NPE patent infringement lawsuits filed in district court targeting high-tech firms from Unified Patents' website[6] and matched the defendants to my sample firms. Unified Patents' is a Non-governmental organization studying NPE patent assertions. Their dataset contains 54,019 patent litigations from 2010 to 2020. I restrict my search to litigation filed by NPE in district court during my event window (between July 2015 and June 2019). To match with my sample firms, I further restrict the search to litigation targeting operating firms in the high-tech industry. The resulting search include 8,095 patent infringement lawsuits. The data include information about the case such as filing date, venue, plaintiff, and defendant. However, Unified Patents' dataset does not provide the outcome of the case. Using the company name in the defendant list, I was able to hand-match 719 cases to firms in my main sample from the standard Compustat database. 481 of the matches are exact match, the other 238 matches are not exact because Compustat and Unified

[6] https://portal.unifiedpatents.com/

Patents spell firm names differently in those cases. I checked extensively to make sure that these fuzzy matches are correct.

In order to understand the implications of firms' patenting as well as patent pledging history in my setting, I combine my main dataset from Compustat with patent application, assignment, and pledging data. The first patent dataset is the standard patent application dataset from the USPTO[7] (United States Patent and Trademark Office) which contains patent number and patent application dates. The second dataset is the KPSS patent data on Noah Stoffman's website[8]. This dataset is used in Kogan, Papanikolaou, Seru, and Stoffman (2017) and was recently updated in 2020. The dataset contains a match between the patent number and the CRSP "permco." I use this link to match patents to my sample firms. The third and last patent dataset is patent pledging data found on William Mann's website[9]. The data is used in Mann (2018) and contains patent numbers and borrower and lender information for each pledge of patents as collateral for a loan. After matching these datasets to my main high-tech sample, I find that 202 of the 912 firms in my high-tech sample has pledged patent as collateral before the beginning of my event window, and that 373 of the 912 firms have produced at least one patent in the twenty years leading up to the beginning of my event window.

B. *Measuring the cost and benefit of debt*

Since an important part of my study is to establish an economic channel through which the cost and benefit of debt determine how firms respond to a reduction in exposure to NPE litigation, measuring the cost and benefit of debt is a critical step. I focus on the two classic frictions: the cost of financial distress and the tax benefit of debt.

I employ six measures of the expected distress cost widely accepted in the literature. The first three measure the probability of financial distress. They are the Altman's Z score (Altman, 1968), the Ohlson's O score (Ohlson, 1980), and size (Titman and Wessels, 1988). The next three measure the conditional cost of distress. They are two measures of product uniqueness (Titman and Wessels, 1988) and the Tobin's Q (John, 1993; Rajan and Zingales, 1995).

Z score and O score are commonly used in the literature to measure the likelihood of financial distress (e.g. MacKie-Mason, 1990; Campbell, Hilscher, and Szilagyi, 2008; Serfling, 2016). These two scores complement each other because they are derived in different time periods, using different samples, different independent variables, and different predictive methodologies. Both of the proxies are shown to have strong predictive power for bankruptcy out of sample (Dichev, 1998). Note that Z score is a measure of financial strength (higher Z means lower probability of distress), whereas O score is a measure of distress intensity (higher O means higher probability of distress). The classic argument in the literature for using size as proxy for distress probability is that large firms tend to be more diversified and less prone to bankruptcy. In my specific setting, large firms tend to have

[7] https://www.uspto.gov/learning-and-resources/electronic-data-products/patent-assignment-dataset
[8] https://kelley.iu.edu/nstoffma/
[9] https://sites.google.com/site/williamgilesmann/

more legal resources and are less likely to suffer distress because of high cost of defending against a lawsuit. For example, the probability of going bankrupt for Microsoft Corporation (treated by TC Heartland, incorporated in the state of Washington) should be less affected by anti-troll protection compared with other smaller technology firms.

Titman and Wessels (1988) and Opler and Titman (1993) measure the conditional financial distress cost using product uniqueness. The direct financial distress cost is likely to be the highest among firms with relatively unique products that may require future service. These firms tend to have large selling expenses. To limit the confounding effect of research and development, I use as an additional proxy product uniqueness excluding R&D. Financial distress will be relatively more costly for firms with higher Tobin's Q, because Q measures the loss of going-concern value due to asset sales (Lindenberg and Ross, 1981; John, 1993).

I measure the tax benefit of debt with John Graham's simulated marginal tax rate (Graham, 1996a,b) and two different measures of non-debt tax shield in Blouin et al. (2010) and Titman and Wessels (1988). As pointed out by DeAngelo and Masulis (1980) and Bradley et al. (1984), non-debt tax shields are substitutes for the tax benefits of debt financing. As a result, firms with large non-debt tax shields relative to their income have lower benefit of debt and vice versa. Blouin et al. (2010) measure non-debt tax shield with the difference between the accrual tax expense and cash tax paid. They argue that "this difference can be viewed as an aggregate measure of non-debt tax shields stemming from timing of reversals in deferred tax differences, aggressive tax planning, and tax deductions from employee stock options. Specifically, firms with higher values of this variable will have less need of debt tax shields" (Blouin et al., 2010, p. 210).

I then assign firms percentile rankings based on each of the nine measure in 2016, the year before the U.S. Supreme Court decision in TC Heartland. The rankings are thus based on ex-ante measures, ruling out reverse causality concerns. Based on 2016 rankings, firms are categorized as having high cost if they are below the median Z score and size, and if they are above the median for O score, product uniqueness, and Tobin's Q. Similarly, they are categorized as having high benefit of debt if they are below the median non-debt tax shields and marginal tax rate.

C. Empirical methodology

I then examine how a firm's leverage responds to the variation in exposure to frivolous patent litigation. I use a standard difference-in-difference approach at the firm-quarter level to exploit the variation in treatment of TC Heartland in both the cross-section (i.e., firms incorporated in anti-troll states) and time-series (i.e., before and after May 2017). The difference-in-difference estimator will plausibly isolate the effect of TC Heartland. Both the treated and control groups include firms from a diverse geographic locations based on whether their incorporation state passed anti-troll laws before 2017. A confounding events violating the identification assumption must meet two requirements: occurring coincidentally with TC Heartland *and* hitting the same firms in 33 specific states.

Although the adoption of anti-troll laws separates the country into two distinct sets of states, the headquarters of treatment firms and control firms are dispersed across the country. Figure 2 shows the geographic distribution of treated firms and untreated firms by headquarter state. States are shaded according to quartiles of the number of firms headquartered there.

I first begin by comparing the average book leverage of the treated and control firms. A visual inspection of leverage trends help motivate my strategy. Figure 3 shows the average book leverage ratio of high-tech firms during the sample period before and after the U.S. Supreme Court decision in TC Heartland. The figure show that the debt ratios for treated and control firms are closely aligned prior to treatment such that the trends are parallel. After the decision quarter, there is a visible increase in debt ratio in treated firms.

This picture change dramatically when the sample is split by cost of distress and benefit of debt, as shown in Figure 4. Firms with low Z score are closer to distress and thus experience a larger drop in cost of distress are TC Heartland. In addition, firms with low non-debt tax shield would benefit more from debt. These two figures suggest that cost of distress and benefit of debt are important frictions impacting firm's decision to increase leverage.

Motivated by these trends, I formally test whether firms increase leverage following an exogenous reduction in exposure to patent litigation. I use an event window extending eight quarters before and after TC Heartland. My baseline specification is:

$$Leverage_{ist} = \alpha + \beta \times Treat_s + \lambda \times After_t + \delta \times Treat_s \times After_t + \varepsilon_{ist} \tag{1}$$

where i indexes firms, s indexes states of incorporation, and t indexes time. $Treat$ is an indicator for being incorporated in the states with anti-troll laws in place at the time of the Supreme Court decision in TC Heartland. $After$ is an indicator for being after the decision date.

To test the robustness of the results to different levels of fixed effects, I also include headquarter, industry, and firm fixed effects. By including headquarter fixed effect, I'm comparing firms headquartered in the same state but are heterogeneously affected by TC Heartland due to their different state of incorporation. This strategy allows me to control for changing local conditions for a firm's primary state of business (the headquarter state). For instance, I compare the leverage evolution around TC Heartland between a Vermont incorporated firm and a Massachusetts incorporated firm, both conducting businesses primarily in New York. Any unobservable shocks to New York state are thus controlled for, and the variation in litigation exposure comes from the fact that Vermont has anti-troll laws and Massachusetts does not. Similarly, by including firm fixed effects, I only use variation in litigation exposure before and after TC Heartland within each firm. My main specification to identify unconditional changes in leverage following TC Heartland is:

$$Leverage_{ist} = \delta \times Treat_s \times After_t + \lambda_t + \alpha_i + \varepsilon_{ist} \tag{2}$$

This specification drops $Treat$ and $After$ from the baseline specification and include time fixed effects λ_t and firm fixed effects α_i, which absorbs time-invariant firm characteristics as well as any aggregate shocks to industries and headquarters states.

Table 1 shows the summary statistics for treated and untreated firms before and after TC Heartland. Panel A reports the full sample and Panel B reports the IT industry sample that are the premier target of patent trolls. The first two columns compare the sample means and the next two columns presents the differences and the standard errors of the difference between treated and untreated firms. Column 5 reports the difference-in-difference estimator. It's computed by subtracting the difference in the *After* panel by the corresponding difference in the *Before* panel. Column 6 reports the standard errors of the difference-in-difference estimator. It's computed by estimating the baseline regression.

Next, to explore the economic channel and analyze the impact of the cost and benefit of debt on the treatment effect, I estimate the following generalized triple difference specifications:

$$\begin{aligned} Leverage_{ist} = \delta \times Treat_s \times After_t + \beta \times Treat_s \times After_t \times \textit{High cost}_i \\ + \lambda_t \times \textit{High cost}_i + \alpha_i + \varepsilon_{ist} \end{aligned} \tag{3}$$

and

$$\begin{aligned} Leverage_{ist} = \delta \times Treat_s \times After_t + \beta \times Treat_s \times After_t \times \textit{High benefit}_i \\ + \lambda_t \times \textit{High benefit}_i + \alpha_i + \varepsilon_{ist} \end{aligned} \tag{4}$$

where *High cost* represents one of six indicators for the group of firms that should experience a larger reduction in distress cost after treatment. Similarly, *High benefit* represents one of three indicators for the group of firms that would benefit more from debt. These indicators are based on ranking of the nine conditioning measures for cost and benefit of debt discussed in the previous section. Based on rankings in 2016, the year before TC Heartland, firms are categorized as having high cost if they are below the median Z score and size, and if they are above the median for O score, product uniqueness, and Tobin's Q. Equivalently, they are categorized as having high benefit of debt if they are below the median non-debt tax shields and if they are above median marginal tax rate. $\lambda \times$ *High cost* and $\lambda \times$ *High benefit* are time fixed effects interacted with the corresponding sensitivity indicator. This specification adds two classes of fixed effects which subsume several indicators used in a triple difference without fixed effects. Time by high sensitivity fixed effects subsume the indicator for high sensitivity and the indicator for post treatment. Firm fixed effects subsume *treat*, *High sensitivity*, and the interaction between the two. Time by high sensitivity fixed effects allow for year fixed effects to differ by subsample and are thus more generalized than triple difference estimation with only year fixed effect. This method specifically tests for difference in treatment effect between samples. I also estimate the unconditional difference-in-difference specification separately for firms with different cost and benefit of debt for completeness.

VI. Empirical results

In this section, I begin by presenting evidence on firms' leverage responses to TC Heartland. The result helps us understand the overall effects of TC Heartland and provide further motivation to explore the economic channel. I then move on to analyze the impact of the cost and benefit of debt on such responses.

A. *Unconditional tests*

I begin by estimating the Specification (1) to show the effect of TC Heartland on book leverage of treated firms. Column 1 of Table II presents the results. In the two-year window after TC Heartland, treated firms increase book leverage by 2.0%, as captured by the coefficient on $Treat \times After$.

I focus on the subsample of high-tech firms in Column 2 to 6. Bessen, Ford, and Meurer (2011) and Feng and Jaravel (2016) find that NPE litigations are concentrated in the IT sector. As noted by Bessen et al. (2011), the scope of software patents is not clear, and they are often written in vague language. It appears that much of the NPE litigation takes advantages of these weaknesses. In addition to being the target of patent trolls, high-tech firms exhibit higher conditional distress cost because of higher information asymmetry. Asymmetric information make it difficult for claimants to re-contract in the event of distress (e.g., Harris and Raviv, 1991; Bhagat et al., 1994). Following Bessen and Meurer (2013) and Cohen et al. (2019), I use SIC codes 73 and 35 to identify software and computer industries. As expected, the difference-in-difference estimators in column 2 (6.0%) are larger than those estimated in column 1.

To check the robustness of the causal effect, Column 3 first adds industry fixed effects and the increase (6.1%) is driven by variation in anti-troll protection within industry. Column 4 includes headquarter fixed effects. The estimate for the difference-in-difference estimator remains similar at 5.8%. The coefficients in column 4 with headquarter fixed effects are driven by variation in anti-troll protection within firms headquartered in the same state. For instance, I'm comparing the changes in leverages around TC Heartland between two firms headquartered in the same region, but one is incorporated in a state with anti-troll laws and the other is not. Column 5 further includes firm fixed effects and drops $Treat$ because it is colinear with firm fixed effects. This specification estimates that treated firms increase book leverage after TC Heartland by 3.9% compared to untreated firms. I also cluster the standard errors at the state of incorporation. The specification in Column 6 is the most general specification as firm fixed effects control for time-invariant firm characteristics that also account for both industry and headquarter fixed effects, and clustering at the state level corrects time-varying correlations within state that also account for within-firm error term correlations over time. Though the firm fixed effects and time fixed effects subsume a small portion of the explanatory power of the difference-in-difference estimator $Treat \times After$, the effect remain statistically significant at the 5% level and economically significant 3.8%. The sign on coefficient $Treat \times After$ is consistently positive across all six specifications, indicating that the causal effect is robust to different level of fixed effects.

Table III shows a similar relationship between TC Heartland and market leverage of the treated firms. The increase in market leverage after the Supreme Court decision is positive and significant for the high-tech firms. In contrast to the results for book leverage, the estimates for all firms are only significant at the 10% level. One possible explanation is that market leverage is a noisier measure than book leverage, in that market equity is more volatile than book asset. Otherwise, the sign on the difference-in-difference coefficient is consistently positive across all specifications, and the magnitude is also similar to those in Table II. The result indicate that the treatment effect is robust to different definitions of leverage. In Section VI.F, I further investigate different definitions of leverage increase.

Figure 5 examines the parallel-trend assumption by interacting the main specification with a full set of quarter dummies and plot the regression coefficients on the interactions between treatment status and quarter dummies. The 16-quarter window around the Supreme Court decision goes from the third quarter of 2015 to the second quarter of 2019. The vertical axis shows the magnitude of the coefficient estimates. They represent the difference in book leverage between the treated and control firms in each of the 16 quarters. The difference are close to zero before decision quarter. The graph is consistent with the parallel assumption that there is no significant difference in the evolution of book leverage between treated and control firms. The coefficient estimates on $Treat$ in Table II suggest that the treated and control firms have slightly different leverage ratio at the beginning of the sample period. However, the coefficient graph in Figure 5 starts at zero in the beginning because the *treat* indicator perfectly captured the permanent difference between the treated and control firms. All remaining differences are explained by the interactions between treatment status and quarter dummies, suggesting that the graph will continue to be flat around zero absent treatment.

Overall, the results in Table II and Table III indicate that treated firms significantly increase book leverage and market leverage after TC Heartland, and the results are especially pronounced in the NPE target industry.

B. *The impact of expected cost of financial distress*

So far, I show that a reduction in exposure to patent trolls leads to higher debt usage in protected firms. In this section, I conduct cross-sectional tests to explore the economic channel where the key frictions are the cost and benefit of debt. I focus on high-tech firms because they are the primary target of patent trolls and exhibit the strongest leverage response as shown in the previous section.

As in the classic trade-off theory, firms are hypothesised to trade off the expected cost of distress with the tax benefit of debt. The expected cost of distress can be broken down into two parts, probability of distress and conditional cost of distress. If the increase in leverage for protected firms is driven by the cost and benefit of debt, consistent with the trade-off theory, we should see different increase in leverage for firms with different probability of distress, different conditional cost of distress, and different tax benefit of debt.

When exposure to patent trolls is reduced, probability of distress and thus distress cost decrease. This reduced distress cost enables firms to take on more debt to take advantage of the tax benefit. However, the exposure to trolls does not affect distress probability for firms far away from distress as much as it affects firms closer to distress. For large firms with deep pockets, the decrease in distress probability and thus distress cost is trivial. For small firms close to distress, the change in probability of distress following reduction in litigation exposure is significant. Hence, I expect that the effects of anti-troll protection to be stronger for firms closer to distress ex-ante. Because the expected cost of distress is the product of distress probability and the conditional distress cost, for protected firms with higher conditional cost of distress, a reduction in likelihood of distress after TC Heartland represents a larger drop in the expected cost. Similarly I expect protected firms with higher conditional cost of distress ex-ante.

As discussed in Section V.B, I measure distance to financial distress with Altman's Z score, Ohlson's O score and size. I also use size as a proxy because smaller firms tend to be less diversified and lack the legal resources to defend against NPE litigations. I measure the conditional financial distress cost using product uniqueness, uniqueness excluding R&D, and Tobin's Q. These measures have become widely accepted as measures of conditional distress cost. Employees, customers, and suppliers incur higher cost when a firm with high product uniqueness becomes distressed because of the specificity of its products and services. Tobin's Q measures the loss of going-concern value in the event of bankruptcy.

For all of the conditioning measures used in this section, I use ex-ante (pre-treatment) value to rank firms, because these measures might be affected by treatment. I calculate the six measures for each firm in 2016, the year before the decision year of TC Heartland. I then rank the firms based on the pre-treatment measures and construct an indicators for having above median cost of financial distress. Firms are categorized as having high distress cost if they have below median Z score and size and if they have above median O score, Uniqueness, and Tobin's Q. Note that Z score measures financial strength, so that low z scores is interpreted as having high probability of going bankrupt. On the other hand, O score directly measures the probability of distress.

I first estimate Specification (2) separately for firms with different likelihood of distress before formally testing the heterogeneity in treatment effect between these firms. Table IV presents results, where the first six columns show results for book leverage and the last six columns show focus on market leverage. The results reveal that firms with high probability of distress as measured by Z score, O score, and size increase leverage more compared to firms not affected by TC Heartland. On the other hand, treated firms with low probability of distress do no exhibit significant change in leverage. These findings are consistent with the hypothesis that firms closer to bankruptcy increase leverage more because they experience larger reduction in expected cost of distress after TC Heartland. Furthermore, the firms with low probability of distress ex-ante as measured by all three proxies exhibit nearly zero change in leverage. This finding is inconsistent with the alternative explanation that the increase in leverage post TC Heartland is driven by change in investment instead of by distress cost.

After analyzing the impact of the probability of financial distress, I focus on the other component of the expected cost: the conditional cost of distress. I investigate whether the effect of anti-troll protection is more pronounced for firms with higher direct financial distress costs. Similarly, Table V shows the treatment effect separately for firms with different conditional cost of financial distress. The coefficient estimates on $Treat_s \times After_t$ from beginning to end of the table are higher for firms with high uniqueness and Tobin's Q, though the treatment effect on book leverage is not statistically significant when the samples are split by product uniqueness. The last six columns investigate market leverage response. For all three measures of conditional distress cost, treated firms show significant increase in market leverage at the 1% level after TC Heartland compared to unaffected firms. In terms of economic significance, in the two-year window after TC Heartland, treated high-tech firms with high product uniqueness, and thus higher conditional distress cost, increase debt by 3.6% of total assets and increase market leverage ratio by 6.4% more than the control firms. Protected firms with high Q increase book leverage by 8.3% and market leverage by 4.9% more compared with control firms with high Q. The results are consistent with the economic hypothesis that firms with higher conditional distress cost have stronger incentive to increase leverage after TC-Heartland.

I then estimate Equation (3) and present the results in Table VI, where the coefficient of interest is the triple-difference estimator on the interaction term $\beta \times Treat_s \times After_t \times High\ cost_i$. It explains how protected firms change their leverage relative to the unprotected firms after TC Heartland, depending on their likelihood of financial distress before the change. While the coefficient on $\beta \times Treat_s \times After_t$ measures how low cost firms behave and its estimate can also be found in Table IV and V, the triple-difference estimator now provides a formal test of the heterogeneity between the high and low cost firms. The estimated coefficient on $\beta \times Treat_s \times After_t \times High\ cost_i$ are positive for all six measures.

Column 1 to 3 focus on the probability of distress whereas column 4 through 6 focus on conditional distress cost. In the two-year window after TC Heartland, treated high-tech firms with lower Z score ex-ante, higher O score, and smaller total assets increase debt more by 9.3%, 6.7%, and 9.1% of total assets, respectively, compared to firms not affected by TC Heartland. This is captured by the triple difference coefficient estimates on $Treat \times After \times High\ cost$ in the first three columns. Similarly, treated firms with high product uniqueness increase market leverage more. And lastly, firms with high Tobin's see their market leverage ratio increase more by 8.3% post TC Heartland compared with control firms.

Table VII presents results from estimating Equation (3) with market leverage as the dependent variable. The triple difference estimator for all six measures are positive, whereas the coefficient estimates on $Treat \times After$, which captures the effect among low distress cost firms, are close to zero. This indicate that the unconditional results that protected firms increase leverage post TC Heartland relative to unprotected firms are driven by the firms' expected cost of financial distress ex-ante. The results presented in VI and VII show that both the probability of distress and the conditional cost of distress have a significant impact on how firms respond to the increase in NPE litigation protection following TC Heartland. The results hold up for both book leverage and market leverage, and establish that the expected cost of distress is an important friction providing an economic channel for the leverage increase post TC Heartland.

Empirically, it is often difficult to find measures of particular attributes that are completely unrelated to other attributes of interest. This suggests that caution should be exercised in interpreting my findings in this section. One possible alternative explanation for the results from conditioning on uniqueness is that firms with higher product uniqueness are more willing to increase innovation activity after their exposure to patent lawsuits are reduced. And their subsequent increase in debt comes from adjustments in financing policy following changed innovation and investment policy. The argument against this scenario is that firms are sued by producing products and not by inventing products. In other words, a firm's patent portfolio does not affect its exposure to patent trolling: the similarity between its product and the patent troll's patent portfolio does. Second, in addition to measuring the loss of going concern value in the event of distress, Tobin's Q also measures investment opportunities. The latter use is perhaps even more common in the literature. The confounding factor is that investment opportunities may also be related to financing decisions. In untabulated analysis, I investigate the change in the level of investment and R&D and find no difference post TC Heartland between treated and control firms as well as between high and low Q firms. It is not clear whether the effect of litigation exposure on innovation and investment is of first-order. NPEs sue another firm by claiming that one of its products infringes on their patent. Ultimately, NPEs sue firms for producing a product instead of for inventing a product. In addition, because the firms' ability to raise debt could affect their innovative investment, one implication of my findings is that some of the results in the literature on NPE litigation risk and firm investment decision could be related to the effects of NPE litigation on firms' financing decision. To sum up, the inherent imperfection in empirical measures is the precise the reason why I employ different proxies to measure the cost of distress. These measure produce consistent results which lend support to the distress cost channel in favor of the alternative explanations.

Because suing a firm close to bankruptcy may produce lower payoff for a patent troll, I expect that the same anti-troll protection is less relevant for firms with low Altman's Z score. However, the group with low Z score in fact exhibit stronger treatment effect, meaning that the coefficient on the triple difference represents an underestimate. Another concern for the interpretation of the results from conditioning on size is that small firms are more likely to become a target of patent litigation, therefore the protection is more relevant for them. Indeed, patent trolls are more likely to target firms that have reduced ability to defend themselves. And small firms usually lack the legal resources that large firms have. However, Cohen et al. (2019) find that the probability of being sued by NPE is increasing in firm total assets. The empirical results do not support the alternative explanation.

Overall, the findings in this section lend support to the hypothesis that the expected cost financial distress is an important economic channel for the leverage increase in protected firms after TC Heartland.

C. *The impact of tax benefit of increasing debt*

After investigating the impact of distress cost on firms' leverage responses to TC Heartland, I now focus on the other side of the classic trade-off: the tax benefit of debt.

After TC Heartland, firms incorporated in anti-troll state have lower exposure to patent trolls, this decrease in negative future shock leads to a decrease in likelihood of distress. As a result, their marginal benefit of debt now exceeds the marginal cost of debt. If firms indeed increase leverage to take advantage of the tax benefit of debt, we should observe stronger treatment effect for firms with higher tax benefit of increasing their debt.

As discussed before, the first measure of benefit of debt is non-debt tax shield. It is a substitute for debt financing. As a result, firms with large non-debt tax shields relative to their income have lower benefit of debt and vice versa. I first use the difference between the accrual tax expense and cash tax paid (Blouin et al., 2010). This is an aggregate measure for how much firms can reduce tax payment without debt tax shields. Note that I do not scale the measure by statutory tax rate as in Blouin et al. (2010) because I do not need to to compare across time. For all conditioning measure I use the values in 2016 to rank firms, and the ranking of firms in 2016 is not affected by scaling. I also use the following definition for non-debt tax shield in Titman and Wessels (1988):

$$NDTS\ TW = OI - i - \frac{T}{t}$$

where OI is operating income, i is interest payments, T is tax paid, and t is tax rate. The equation follows from:

$$T = t \times (OI - i - NDTS\ TW)$$

From the second equality we can see that $NDTS\ TW$ measures the current non-debt tax deductions. I scale it with total assets to make it comparable across firms. For the third measure I use simulated marginal tax rate from John Graham's website (https://faculty.fuqua.duke.edu/ jgraham/taxform.html). All else equal, firms with higher marginal tax rate should have stronger incentives to deduct taxable income with interest payment.

As before I first estimate Specification (2) separately for firms with different tax benefit of increasing debt, and then move on to formally test the heterogeneity in treatment effect by estimating Equation (4).

Table VIII presents results of the difference-in-difference estimation separately for firms with different tax benefit of increasing debt. As shown in the first four columns, protected firms with lower non-debt tax shield increase leverage eight to nine percent more after TC Heartland compared with control firms with low non-debt tax shield. These increase are significant at the 5% level and the economic magnitude are similar using the two different measures of non-debt tax shield. On the other hand, the group of firms with high non-debt tax shield and thus low incentive to use debt exhibit much lower increase in book leverage. The impact on market leverage is similar. When the firms are split by marginal tax rate, treated firms with high tax rate do not appear to increase leverage more than the treated firms with low tax rate. One potential explanation is that the marginal tax rate is correlated with firm size. This fact has long been established in the accounting literature (e.g. Zimmerman (1983)), and potentially has a confounding effect of the triple difference estimation. As shown in the previous section, size is one of the strongest predictor for treated firms' leverage response to TC Heartland. In addition, small firms are driving the results. The economic hypothesis tells us that protected firms with high tax rates should drive the leverage increase. However, firms with high tax rates are large firms. Holding size constant, tax rates should have an impact on the treatment effect. To show this, I first run the same difference-in-difference estimation controlling for firm size, and then split the sample by size and investigate the impact of tax rate on firms' leverage responses. I find that firms with high tax rate increase leverage more after controlling for size. In addition, in the small firm sample, treated firms with high tax rate increase leverage significantly more than the treated firms with low tax rate. In the large firm sample, neither firms with high nor low tax rate show significant increase in their leverage post TC Heartland. In untabulated analysis, I find that in the sample of firms with low Z score and therefore high distress probability, treated firms with high tax rate increase leverage significantly more. This is consistent with the view in MacKie-Mason (1990) that tax effects are important primarily for firms approaching a state of financial distress.

In Table IX, the coefficient of interest is the triple-difference estimator on the interaction term $\beta \times Treat_s \times After_t \times High\ cost_i$, which explains the impact of tax benefit on protected firms' leverage response after TC Heartland. Firms are categorized as having high benefit of debt if they are below the median non-debt tax shields and if they are above median marginal tax rate in 2016. Treated firms with low non-debt tax shields and thus high benefit of increasing debt increase book leverage by six to seven percent more compared with treated firms with high non-debt tax shields, as evident by the triple difference estimate in the first two columns. Marginal tax rate do not appear to have a significant impact on how firms respond to TC Heartland because of the confounding effect of firm size. Similarly, the results for market leverage changes are reported in Table X.

Overall, the results presented in this section provide evidence that protected firms with higher tax benefit of debt increase leverage more compared with protected firms with lower benefit. This is consistent with the economic hypothesis that the tax benefit of increasing debt have an important impact on how firms' leverage respond to the decrease in exposure to patent trolls.

D. Intensity of treatment

To rule out alternative explanations that may confound the interpretation of the triple-difference results, I investigate whether (a) the treatment intensity among the high and low distress cost firms are the same, (b) whether NPE litigation affects the distress probability of financially healthy firms ex-post.

At this point I introduce the Unified Patents' data describe in the data section (Section V.A). The data contains 8,095 patent infringement lawsuits filed by NPE in district court during my event window. I was able to hand-match 719 cases to firms in my high-tech sample.

Figure 6 shows how often sample high-tech firms are sued by patent trolls. In the graph on the left, the diamond markers show the average number of times high-tech firms are sued by patent trolls per quarter for each size decile. It appears in the graph that larger firms are getting sued by patent trolls more often than small firms. In fact, they are getting sued exponentially more often. However, as we go from left to right on the size decile scale, firm size also grows exponentially. As a result, the average number of cases per unit of asset is similar across big and small firms. The skewed number of times sued in the tenth decile is driven by a few largest technology companies. For example, Microsoft was sued 11 times in the second quarter of 2016 by patent trolls. The graph on the right shows the fraction of firms in each decile that have been sued by an NPE at least once during the sample period. Notably, the lower bounds of the 95% confidence intervals are larger than zero for all ten deciles. All deciles have a non-zero expectation of times getting sued per quarter. One the one hand, larger firms have legal resources to defend lawsuits from NPE. On the other hand, larger firms settle low quality patent lawsuit more often because of their higher opportunity cost. Therefore, patent trolls are likely not targeting firms with specific size.

If patent trolls only target firms close to bankruptcy (i.e. firms with lower Z score), then the difference in the treatment effect between high and low Z firms may be attributed to difference in treatment intensity between the two groups. In Figure 7, the graph on the left shows the quarterly average number of times sample high-tech firms are sued by NPE by Z score decile. The figure on the right shows the fraction of firms in each decile that have been sued by an NPE at least once during the sample period. The figure shows that firms with Z scores in the middle are getting sued by patent trolls more often. Firms in the first and the tenth Z score decile have the lowest average number of NPE litigation filed against them. A comforting observation from Figure 7 is that the graph is close to symmetric at the median Z score, justifying the sample split at the median Z in the previous sections.

Figure 8 shows decrease in quarterly average number of times sample firms are sued by NPE before and after TC Heartland, again separately for each Z score decile. The blue diamond markers show the quarterly average number of cases during the 8 quarters before TC Heartland. The red square markers show the quarterly average number of cases during the 8 quarters after TC Heartland. The figure shows that the decline in NPE litigation among firms with different bankruptcy probabilities are almost symmetric at the median Z score. This suggests that the treatment intensity is similar among firms with high and low Z scores when I separate the firms into two bins by the median Z.

Table XI further shows that difference-in-difference estimate of the decline in number of times sued by an NPE for Low Z score and high Z score firms. The two group of firms experience the same amount of decline in the number of times sued by an NPE after TC Heartland. The table agrees well with Figure 8 and further supports that the treatment intensity is similar between low Z and high Z firms.

Table XII shows the effect of NPE lawsuits on Z score and O score for treated high-tech firms. I find no evidence that lawsuits from patent trolls affect the bankruptcy probability of financially healthy firms. The coefficients on the post lawsuit variable is not statistically significant in all but one regression. In column 5 of Table XII, the estimated post NPE lawsuits change in O score is 0.05, significant at the 10% level. The results suggest that financially healthy firms are not affected by the financial distress channel.

A caveat in interpreting the results in this section is that the total impact of NPE litigation protection is decided by not only the frequency of getting sued by patent trolls, but also the outcome of the case and the length of times it takes to resolve a case. Therefore, instead of measuring the direct impact of TC Heartland on different firms, this section aims to provide descriptive evidence to shed light on NPEs' target selection.

Overall, the results in this sections show that (a) the treatment intensity among the high and low distress cost firms are similar, (b) that NPE litigation does not affect the distress probability of financially healthy firms ex-post.

E. Investment trends for firms with different distress cost

In the previous two sections, I employ triple-difference estimation which reveals how much larger the TC Heartland effect is for the high cost and high benefit group. To further understand the distress cost channel and the alternative channel that may confound the interpretation of my results, I investigate investment trends for firms with different distress cost.

Because larger firms and financially healthier firms are less affected by the financial distress channel, the triple difference estimator conditioning on high distress cost identify the treatment effect from the financial distress channel. The identifying assumption is that the investment trends are similar among firms with different distress cost, so that the "third difference" between high and low distress cost firms differences away the investment channel. An alternative explanation challenging this assumption is that firms closer to distress are financially constrained so that they find investment more attractive after TC Heartland.

Table XIII investigate the investment trends for firms with different distress cost. The treatment effect of TC Heartland on investment is not statistically different from zero for *both* the high and low distress cost firms. The findings here are in stark contrast with that presented in Table IV, where the same trend analysis shows stronger increases in book and market leverage among firms with higher distress cost. The results presented in Table XIII lend support to the assumption that investment is similar among firms with different distress cost and are inconsistent with the investment channel.

F. Decomposing deliberate leverage effect of net debt and equity issuance

Leverage changes could reflect the combined effects of factors not directly under managers' control. To further understand the increase in firm leverage after TC Heartland, I focus on the net leverage effect of debt and equity issues and retirements. Following Berger, Ofek, and Yermack (1997); Garvey and Hanka (1999) I measure firm's deliberate leverage changes through net debt and equity financings with:

$$\Delta Leverage = \frac{D + \Delta D}{A + \Delta D + \Delta E} - \frac{D}{A} \tag{5}$$

where D and A are lagged total debt and total assets. A' equals the current period total assets. ΔD equals the change in total debt. It represents a composite effect of debt issuance and retirement decisions and measures the amount of funds firms actively raise through debt. ΔE equals the change in stockholder's equity minus cash dividend. It represents a composite effect of equity issuance, repurchases, and dividend decisions.

Note that net debt financing increases the firm's fixed obligations as well as its assets (except when the proceeds are used to pay dividend. I consider dividend in net equity financing). In other words, the net proceeds from debt financing activities increase both the numerator and the denominator of the new leverage ratio, whereas the net proceeds from equity financing activities only increase the denominator of the the new leverage ratio. This measure of leverage change helps capturing this asymmetrical effect of debt and equity financing on leverage ratio.

The deliberate effect of leverage change can be decomposed into debt effect and equity effect as follows:

$$\begin{aligned} \Delta Leverage = \frac{D + \Delta D}{A + \Delta D + \Delta E} - \frac{D}{A} &= \frac{\Delta D}{A'} \times \left(1 - \frac{D}{A}\right) + \left(-\frac{\Delta E}{A'} \times \frac{D}{A}\right) \\ &= Debt\ effect + Equity\ effect \end{aligned} \tag{6}$$

The equity effect on leverage will be negative for a net issue of equity and positive for a net repurchase of equity. For equal-size debt and equity issues, the debt effect on leverage is typically larger than the equity effect since the debt ratio is usually less than 0.5.

Next, I estimate the main specification in Equation (2) using components from the above decomposing equation as dependent variable to understand whether the increase in leverage for protected firms after TC Heartland is a result of an active change through debt and equity financing activities. Specifically, I estimate the following regression:

$$Leverage\ effect_{ist} = \delta \times Treat_s \times After_t + \lambda_t + \alpha_i + \varepsilon_{ist} \tag{7}$$

where, as before, i indexes firms, s indexes states of incorporation, and t indexes time. $Treat$ is an indicator for being incorporated in the states with anti-troll laws in place at the time of the Supreme Court decision. $After$ is an indicator for being after the decision date. *Leverage effect* are components in Equation (6): deliberate leverage change, $\Delta Leverage = (\Delta D/A') \times (1 - D/A) - (\Delta E/A') \times (D/A)$, net debt issuance (retirement) over assets, $\Delta D/A'$, and net equity issuance (repurchase) over total assets $\Delta E/A'$. D and A are lagged total debt and total assets (Compustat items *dlttq* + *dlcq* and *atq*). A' equals the current period total assets. ΔD equals the change in total debt. ΔE equals the change in stockholder's equity (Compustat item *seqq*), which excludes accumulated retained earnings, minus cash dividend.

Following Fama and French (2005); Covas and Den Haan (2011), I measure the total net amount of equity raised with the change in the book value of equity. As pointed out by Covas and Den Haan (2011), it is important to use the book value to study the deliberate leverage changes, because I am interested in measuring how much funds firms raise, not in changes in the valuation of existing equity. Compustat records retained earnings and stockholder's equity in separate accounts, so that book value of equity excludes accumulated retained earnings.

To understand changes in asset resulting form financing activities and changes in investment and innovation, I also include as dependent variables financing deficit, capital expenditure, and research and development expense. Following Fama and French (2005), I measure financing deficit as change in assets minus the change in retained earnings. It is equal to the increase in assets that does not come from growth in retained earnings. In other words, it measures the increase in assets from financing activities including both equity and debt financing. Additionally, because book assets equal the sum of book debt and book equity, I trim the ratios $\Delta Leverage$, at -1 and 1 to mitigate the effect of outliers. Without trimming, the results do not change qualitatively, but the coefficient estimates are unusually large because of a few ratios that are significantly larger than one and a few are significantly smaller than negative one.

The results from estimating Equation (7) are presented in table XIV. The coefficient on $Treat \times After$ shows the post-TC Heartland change for protected firms in the corresponding dependent variable. The change in leverage is 3.5%, implying an abnormal post-TC Heartland leverage increase of three percent per quarter for protected firms. These leverage increase would accumulate to a magnitude larger than the level estimates found in Table II. The change in leverage measured here is different from period to period change in the level of leverage. Instead, $\Delta Leverage$ measures the change in leverage stemming from debt and equity issues and retirements. Overall, the magnitude agrees well with the leverage increase documented in Section VI.A. The next two columns show the post-TC Heartland change in net debt issuance (retirement) and net equity issuance (repurchase). The estimated changes in protected firms are 3% for $\Delta D/A'$ and -1.3% for $\Delta E/A'$. The estimated increase in net debt issuance is significant at the 10% level. As mentioned before, the debt effect on leverage is typically larger than the equity effect for equal-size debt and equity issues, because the debt ratio is usually less than 0.5. The sample average book leverage is 27%, further magnifying the difference between the size of debt effect and equity effect. This result suggest that the increase in leverage for protected firms are driven by net debt issuance. Positive $\Delta D/A'$ means net debt issuance whereas negative $\Delta E/A'$ means net equity payout. Both debt issuance and equity payout increase leverage. Although the separate estimates for the two actions show relatively low statistical power, the combined effect of them have a statistically significant effect on leverage. The estimated $\Delta Leverage$ is not equal to the exact weighted average of $\Delta D/A'$ and $\Delta E/A'$ because of trimming.

Financing deficit can be seen as net inflow from all financing activities. The coefficient estimate in column 4 shows that treated firms have 3.7% higher financing deficit than control firms after TC Heartland, meaning that protected firms are raising more fund from debt and equity financing combined. The next two columns show the estimated treatment effect on capital expenditures and R&D expenses. Protected firms show a relative 0.2% increase capital expenditures (significant at 5% level) and no statistical significant increase in R&D expenses. Notably, the increase in investment observed in the protected firms accounts for less than ten percent of the increase in financing deficit. This finding is inconsistent with the alternative view that protected firms find investment more attractive after their exposure to patent trolls decrease, and thus issue debt to fund their new investment. Instead, the results suggest that protected firms raise significantly more fund from financing activities than they spend on new investment. This result agrees well with the difference-in-difference estimators in Panel B, Table I. Treated High-tech exhibit 6% more increase in debt to asset ratio and only 1% more increase in PP&E to asset ratio. Therefore, the increase in leverage post TC Heartland observed in protected firms can not be driven by increase in investment.

Overall, the evidence supports the view that (a) protected firms deliberately increase firm leverage after TC Heartland through the combined effects of net debt issuances and net equity payouts, (b) that the higher net inflow from financing activities in protected firms post TC Heartland is not driven by increase in investment in these firms, which is only a fraction of the positive financing deficit.

G. Heterogeneity in treatment effects by patent portfolio and pledging history

In order to understand the implications of firms' patenting as well as patent pledging history in my setting, I introduce the patent and patent collateral data described in the data section (Section V.A). I combine my main dataset from Compustat with patent application, assignment, and pledging data. I find that 202 of the 912 firms in my high-tech sample has pledged patent as collateral before the beginning of my event window, and that 373 of the 912 firms have produced at least one patent in the twenty years leading up to the beginning of my event window.

One alternative mechanism for the leverage increase in protected firms is the patent collateral channel. After TC Heartland, treated firms may experience an increase in the collateral value of their patents. If this is the underlying mechanism, the treatment effect are expected to be stronger for firms with more patent and for firms that pledged patents as collateral.

Table XV presents the heterogeneity in treatment effects by patent count and patent pledging history. In the first two columns, the sample firms are split by the total number of patents produced in twenty years as of the beginning of the event window. In the last two columns, the sample firms are split by whether they have been observed to pledge patents as collateral before the the beginning of the event window. Contrary to what the patent collateral channel predicts, firms with at least one patent and firms that has been observed to pledge patent to raise debt are exhibiting weaker effects. Due to the lack of legal resources, small firms are in a weaker position than larger firms to enforce and protect their intellectual property. It is common for smaller firms to have no patents. Section VI.B demonstrated that the effects of the natural experiment is the strongest among small firms. The results in this section and in Section VI.B together suggest that the treatment effect comes from smaller firms closer to bankruptcy, not bigger firms with a large patent portfolio and have pledged patent as collateral to raise debt.

H. Effects of TC Heartland versus effects of the initial enactment of the anti-troll laws

Not all firms can be sued out of state for patent infringement. The initial enactment of the anti-troll laws likely increased protection for those firms and TC Heartland likely increased protection for firms doing business all over the country. Hence, the initial enactment of the anti-troll laws should be expected to have effects in the same direction as the effect of TC Heartland. To compare the effects of TC Heartland to the effects of the initial enactment of the anti-troll laws, I estimate the following specifications:

$$Leverage_{ist} = \delta \times Antitroll_s \times After\,enactment_{st} + \lambda_t + \alpha_i + \varepsilon_{ist} \tag{8}$$

$$Leverage_{ist} = \delta \times Treat_s \times After\,TC\,Heartland_t + \lambda_t + \alpha_i + \varepsilon_{ist} \tag{9}$$

where i indexes firms, s indexes states of incorporation, and t indexes time. *Antitroll* is an indicator set equal to one if the firm is either incorporated or headquartered in a state with anti-troll laws already signed into law (Appel et al., 2019). *After Enactment* is and indicator for being after the enactment of the state anti-troll legislation. Note that it is subscripted with both state and time. $Treat$ is the same as defined in Table II. *After TC Heartland* is the same as $After$ in Table II. Specification (8) and (9) extend the main sample period to 8 quarters before the earliest enactment of state anti-troll law (Vermont May 2013). Because year-quarter fixed effect is included and the effect of anti-troll law are identified using variation within year-quarter, the sample period choice does not affect the results.

The results in Table XVI indicate that the effect of TC Heartland on leverage is stronger than the effect of the enactment of the anti-troll laws. The estimates with firm fixed effect and time fixed effect are precise and the point estimate is close to zero. This shows that firms did not respond to the initial enactment of the anti-troll laws as they did to the U.S. Supreme Court decision limiting the patent litigation venue to defendant's home state. The results are consistent with the argument that the patent troll's ability to choose venue before TC Heartland render anti-troll laws less effective than intended.

I. Treatment effect using propensity score matched samples

To address the concern that firms incorporated in treated and untreated states might have different characteristics, I next examine the robustness of the leverage increasing effect after controlling for differences in firm characteristics. I create two matched samples using propensity score matching. I start by keeping all observations in the first quarter of 2017, $t-1$ relative to the U.S. Supreme Court's decision in TC Heartland. I then estimate the propensity scores for being treated for each firm using a logit model and controls including the log of assets, profitability, fixed assets, cash, and whether a firm is a dividend payer. I match each treated firm in $t-1$ to one control firm with the closest propensity score with replacement. After identifying the matched sample, I retrieve all 16 quarters around TC Heartland for the treated and matched firms and perform the same analysis as in the previous section. The first matched sample uses all the treated and control firms. The second matched sample uses only treated high-tech firms and are only matched with high-tech control firms. The treated and matched firms have similar total assets, profitability, fixed assets, cash, and dividend history. The full sample consists of 524 treated and 524 control firms for a total of 15,193 observations. The high-tech sample include 85 treated and 85 control firms for a total of 2,488 observations.

Table XVII and XVIII present the treatment effects in the matched samples. The results show that economically and statistically significant relative increase in both book leverage and market leverage after TC Heartland among protected firms. Notably, the increases are larger in magnitude compared with estimates in Table II and III. The estimated results from the main specification in Equation (2) should not differ munch because the firm fixed effects will absorb the time-invariant portion of the differences in firm characteristics.

Overall, the results show that the leverage increase in protected firms post TC Heartland is robust to controlling for observable firm characteristics.

VII. Conclusions

My findings demonstrate that the exposure to patent litigation from patent trolls have a causal effect on firm capital structure decisions. Heterogeneity in the causal effect by distance to financial distress, size, and conditional cost of financial distress support the prediction that lower exposure to NPE litigation leads to higher optimal debt ratios by decreasing a firm's cost of financial distress. Because the firms' ability to raise debt could affect their innovative investment, one implication of my findings to the growing literature on the economic consequences of NPEs is that some of the results in this literature could be related to the effects of NPEs litigation on firms' financing decision. My results also suggest that litigation risk is an important factor contributing to innovative firms' reluctance to use debt.

REFERENCES

Altman, Edward I, 1968, Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, *The journal of finance* 23, 589–609.

Appel, Ian, Joan Farre-Mensa, and Elena Simintzi, 2019, Patent trolls and startup employment, *Journal of Financial Economics* .

Berger, Philip G, Eli Ofek, and David L Yermack, 1997, Managerial entrenchment and capital structure decisions, *The journal of finance* 52, 1411–1438.

Bessen, James, Jennifer Ford, and Michael J Meurer, 2011, The private and social costs of patent trolls, *Regulation* 34, 26.

Bessen, James, and Michael J Meurer, 2013, The patent litigation explosion, *Loy. U. Chi. LJ* 45, 401.

Bessen, James E, and Michael J Meurer, 2012, The direct costs from npe disputes .

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

Bhagat, Sanjai, James A Brickley, and Jeffrey L Coles, 1994, The costs of inefficient bargaining and financial distress: Evidence from corporate lawsuits, *Journal of Financial Economics* 35, 221–247.

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

Blanchard, Olivier Jean, Florencio Lopez-de Silanes, and Andrei Shleifer, 1994, What do firms do with cash windfalls?, *Journal of financial economics* 36, 337–360.

Blouin, Jennifer, John E Core, and Wayne Guay, 2010, Have the tax benefits of debt been overestimated?, *Journal of Financial Economics* 98, 195–213.

Bone, Robert G, 2017, Forum shopping and patent law-a comment on tc heartland, *Tex. L. Rev.* 96, 141.

Bradley, Michael, Gregg A Jarrell, and E Han Kim, 1984, On the existence of an optimal capital structure: Theory and evidence, *The journal of Finance* 39, 857–878.

Brown, James R, Steven M Fazzari, and Bruce C Petersen, 2009, Financing innovation and growth: Cash flow, external equity, and the 1990s r&d boom, *The Journal of Finance* 64, 151–185.

Brown, James R, Gustav Martinsson, and Bruce C Petersen, 2013, Law, stock markets, and innovation, *The Journal of Finance* 68, 1517–1549.

Calomiris, Charles W, and R Glenn Hubbard, 1993, Internal finance and investment: Evidence from the undistributed profits tax of 1936-1937, Technical report, National Bureau of Economic Research.

Campbell, John Y, Jens Hilscher, and Jan Szilagyi, 2008, In search of distress risk, *The Journal of Finance* 63, 2899–2939.

Chen, Emily H, 2013, Making abusers pay: Deterring patent litigation by shifting attorneys' fees, *Berkeley Technology Law Journal* 28, 351–381.

Chien, Colleen, and Michael Risch, 2016, What would happen to patent cases if they couldn't all be filed in texas? .

Cohen, Lauren, Umit G Gurun, and Scott Duke Kominers, 2019, Patent trolls: Evidence from targeted firms, *Management Science* .

Covas, Francisco, and Wouter J Den Haan, 2011, The cyclical behavior of debt and equity finance, *American Economic Review* 101, 877–99.

Cutler, David M, James M Poterba, and Lawrence H Summers, 1988, What moves stock prices?

DeAngelo, Harry, and Ronald W Masulis, 1980, Optimal capital structure under corporate and personal taxation, *Journal of financial economics* 8, 3–29.

Dichev, Ilia D, 1998, Is the risk of bankruptcy a systematic risk?, *the Journal of Finance* 53, 1131–1147.

Eldar, Ofer, and Neel U Sukhatme, 2018, Will delaware be different: An empirical study of tc heartland and the shift to defendant choice of venue, *Cornell L. Rev.* 104, 101.

Fama, Eugene F, and Kenneth R French, 2005, Financing decisions: who issues stock?, *Journal of financial economics* 76, 549–582.

Feng, Josh, and Xavier Jaravel, 2016, Who feeds the trolls? patent trolls and the patent examination process, Technical report, Working Paper.

Frank, Murray Z, and Vidhan K Goyal, 2008, Trade-off and pecking order theories of debt, in *Handbook of empirical corporate finance*, 135–202 (Elsevier).

Garvey, Gerald T, and Gordon Hanka, 1999, Capital structure and corporate control: The effect of antitakeover statutes on firm leverage, *The Journal of Finance* 54, 519–546.

Giroud, Xavier, Holger M Mueller, Alex Stomper, and Arne Westerkamp, 2012, Snow and leverage, *The Review of Financial Studies* 25, 680–710.

Givoly, Dan, Carla Hayn, Aharon R Ofer, and Oded Sarig, 1992, Taxes and capital structure: Evidence from firms' response to the tax reform act of 1986, *The Review of Financial Studies* 5, 331–355.

Graham, John, and Campbell Harvey, 2002, How do cfos make capital budgeting and capital structure decisions?, *Journal of applied corporate finance* 15, 8–23.

Graham, John R, 1996a, Debt and the marginal tax rate, *Journal of financial Economics* 41, 41–73.

Graham, John R, 1996b, Proxies for the corporate marginal tax rate, *Journal of Financial Economics* 42, 187–221.

Graham, John R, and Mark T Leary, 2011, A review of empirical capital structure research and directions for the future, *Annu. Rev. Financ. Econ.* 3, 309–345.

Harris, Milton, and Artur Raviv, 1991, The theory of capital structure, *the Journal of Finance* 46, 297–355.

Heider, Florian, and Alexander Ljungqvist, 2015, As certain as debt and taxes: Estimating the tax sensitivity of leverage from state tax changes, *Journal of financial economics* 118, 684–712.

Hochberg, Yael V, Carlos J Serrano, and Rosemarie H Ziedonis, 2018, Patent collateral, investor commitment, and the market for venture lending, *Journal of Financial Economics* 130, 74–94.

Hovakimian, Armen, Tim Opler, and Sheridan Titman, 2001, The debt-equity choice, *Journal of Financial and Quantitative analysis* 36, 1–24.

Hutton, Irena, David R Peterson, Aimee Hoffmann Smith, et al., 2014, The effect of securities litigation on external financing, *Journal of Corporate Finance* 27, 231–250.

Jensen, Michael C, 1986, Agency costs of free cash flow, corporate finance, and takeovers, *The American economic review* 76, 323–329.

Jiam, Hannah, 2015, Fee-shifting and octane fitness: An empirical approach toward understanding "exceptional", *Berkeley Technology Law Journal* 30, 611–674.

John, Teresa A, 1993, Accounting measures of corporate liquidity, leverage, and costs of financial distress, *Financial Management* 91–100.

Kempf, Elisabeth, and Oliver G Spalt, 2019, Litigating innovation: Evidence from securities class action lawsuits, *Available at SSRN 3143690* .

Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman, 2017, Technological innovation, resource allocation, and growth, *The Quarterly Journal of Economics* 132, 665–712.

Kraus, Alan, and Robert H Litzenberger, 1973, A state-preference model of optimal financial leverage, *The journal of finance* 28, 911–922.

Lindenberg, Eric B, and Stephen A Ross, 1981, Tobin's q ratio and industrial organization, *Journal of business* 1–32.

Love, Brian J, and James Yoon, 2017, Predictably expensive: A critical look at patent litigation in the eastern district of texas, *Stan. Tech. L. Rev.* 20, 1.

MacKie-Mason, Jeffrey K, 1990, Do taxes affect corporate financing decisions?, *The journal of finance* 45, 1471–1493.

Malm, James, and Marcin Krolikowski, 2017, Litigation risk and financial leverage, *Journal of Economics and Finance* 41, 180–194.

Mann, William, 2018, Creditor rights and innovation: Evidence from patent collateral, *Journal of Financial Economics* 130, 25–47.

Miller, Merton H, 1977, Debt and taxes, *the Journal of Finance* 32, 261–275.

Myers, Stewart C, 1977, Determinants of corporate borrowing, *Journal of financial economics* 5, 147–175.

Myers, Stewart C, 1984, The capital structure puzzle, *The journal of finance* 39, 574–592.

Myers, Stewart C, 2003, Financing of corporations, in *Handbook of the Economics of Finance*, volume 1, 215–253 (Elsevier).

Ohlson, James A, 1980, Financial ratios and the probabilistic prediction of bankruptcy, *Journal of accounting research* 109–131.

Opler, Tim, and Sheridan Titman, 1993, The determinants of leveraged buyout activity: Free cash flow vs. financial distress costs, *The Journal of Finance* 48, 1985–1999.

Rajan, Raghuram G, and Luigi Zingales, 1995, What do we know about capital structure? some evidence from international data, *The journal of Finance* 50, 1421–1460.

Serfling, Matthew, 2016, Firing costs and capital structure decisions, *The Journal of Finance* 71, 2239–2286.

Thoman, Elizabeth M, 2014, A modern adaptation of three billy goats gruff: Is vermont's bad faith assertions of patent infringement statute strong enough to help patent owner's safely cross the bridge, *U. Cin. L. Rev.* 83, 989.

Titman, Sheridan, and Roberto Wessels, 1988, The determinants of capital structure choice, *The Journal of finance* 43, 1–19.

Todd, Jonathan, 2016, Stopping the troll tax: An analysis of the patent troll issue and south carolina's bad faith assertion of patent infringement act, *SCL Rev.* 68, 761.

Weidman, John David, 2017, The future of patent troll legislation and its effects on the energy industry, *ONE J* 3, 39.

Welch, Ivo, 2004, Capital structure and stock returns, *Journal of political economy* 112, 106–131.

Yuan, Qingbo, and Yunyan Zhang, 2015, Do banks price litigation risk in debt contracting? evidence from class action lawsuits, *Journal of Business Finance & Accounting* 42, 1310–1340.

Zimmerman, Jerold L, 1983, Taxes and firm size, *Journal of accounting and economics* 5, 119–149.

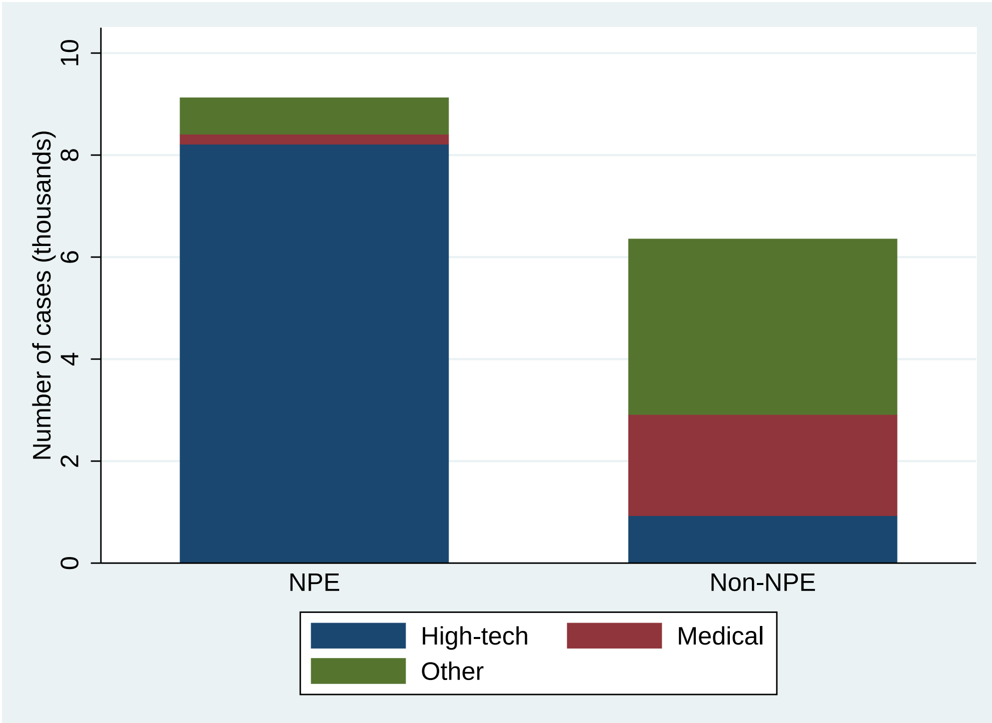
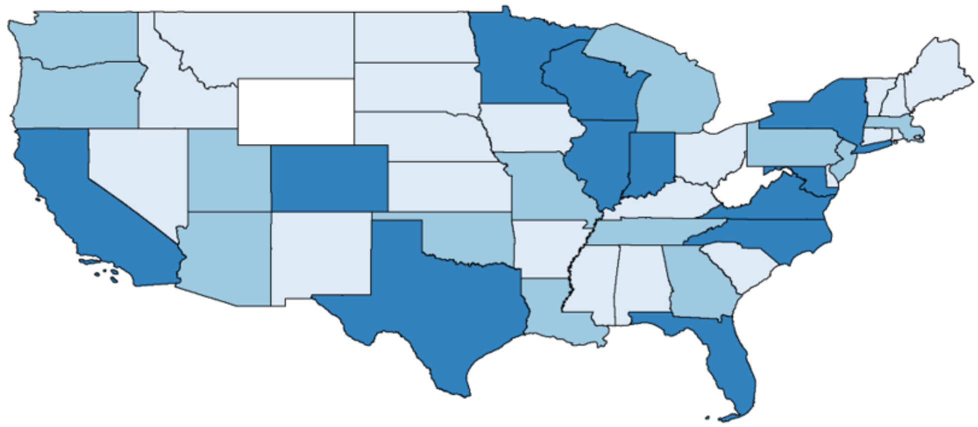


Figure 1. Patent litigation by industry and plaintiff entity type. The figure shows the number of patent infringement cases filed in district courts from July 2015 to June 2019 by industry and plaintiff entity type. High-tech industry includes software, hardware, and networking companies. I collected the patent litigation data from Unified Patents (https://portal.unifiedpatents.com/).

A. Treated firms



B. Control firms

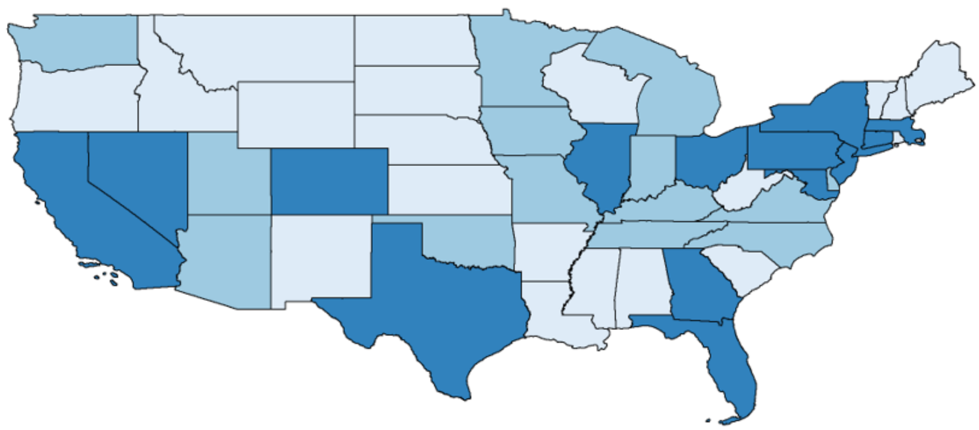


Figure 2. Geographic distribution of treated firms and control firms by headquarter state. States are shaded according to quartiles of the number of firms headquartered there. Treated firms are firms incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland.

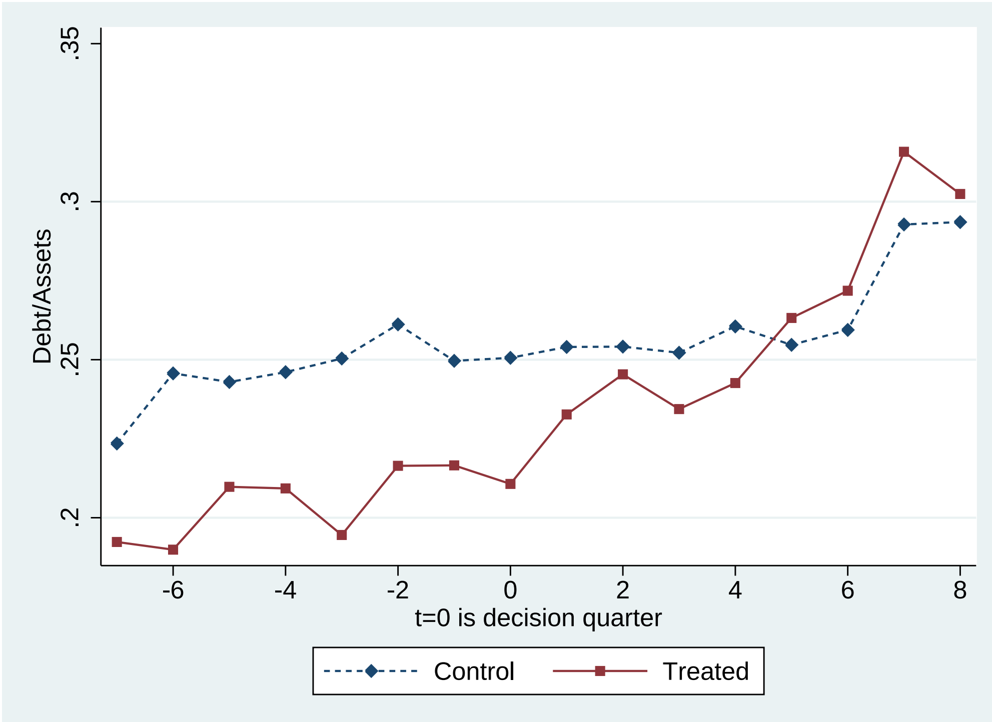


Figure 3. Average book leverage ratio of high-tech firms during the sample period before and after the U.S. Supreme Court decision in TC Heartland, i.e. from the third quarter of 2015 to the second quarter of 2019. Treated firms are firms incorporated in the states with anti-troll laws in place at the time of the decision. Outcome variables of the treated and control group are plotted as solid and dotted lines, respectively.

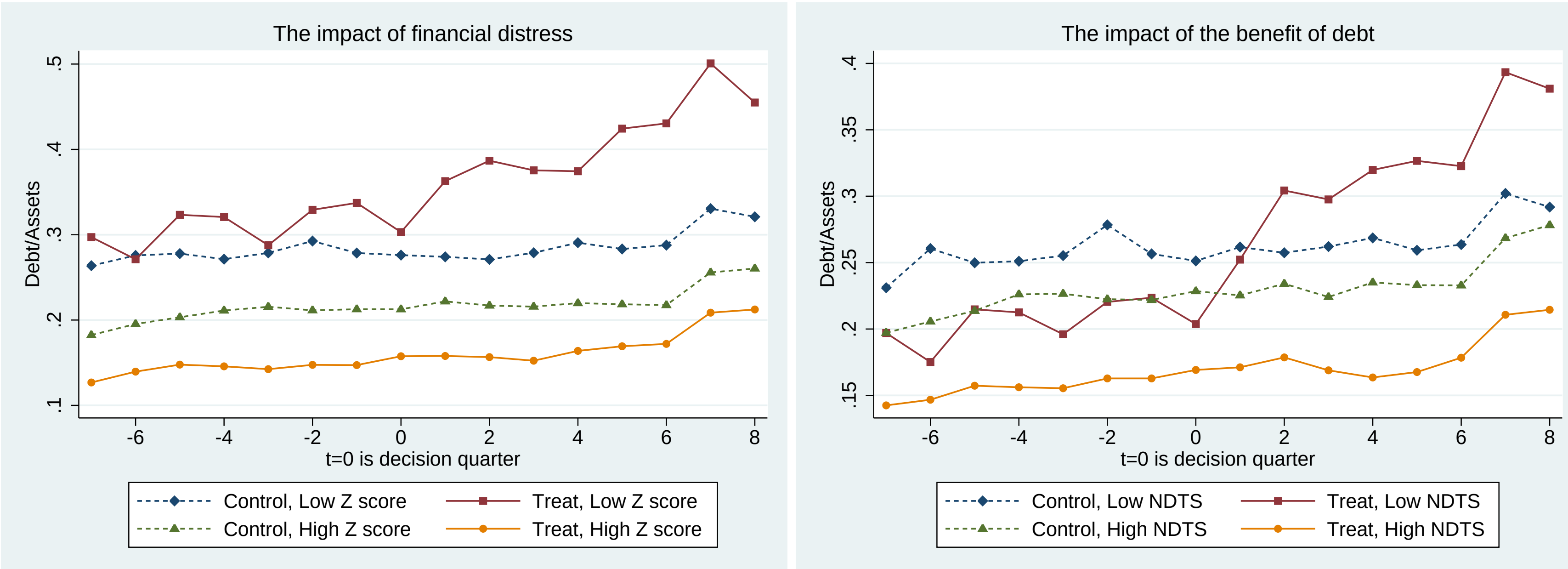


Figure 4. Average book leverage ratio of high-tech firms during the sample period separately for firms with different distress cost and tax incentive of debt. Outcome variables of the treated and control group are plotted as solid and dotted lines, respectively. Low Z score firms are firms having below median modified Altman's Z score in 2016, the year before the decision year. Low NDTS firms are firm having below median non-debt tax shield in 2016. These variables are discussed in detail in section V.B.

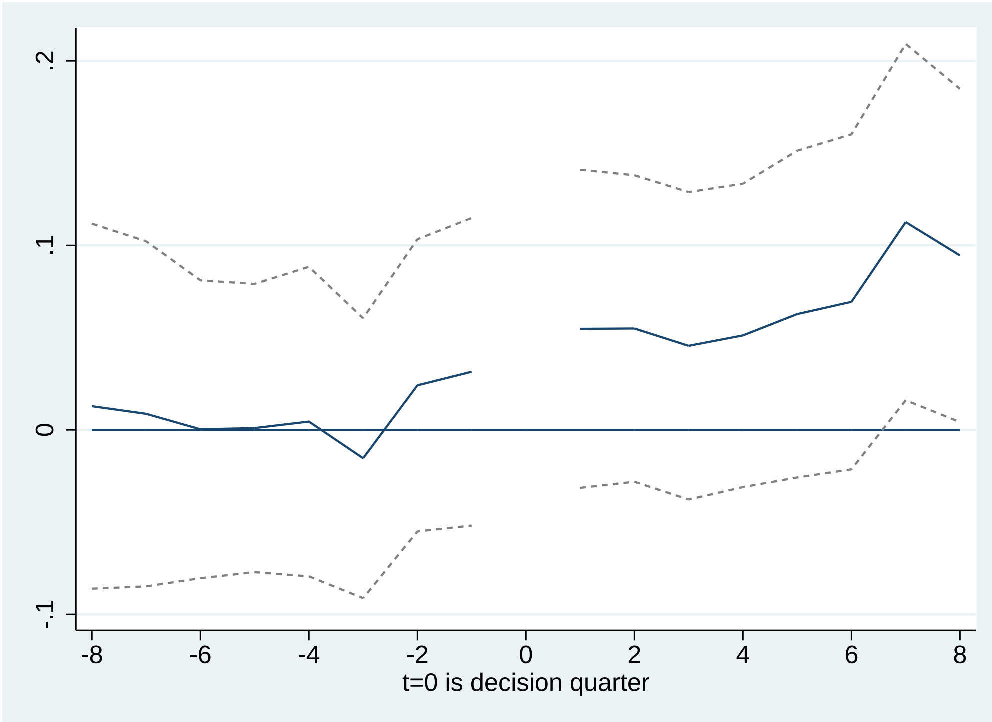


Figure 5. High-tech firms' book leverage coefficient trend in event time. The analysis is identical to specification 2 in Table II, except that the $After$ indicator is replaced with a full set of quarter dummies (t-8, t-7, . . . , t+8). The figure shows the regression coefficients on the interactions between treatment status and quarter dummies. The base quarter is the one before the 16-quarter event window. The dashed lines show 95% confidence intervals where standard errors are clustered by state of incorporation.

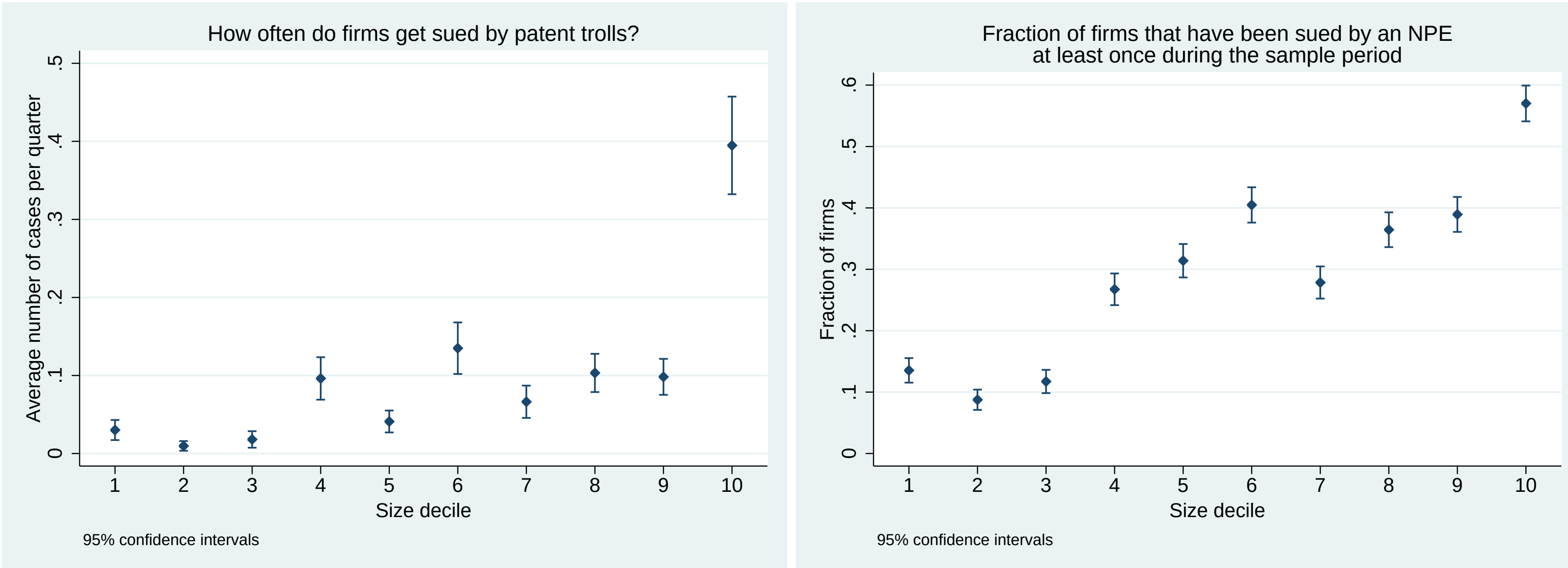


Figure 6. The figure on the left shows the quarterly average number of times sample high-tech firms are sued by patent trolls, for each size decile. The figure on the right shows the fraction of firms in each decile that have been sued by an NPE at least once during the sample period. The size ranking is based on sample firms' total assets in 2016, the year before TC Heartland. For firms in each decile, I average the number of times they are sued by patent trolls over the 16 quarters during my sample period. The figure also shows the 95% confidence interval around the estimated average number of cases.

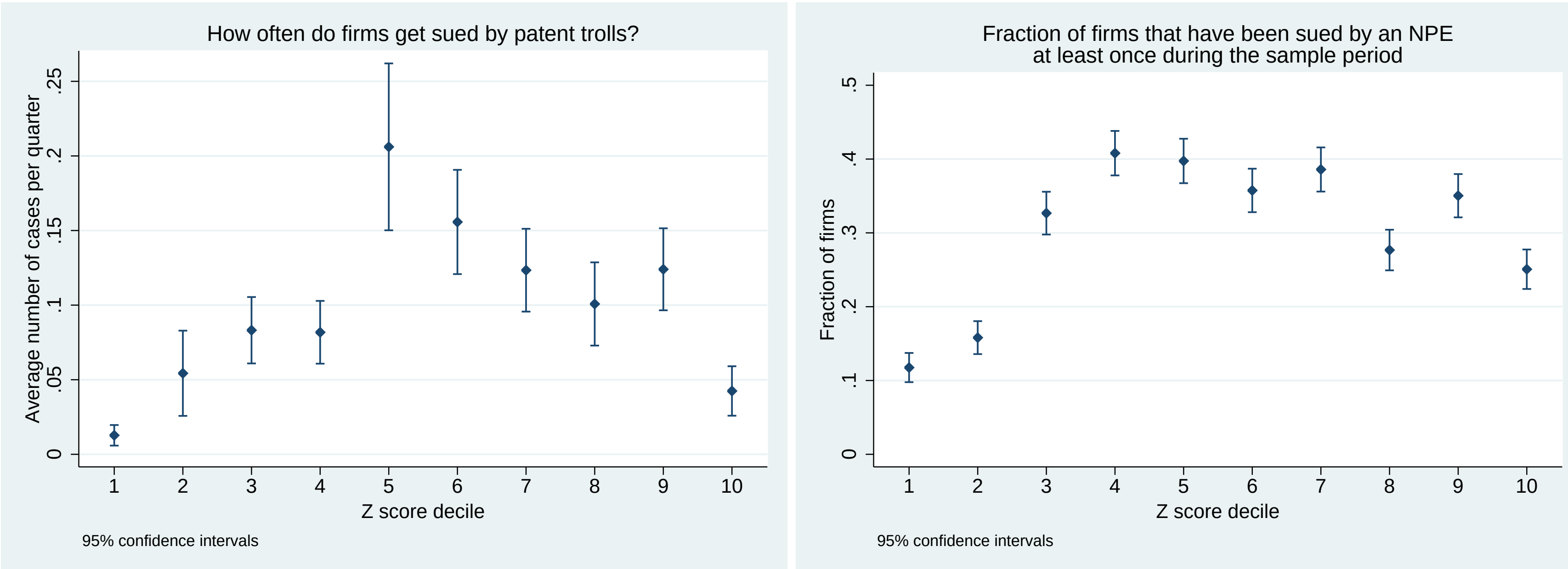


Figure 7. The figure on the left shows the average number of times sample high-tech firms are sued by patent trolls per quarter, for each Z score decile. The figure on the right shows the fraction of firms in each decile that have been sued by an NPE at least once during the sample period. The Z score ranking is based on sample firms' Z scores in 2016, the year before TC Heartland. For firms in each decile, I average the quarterly number of times they are sued by patent trolls over the 16 quarters during my sample period. The figure also shows the 95% confidence interval around the estimated average number of cases.

Figure 8. Decrease in average number of times sued by NPE per quarter by Z score decile. The blue diamond markers show the average number of times high-tech firms are sued by patent trolls per quarter before TC Heartland. The red square markers show the average number of times sued per quarter after TC Heartland. The Z score ranking is based on sample firms' Z scores in 2016, the year before TC Heartland. For firms in each decile, I average the quarterly number of times they are sued by patent trolls before and after TC Heartland. The figure also shows the 95% confidence interval around the estimated average number of cases.

Table I

Summary statistics for treated and control companies. Panel A presents the summary statistics for the full sample. Panel B presents the summary statistics for the high-tech sample. I use SIC codes 73 and 35 to identify high-tech firms (see Bessen and Meurer, 2013; Cohen et al., 2019). The top halves of the panels show the summary statistics during 8 quarters before TC Heartland. The bottom halves of the panels show the summary statistics during 8 quarters after TC Heartland. Column 1 shows the sample means of untreated firms. Column 2 shows the sample means for treated firms. Column 3 shows the differences between the two sample means. Column 4 shows the t tests of the differences calculated using standard errors clustered by the state of incorporation. Column 5 shows the difference-in-difference estimators. Column 6 shows the t statistics of the difference-in-difference estimators calculated using robust standard errors clustered by the state of incorporation.

Panel A: Full sample		(1) Control	(2) Treated	(3) Difference	(4) t statistics	(5) DiD	(6) t statistics
Before	Total assets	4083.59	3315.55	-768.04	-0.84		
	Ln(Assets)	5.17	5.10	-0.07	-0.08		
	R&D	21.52	14.2	-7.31	-0.98		
	R&D / Total assets	0.04	0.02	-0.02***	-3.56		
	PP&E / Total assets	0.21	0.25	0.04**	2.37		
	Debts / Total assets	0.30	0.28	-0.02	-0.82		
	Market leverage	0.24	0.22	-0.02	-1.57		
After	Total assets	4774.11	4002.53	-771.58	-0.77	-3.54	-0.02
	Ln(Assets)	5.47	5.38	-0.08	-0.12	-0.02	-0.12
	R&D	28.28	18.52	-9.76	-0.98	-2.44	-0.91
	R&D / Total assets	0.04	0.02	-0.02***	-4.20	-0.00	-1.50
	PP&E / Total assets	0.21	0.26	0.05***	2.84	0.01**	2.46
	Debts / Total assets	0.29	0.29	-0.00	-0.12	0.02***	3.02
	Market leverage	0.23	0.22	-0.01	-0.84	0.01*	1.76
	Number of firms	4102	605				

(continued)

Table I (continued)

Panel B: High-tech sample		Control	Treated	Difference	t statistics	DiD	t statistics
Before	Total assets	3201.63	3734.47	532.83	0.24		
	Ln(Assets)	5.11	4.46	-0.65	-0.63		
	R&D	34.64	41.09	6.44	0.19		
	R&D / Total assets	0.03	0.04	0.00	0.27		
	PP&E / Total assets	0.12	0.11	-0.01	-0.47		
	Debts / Total assets	0.28	0.22	-0.06	-1.42		
	Market leverage	0.20	0.14	-0.06**	-2.55		
After	Total assets	4008.25	4932.3	924.05	0.33	391.22	0.65
	Ln(Assets)	5.60	4.83	-0.77	-0.82	-0.12	-0.65
	R&D	47.06	58.44	11.37	0.23	4.93	0.33
	R&D / Total assets	0.03	0.04	0.01	0.61	0.01	0.81
	PP&E / Total assets	0.12	0.12	0.00	0.05	0.01**	2.31
	Debts / Total assets	0.27	0.28	0.00	0.09	0.06***	3.41
	Market leverage	0.19	0.17	-0.02	-0.71	0.03**	2.19
	Number of firms	809	103				

Table II

Increase in debt due to treatment, robustness to different fixed effects, and stronger effects for high-tech firms. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. Industry fixed effects are based on three-digit SIC codes. HQ fixed effects control for a company's state of headquarter (Compustat item STATE). I use SIC codes 73 and 35 to identify high-tech firms (see Bessen and Meurer, 2013; Cohen et al., 2019). When fixed effects are included, the R^2 displayed is the within R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Debt/Assets					
	All firms	High-tech firms				
	(1)	(2)	(3)	(4)	(5)	(6)
Treat	-0.0247***	-0.0569***	-0.0623**	-0.0733**		
	(-4.95)	(-4.67)	(-2.31)	(-2.06)		
After	-0.0127***	-0.00858	-0.00831	-0.00716	0.0208***	
	(-4.72)	(-1.39)	(-1.45)	(-0.86)	(3.05)	
Treat × After	0.0219***	0.0607***	0.0610***	0.0578***	0.0389**	0.0384**
	(3.02)	(3.41)	(3.11)	(3.07)	(2.31)	(2.28)
Fixed effects	None	None	Industry	HQ	Firm	Firm & Time
No. obs.	58448	11101	11101	10796	11101	11101
R^2	0.001	0.002	0.002	0.003	0.011	0.023

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table III

Increase in market leverage due to treatment, robustness to different fixed effects, and stronger effects for high-tech firms. $Treat$ is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. $After$ is an indicator for being after the decision date. Industry fixed effects are based on three-digit SIC codes. HQ fixed effects control for a company's state of headquarter (Compustat item STATE). I use SIC codes 73 and 35 to identify high-tech firms (see Bessen and Meurer, 2013; Cohen et al., 2019). When fixed effects are included, the R^2 displayed is the within R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Market leverage					
	All firms	High-tech firms				
	(1)	(2)	(3)	(4)	(5)	(6)
Treat	-0.0224***	-0.0562***	-0.0680**	-0.0913***		
	(-4.91)	(-5.57)	(-2.71)	(-3.04)		
After	-0.00808***	-0.00644	-0.00552	-0.00699	-0.0161**	
	(-3.27)	(-1.26)	(-0.98)	(-1.20)	(-2.48)	
Treat × After	0.0117*	0.0323**	0.0271*	0.0293**	0.0454***	0.0453***
	(1.76)	(2.19)	(1.80)	(2.26)	(2.94)	(2.93)
Fixed effects	None	None	Industry	HQ	Firm	Firm & Time
No. obs.	57783	10993	10993	10692	10993	10993
R^2	0.001	0.003	0.006	0.008	0.004	0.012

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table IV

Impact of probability of distress on leverage responses. The table presents results from difference-in-difference regressions, separately for subsamples with different ex-ante probability of financial distress. The *High* columns include firms with above median measure of distress in 2016, the year before the decision year. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. The modified Altman's Z score is computed using Compustat annual items: $1.2 \times (wcap/at) + 1.4 \times (re/at) + 3.3 \times (ebit/at) + (sale/at)$. The O score is computed using Compustat annual items: $-1.32 - 0.407 \times log(at/GNP) + 6.03 \times (lt/at) - 1.43 \times (wcap/at) + 0.076 \times (lct/act) - 1.72 \times (1\ if\ lt > at, else\ 0) - 2.37 \times (ni/at) - 1.83 \times (oancf/lt) + 0.258 \times (1\ if\ net\ loss\ for\ last\ two\ years, else\ 0) - 0.521 \times (ni_t - ni_{t-1})/(|ni_t| + |ni_{t-1}|)$. The GNP index assumes a base value of 100 for 2012. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Debt/Assets						Market leverage					
	Z score		O score		Size		Z score		O score		Size	
	High	Low	High	Low	Large	Small	High	Low	High	Low	Large	Small
Treat × After	0.00647	0.0997***	0.0648*	-0.00235	-0.00675	0.0840***	0.0193	0.0848***	0.0638**	0.0132	0.0125	0.0813***
	(0.60)	(3.18)	(1.98)	(-0.21)	(-0.66)	(3.10)	(1.22)	(3.75)	(2.51)	(1.25)	(1.01)	(3.33)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	5187	4743	4597	4938	5554	5272	5172	4710	4582	4918	5536	5207
R^2	0.058	0.028	0.020	0.095	0.050	0.020	0.022	0.016	0.014	0.021	0.017	0.016

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table V

Impact of conditional distress cost on leverage responses. The table presents results from difference-in-difference regressions, separately for subsamples with different ex-ante conditional cost of financial distress. The *High* columns include firms with above median measure of distress cost in 2016, the year before the decision year. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. *Uniqueness* is a selling expenses divided by sales, computed by using Compustat annual items: $xsga/sale$. *Uniqueness** is computed by using Compustat annual items: $(xsga - xrd)/sale$. *Tobin's Q* is computed by using Compustat annual items: $(prcc\_c * csho + at - ceq - txdb)/at$. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Debt/Assets						Market leverage					
	Uniqueness		Uniqueness*		Tobin's Q		Uniqueness		Uniqueness*		Tobin's Q	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Treat × After	0.0361	0.0164	0.0487	0.0116	0.0831**	-0.000340	0.0642***	0.0309*	0.0887***	0.0276	0.0492***	0.0154
	(0.92)	(1.50)	(1.32)	(0.80)	(2.60)	(-0.03)	(3.45)	(1.91)	(3.59)	(1.53)	(2.95)	(0.77)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	4559	4853	3183	3456	4794	4934	4513	4837	3145	3449	4781	4929
R^2	0.031	0.031	0.058	0.033	0.027	0.045	0.016	0.019	0.029	0.021	0.015	0.031

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table VI

Heterogeneous treatment effect on debt for firms with different cost of financial distress. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. *Low Z* is an indicator for having below median *Z score* in 2016, the year before TC Heartland. *High O* is an indicator for having above median *O score* in 2016. *Small* is an indicator for having below median *Size* in 2016. *Unique* is an indicator for having above median *Uniqueness* in 2016. *Unique** is an indicator for having above median *Uniqueness** in 2016. *High Q* is an indicator for having above median *Tobin's Q* in 2016. The conditioning variables are defined in Table IV and Table V. Time FE are interacted with the corresponding high cost indicator to allow for year fixed effects to differ by subsample. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Debt/Assets					
	High probability of distress			High conditional distress cost		
	Z score	O score	Size	Uniqueness	Uniqueness*	Tobin's Q
Treat × After	0.00647	-0.00202	-0.00675	0.0164	0.0116	-0.000340
	(0.60)	(-0.18)	(-0.66)	(1.50)	(0.80)	(-0.03)
Treat × After × Low Z	0.0932***					
	(2.87)					
Treat × After × High O		0.0665*				
		(1.83)				
Treat × After × Small			0.0908***			
			(3.14)			
Treat × After × Unique				0.0197		
				(0.51)		
Treat × After × Unique*					0.0372	
					(0.96)	
Treat × After × High Q						0.0834**
						(2.66)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	9930	9535	10826	9412	6639	9728
R^2	0.033	0.033	0.026	0.031	0.050	0.031

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table VII

Heterogeneous treatment effect on market leverage for firms with different cost of financial distress. $Treat$ is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. $After$ is an indicator for being after the decision date. *Low Z* is an indicator for having below median *Z score* in 2016, the year before TC Heartland. *High O* is an indicator for having above median *O score* in 2016. *Small* is an indicator for having below median *Size* in 2016. *Unique* is an indicator for having above median *Uniqueness* in 2016. *Unique** is an indicator for having above median *Uniqueness** in 2016. *High Q* is an indicator for having above median *Tobin's Q* in 2016. The conditioning variables are defined in Table IV and Table V. Time FE are interacted with the corresponding high cost indicator to allow for year fixed effects to differ by subsample. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Market leverage					
	High probability of distress			High conditional distress cost		
	Z score	O score	Size	Uniqueness	Uniqueness*	Tobin's Q
Treat × After	0.0193 (1.22)	0.0133 (1.26)	0.0125 (1.01)	0.0309* (1.91)	0.0276 (1.54)	0.0154 (0.77)
Treat × After × Low Z	0.0655** (2.66)					
Treat × After × High O		0.0504* (1.73)				
Treat × After × Small			0.0688** (2.59)			
Treat × After × Unique				0.0333 (1.61)		
Treat × After × Unique*					0.0611** (2.26)	
Treat × After × High Q						0.0338 (1.55)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	9882	9500	10743	9350	6594	9710
R^2	0.018	0.016	0.016	0.018	0.026	0.022

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table VIII

Impact of benefit of debt on leverage responses. The table presents results from difference-in-difference regressions, separately for subsamples with different ex-ante conditional cost of financial distress. The *High* columns include firms with above median measure of benefit of debt in 2016, the year before the decision year. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. *NDTS* is the non-debt tax shield measured in Blouin et al. (2010), computed by using Compustat annual items: $(txc - txpd)/pi$. Note that I do not scale the measure by statutory tax rate as in Blouin et al. (2010) because I do not need to to compare across time and the ranking of firms by *NDTS* in 2016 is not affected by scaling. *NDTS TW* is the non-debt tax shield measured in Titman and Wessels (1988), computed by using Compustat annual items: $(oibdp - xint - txpd/0.4)/at$. *MTR* is simulated marginal tax rate from John Graham's website (https://faculty.fuqua.duke.edu/ jgraham/taxform.html). When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Debt/Assets						Market leverage					
	NDTS		NDTS TW		MTR		NDTS		NDTS TW		MTR	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Treat × After	0.0163	0.0821**	0.0220	0.0904**	0.0120	0.0160	0.0190	0.0676**	0.0471**	0.0335*	0.0304	0.0108
	(1.07)	(2.56)	(1.60)	(2.64)	(0.75)	(0.56)	(1.39)	(2.25)	(2.55)	(1.84)	(1.21)	(0.62)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	4538	4373	4497	4198	4132	4053	4522	4344	4484	4168	4121	4047
R^2	0.055	0.023	0.035	0.025	0.045	0.039	0.011	0.018	0.023	0.010	0.031	0.014

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table IX

Heterogeneous treatment effect on debt for firms with different benefit of debt. $Treat$ is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. $After$ is an indicator for being after the decision date. *Low NDTS* is an indicator for having below median *NDTS* in 2016, the year before TC Heartland. *Low NDTS TW* is an indicator for having below median *NDTS TW* in 2016. *High MTR* is an indicator for having above median *MTR* in 2016. The conditioning variables are defined in Table VIII. Time FE are interacted with the corresponding high cost indicator to allow for year fixed effects to differ by subsample. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Debt/Assets		
	NDTS	NDTS TW	MTR
Treat × After	0.0163	0.0220	0.0160
	(1.08)	(1.60)	(0.56)
Treat × After × Low NDTS	0.0658*		
	(1.95)		
Treat × After × Low NDTS TW		0.0683*	
		(1.95)	
Treat × After × High MTR			-0.00397
			(-0.12)
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. obs.	8911	8695	8185
R^2	0.030	0.028	0.041

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table X

Heterogeneous treatment effect on market leverage for firms with different benefit of debt. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date.*Low NDTS* is an indicator for having below median *NDTS* in 2016, the year before TC Heartland. *Low NDTS TW* is an indicator for having below median *NDTS TW* in 2016. *High MTR* is an indicator for having above median *MTR* in 2016. The conditioning variables are defined in Table VIII. Time FE are interacted with the corresponding high cost indicator to allow for year fixed effects to differ by subsample. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Market leverage		
	NDTS	NDTS TW	MTR
Treat × After	0.0190	0.0471**	0.0108
	(1.40)	(2.56)	(0.62)
Treat × After × Low NDTS	0.0486		
	(1.44)		
Treat × After × Low NDTS TW		-0.0135	
		(-0.60)	
Treat × After × High MTR			0.0196
			(0.58)
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. obs.	8866	8652	8168
R^2	0.015	0.015	0.023

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XI
Average number of times sued by an NPE per quarter. The table shows the average number of times treated high-tech firms are sued by an NPE per quarter. Column 1 shows the average number of cases for low Z score firms, which are firms with below median Z score in 2016. Column 2 shows the average number of cases for high Z score firms. Column 3 shows the differences between the two sample means. Column 4 shows the difference-in-difference estimators. Robust standard errors clustered by the state of incorporation are displayed in parentheses.

Number of cases	Low Z score	High Z score	Difference	DiD
Before	0.056	0.170	-0.114	
	(0.033)	(0.118)	(0.095)	
After	0.022	0.132	-0.114	0.003
	(0.015)	(0.112)	(0.110)	(0.030)
Number of firm-quarter	1235			

Table XII
The effect of NPE lawsuits on financially healthy treated firms. The dependant variable is Z score in the first three columns and O score in the last three columns. Column 1 and 4 use the sample of firms having above median *Z score* in 2016, the year before TC Heartland. Column 2 and 5 use the sample of firms having above median *total assets* in 2016. Column 3 and 6 use the sample of firms having below median *O score* in 2016. *Post lawsuits* is the cumulative number of times a firm is sued by an NPE in my sample period. Standard errors are clustered by the state of incorporation.

Dep. var. =	Z score			O score		
	High Z	Large	Low O	High Z	Large	Low O
Post lawsuits	0.00627	0.0207	0.0190	0.0517	0.0521*	0.0271
	(0.55)	(1.69)	(0.92)	(1.39)	(1.92)	(0.51)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	722	550	636	713	541	633
R^2	0.052	0.115	0.031	0.037	0.042	0.019

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XIII

Investment trends for firms with different distress cost. The table presents results from difference-in-difference regressions on firm capital expenditure and R&D expense over assets, separately for subsamples with different ex-ante probability of financial distress. The $High$ columns include firms with above median measure of distress in 2016, the year before the decision year. $Treat$ is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. $After$ is an indicator for being after the decision date. *Capital expenditure* and *R&D expense* are computed from Compustat quarterly items $xrdy$ and $capxy$, which are quarterly year-to-date sums. When fixed effects are included, the R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Capital expenditure/Assets						R&D expense/Assets					
	Z score		O score		Size		Z score		O score		Size	
	High	Low	High	Low	Large	Small	High	Low	High	Low	Large	Small
Treat × After	0.000786	0.00144	0.000106	0.00154	0.000584	0.000382	0.000378	0.00719	-0.0105	0.00115*	0.00110	0.00582
	(0.70)	(0.59)	(0.05)	(0.90)	(0.44)	(0.18)	(0.58)	(0.25)	(-0.56)	(1.76)	(1.71)	(0.30)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	4864	4386	4305	4632	5177	4805	5187	4743	4608	4927	5554	5272
R^2	0.048	0.012	0.013	0.048	0.064	0.011	0.006	0.007	0.009	0.006	0.010	0.006

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XIV
Decomposing deliberate leverage effect of net debt and equity issuance. Dependent variables are components in Equation (6): deliberate leverage change, $\Delta Leverage = (\Delta D/A') \times (1 - D/A) - (\Delta E/A') \times (D/A)$, net debt issuance (retirement) over assets, $\Delta D/A'$, and net equity issuance (repurchase) over total assets $\Delta E/A'$. D and A are lagged total debt and total assets (Compustat items $dlttq + dlcq$ and atq). A' equals the current period total assets. ΔD equals the change in total debt. ΔE equals the change in stockholder's equity (Compustat item $seqq$), which excludes accumulated retained earnings, minus dividends (quarterly dividends are calculated using Compustat item dvy, which records the year-to-date sum). FD is financing deficit, defined as $\Delta A - \Delta RE$, where RE is retained earnings (Compustat item req). $CAPX$ and $R\&D$ are capital expenditure and research and development expense, respectively (computed from Compustat quarterly items $xrdy$ and $capxy$, which are quarterly year-to-date sums).

	ΔLeverage	$\Delta D/A'$	$\Delta E/A'$	FD/A'	$CAPX/A'$	$R\&D/A'$
Treat × After	0.0352**	0.0308*	-0.0125	0.0374*	0.00245**	-0.00166
	(2.25)	(1.72)	(-0.50)	(1.74)	(2.14)	(-0.28)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
No. obs.	10746	11166	10746	10731	10814	11181
R^2	0.002	0.002	0.002	0.003	0.002	0.002

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XV

Heterogeneity in treatment effects by patent portfolio and pledging history. The sample is restricted to high-tech firms. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. In the first two columns, the sample firms are split by the total number of patents produced in twenty years leading up to the beginning of the event window. In the last two columns, the sample firms are split by whether they have been observed to pledge patents as collateral before the the beginning of the event window. The R^2 displayed is the within R^2. Standard errors are clustered by the state of incorporation.

Dep. var. =	Debt/Assets			
	Number of patent		Has pledged patent	
	=0	≥1	No	Yes
Treat × After	0.0603**	0.0110	0.0527**	0.000728
	(2.37)	(0.99)	(2.51)	(0.07)
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
No. obs.	6502	4599	8351	2750
R^2	0.021	0.048	0.023	0.037

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XVI

The enactment effects versus the TC Heartland effects. The outcome variable in the first two columns is book leverage. The outcome variable in the last two columns is market leverage. *Antitroll* is an indicator for being incorporated or headquartered in the state that passed anti-troll legislation. *After Enactment* is an indicator for being after the enactment of the state anti-troll legislation. *Treat* is the same as defined in Table II. *After TC Heartland* is the same as *After* in Table II, the TC heartland is added to differentiate post-enactment from post-TC Heartland. Column 1 and 3 extend the main sample period to eight quarters before the earliest enactment of state anti-troll law (Vermont May 2013). The R^2 displayed is the within R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Debt/Assets		Market leverage	
	(1)	(2)	(3)	(4)
Antitroll × After Enactment	-0.00349		0.0121	
	(-0.31)		(1.14)	
Treat × After TC Heartland		0.0323^{**}		0.0447^{***}
		(2.09)		(2.89)
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
No. obs.	24757	10986	24616	10929
R^2	0.045	0.023	0.014	0.013

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XVII
The treatment effect on debt using propensity score matched samples. Propensity scores are estimated using log of total assets, profitability, fixed assets, cash, and a dummy for dividend payer. Profitability is income before extraordinary items plus depreciation and amortization divided by total assets (Compustat items: $(ibq + dbq)/atq$). Fixed Asset is property, plant, and equipment divided by total assets (Compustat itmes: $ppentq/atq$). Cash is cash divided by total assets (Compustat items: chq/atq). Finally, dividend payer is an indicator for the firm having a positive average dividend payout over the eight quarters before treatment. All financial outcomes are scaled by total assets and further winsorized at zero and one. R^2 displayed are the overall R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Debt/Assets					
	All firms	High-tech firms				
	(1)	(2)	(3)	(4)	(5)	(6)
Treat	-0.0578***	-0.0744***	-0.0991*	-0.0782		
	(-8.61)	(-4.45)	(-2.02)	(-1.27)		
After	-0.0150**	-0.00618	-0.00281	-0.0194	0.0140*	
	(-2.16)	(-0.36)	(-0.15)	(-0.73)	(1.84)	
Treat × After	0.0254***	0.0644***	0.0586**	0.0786**	0.0392**	0.0386**
	(2.62)	(2.67)	(2.55)	(2.36)	(2.24)	(2.20)
Fixed effects	None	None	Industry	HQ	Firm	Firm & Time
No. obs.	14928	2451	2451	2392	2451	2451
R^2	0.006	0.010	0.052	0.100	0.826	0.829

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XVIII

The treatment effect on market leverage using propensity score matched samples. Propensity scores are estimated using log of total assets, profitability, fixed assets, cash, and a dummy for dividend payer. Profitability is income before extraordinary items plus depreciation and amortization divided by total assets (Compustat items: $(ibq + dbq)/atq$). Fixed Asset is property, plant, and equipment divided by total assets (Compustat itmes: $ppentq/atq$). Cash is cash divided by total assets (Compustat items: chq/atq). Finally, dividend payer is an indicator for the firm having a positive average dividend payout over the eight quarters before treatment. All financial outcomes are scaled by total assets and further winsorized at zero and one. R^2 displayed are the overall R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Market leverage					
	All firms	High-tech firms				
	(1)	(2)	(3)	(4)	(5)	(6)
Treat	-0.0169***	-0.0594***	-0.0785**	-0.0953*		
	(-2.92)	(-4.66)	(-2.37)	(-1.88)		
After	-0.00371	-0.0380***	-0.0338**	-0.0373	-0.0239***	
	(-0.62)	(-2.90)	(-2.46)	(-1.63)	(-3.69)	
Treat × After	0.00911	0.0730***	0.0665***	0.0716***	0.0554***	0.0548***
	(1.09)	(3.98)	(3.47)	(2.90)	(3.07)	(3.05)
Fixed effects	None	None	Industry	HQ	Firm	Firm & Time
No. obs.	14910	2445	2445	2386	2445	2445
R^2	0.001	0.009	0.106	0.148	0.756	0.760

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix A. State anti-troll laws

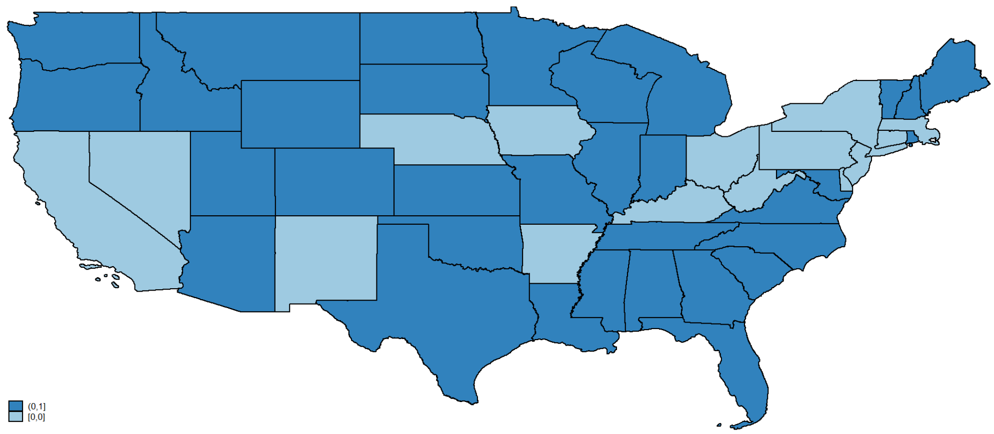


Figure A.1. The figure shows the states with anti-troll laws. States shaded by darker blue passed anti-troll state laws before TC Heartland. States shaded by lighter blue do not have anti-troll state laws before TC Heartland.

Table A.1
The table reports the signing year for the 33 states that passed state laws against patent trolls.

State	Year	State	Year
Alabama	2014	Montana	2015
Alaska		Nebraska	
Arizona	2016	Nevada	
Arkansas		New Hampshire	2014
California		New Jersey	
Colorado	2015	New Mexico	
Connecticut		New York	
Delaware		North Carolina	2014
Florida	2015	North Dakota	2015
Georgia	2014	Ohio	
Hawaii		Oklahoma	2014
Idaho	2014	Oregon	2014
Illinois	2014	Pennsylvania	
Indiana	2015	Rhode Island	2016
Iowa		South Carolina	2016
Kansas	2015	South Dakota	2014
Kentucky		Tennessee	2014
Louisiana	2014	Texas	2015
Maine	2014	Utah	2014
Maryland	2014	Vermont	2013
Massachusetts		Virginia	2014
Michigan	2017	Washington	2015
Minnesota	2016	West Virginia	
Mississippi	2015	Wisconsin	2014
Missouri	2014	Wyoming	2016

Appendix B. A static trade-off model of optimal capital structure under anti-troll protection

To illustrate the idea from the previous section, I develop a static trade-off model in this section, representing anti-troll protection as a stochastic increase in the value of protected firms. Formally, the value of a protected firm is modeled as stochastically dominating that of an unprotected firm according to likelihood ratio. The basic framework follows the standard presentation of the static trade-off theory (Bradley et al., 1984). Modeling anti-troll protection as a stochastic increase in firm value has two advantages. First, the stochastic increase assumes that patent trolls increase a targeted firm's chance of default without assuming a functional form of extraction (e.g. fixed monetary cost, proportional extraction of value, and etc.) Second, the stochastic increase in firm value captures both the decrease in expected monetary damage from defending patent litigation and the potential increase in innovative investment, thus allowing for both the distress cost channel and the innovation channel. Graham and Harvey (2002) present survey evidence that tax benefit is an important factor affecting debt policy decisions (ranking above comparable firm debt levels, equity undervaluation/overvaluation, and transactions costs and fees), and is most important for firms with stronger tax incentives to use debt such as large industrial firms.

Model setup

Investors are risk-neutral and there are no tax on income from stock and debt. The firm faces a constant tax rate τ_c on end-of-period wealth X. Both interest and principle payments on debt are tax deductable. If the firm is unable to make the promised debt payment B, then it incurs cost of financial distress, assumed to be a fraction k of the end-of-period value of the firm. The probability density of end-of-period wealth for firms protected by anti-troll laws is $g(X)$. The density for unprotected firms is $f(X)$. The respective cumulative probability density functions are $G(X)$ and $F(X)$. $G(X)$ stochastically dominates $F(X)$ according to the likelihood ratio:

$$\frac{g(X)}{g(X')} \leq \frac{f(X)}{f(X')} \quad \forall X < X' \tag{B1}$$

This assumption is also called the monotonic likelihood ratio property and is common in the literature. The assumption states that the realization of end-of-period wealth for anti-troll protected firms are typically higher than those of unprotected firms. Likelihood ratio dominance implies first-order stochastic dominance.

More specifically, patent litigation brought by patent trolls reduces the end-of-period wealth of the targeted firm by incurring monetary damage for the defendants (e.g. lawyer fees, settlement fees, loss in litigation, and etc.). This monetary damage reduce the targeted firm's probability of repaying its debt claim, thus increasing the firm's probability of incurring financial distress cost k. As discussed in the previous section, protected firms could have stronger incentive to innovate. They may take better projects that have better payoffs. Stochastic dominance in the distribution of end-of-period wealth accounts for this possibility. This assumption also does not eliminate the scenario where protected firms are sued by patent trolls nonetheless and where unprotected firms are not sued by patent trolls.

Under the above assumptions, the end-of-period returns to bondholders and stockholders can be described as follows:

$$\hat{V_B} = \begin{cases} B, & X \geq B \\ X(1-k), & 0 \leq X < B \\ 0, & X < 0 \end{cases} \tag{B2}$$

$$\hat{V_S} = \begin{cases} (X-B)(1-\tau_c), & X \geq B \\ 0, & X < B \end{cases} \tag{B3}$$

where $\hat{V_B}$ and $\hat{V_S}$ are the end-of-period returns to bondholders and stockholders, respectively.

The market value of debt and equity are found by integrating the returns across different states:

$$V_B = \frac{1}{1+r_f}\left[\int_B^\infty Bf(X)dX + \int_0^B X(1-k)f(X)dX\right] \tag{B4}$$

$$V_S = \frac{1}{1+r_f}\left[\int_B^\infty (X-B)(1-\tau_c)f(X)dX\right] \tag{B5}$$

where V_B and V_S are the market value of the firm's bonds and stocks, respectively. r_f is the risk-free rate.

For the firms with stronger anti-troll protection, the market values can be written as follows:

$$V_B' = \frac{1}{1+r_f}\left[\int_{B'}^\infty B'g(X)dX + \int_0^{B'} X(1-k)g(X)dX\right] \tag{B6}$$

$$V_S' = \frac{1}{1+r_f}\left[\int_{B'}^\infty (X-B')(1-\tau_c)g(X)dX\right] \tag{B7}$$

where V_B' and V_S' are the market value of the firm's bonds and stocks, respectively. B' is the promised debt payment of the protected firm.

Adding equation (B4) and (B5) yields the market value V of the unprotected firms:

$$V = \frac{1}{1+r_f}\left[\int_B^\infty Bf(X)dX + \int_0^B X(1-k)f(X)dX + \int_B^\infty (X-B)(1-\tau_c)f(X)dX\right] \tag{B8}$$

Adding equation (B6) and (B7) yields the market value V' of protected firms:

$$V' = \frac{1}{1+r_f}\left[\int_{B'}^{\infty} B'g(X)dX + \int_0^{B'} X(1-k)g(X)dX + \int_{B'}^{\infty}(X-B')(1-\tau_c)g(X)dX\right] \quad \text{(B9)}$$

Rearrange equation (B8) and (B9) to highlight the tax-bankruptcy cost trade-off:

$$V = \frac{1}{1+r_f}\left[\int_0^{\infty} X(1-\tau_c)f(X)dX + \int_B^{\infty} B\tau_c f(X)dX + \int_0^{B} X\tau_c f(X)dX - \int_0^{B} Xkf(X)dX\right] \quad \text{(B10)}$$

$$V' = \frac{1}{1+r_f}\left[\int_0^{\infty} X(1-\tau_c)g(X)dX + \int_{B'}^{\infty} B'\tau_c g(X)dX + \int_0^{B'} X\tau_c g(X)dX - \int_0^{B'} Xkg(X)dX\right] \quad \text{(B11)}$$

In equation (B10), and similarly in equation (B11), the second and third integrals in the square bracket capture the expected tax benefit of debt. The fourth integral in the square bracket captures the expected cost of financial distress. Protected firms draw end-of-period wealth from distribution $G(X)$, which stochastically dominate $F(X)$. Focusing on the fourth integral in equation (B10) and (B11), protected firms have lower expected cost of financial distress at the same level of debt. This decrease in expected cost financial distress enable protected firms to take more debt in order to capture greater tax benefit. Next I show that under the above assumptions, the optimal debt for protected firms are higher compared to unprotected firms.

Optimal leverage under anti-troll protection

The firms choose leverage such that the market value of the firm is maximized. The assumption that B is chosen to maximize V is conventional in the literature. I assume that the hazard ratios for both distributions $F(X)$ and $G(X)$ are monotonically increasing, which is an innocuous regularity condition insuring that the optimal solution is unique.

Differentiating equation (B8) and (B9) with respect to B yields the first order conditions for unprotected firms:

$$\frac{\partial V}{\partial B} = \frac{1}{1+r_f}\{\tau_c[1-F(B)] - Bkf(B)\} \quad \text{(B12)}$$

and for protected firms:

$$\frac{\partial V'}{\partial B'} = \frac{1}{1+r_f}\{\tau_c[1-G(B')] - B'kg(B')\} \quad \text{(B13)}$$

The first term in the braces in equation (B12), and similarly in equation (B13), is the marginal expected tax benefit of debt, where as the second term in the braces is the marginal expected cost of financial distress. Comparing equation (B12) and (B13), it is clear that at the same level of debt, protected firm will have higher tax base and lower distress probability.

Setting equation (B12) and (B13) to zero and rearrange yield the optimality conditions for the unprotected firms:

$$\frac{\tau_c}{k} = \frac{Bf(B)}{1 - F(B)} \tag{B14}$$

and for the protected firms:

$$\frac{\tau_c}{k} = \frac{B'g(B')}{1 - G(B')} \tag{B15}$$

Integrating equation (B1) and multiplying by X, we get

$$H_G(X) \equiv \frac{Xg(X)}{1 - G(X)} = \frac{Xg(X)}{\int_X^\infty g(X')dX'} \leq \frac{Xf(X)}{\int_X^\infty f(X')dX'} = \frac{Xf(X)}{1 - F(X)} \equiv H_F(X) \tag{B16}$$

At optimum $H_G(B') = H_F(B)$. Since both functions are monotonically increasing, it follows that

$$B' \geq B \tag{B17}$$

thus the optimal debt B' for protected firms are higher than the optimal debt B for unprotected firms.

Appendix C. Market leverage responses

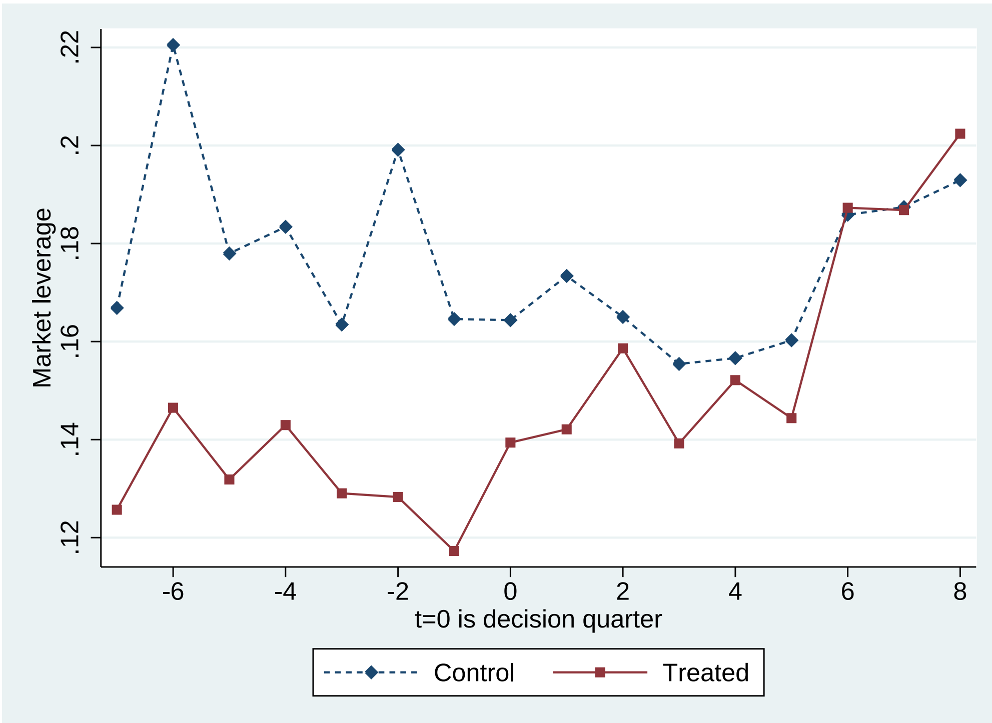


Figure A.2. Average market leverage ratio of high-tech firms during the sample period before and after the U.S. Supreme Court decision in TC Heartland, i.e. from the third quarter of 2015 to the second quarter of 2019. Treated firms are firms incorporated in the states with anti-troll laws in place at the time of the US Supreme Court decision in TC Heartland. Outcome variables of the treated and control group are plotted as solid and dotted lines, respectively.

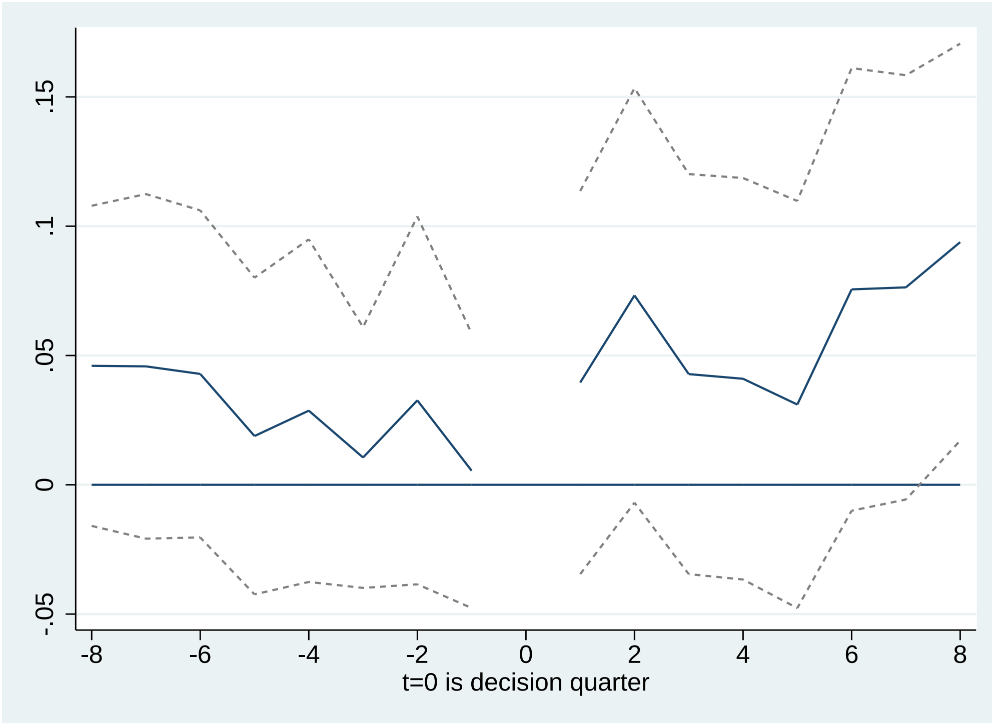


Figure A.3. High-tech firms' market leverage coefficient trend in event time. The analysis is identical to specification 2 in Table III, except that the $After$ indicator is replaced with a full set of quarter dummies (t-8, t-7, ..., t+8). The figure shows the regression coefficients on the interactions between treatment status and quarter dummies. The dashed lines show 95% confidence intervals where standard errors are clustered by state of incorporation.

Appendix D. Baseline results when the data are not winsorized

Table A.2
The table presents main results in Table II when the data are not winsorized. Increase in debt due to treatment, robustness to different fixed effects, and stronger effects for high-tech firms. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. Industry fixed effects are based on three-digit SIC codes. HQ fixed effects control for a company's state of headquarter (Compustat item STATE). I use SIC codes 73 and 35 to identify high-tech firms (see Bessen and Meurer, 2013; Cohen et al., 2019). When fixed effects are included, the R^2 displayed is the within R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Debt/Assets					
	All firms	High-tech firms				
	(1)	(2)	(3)	(4)	(5)	(6)
Treat	-0.0250***	-0.0583***	-0.0644**	-0.0777**		
	(-5.03)	(-4.76)	(-2.57)	(-2.38)		
After	-0.0120***	-0.00782	-0.00757	-0.00616	0.0209***	
	(-4.49)	(-1.27)	(-1.31)	(-0.75)	(3.07)	
Treat × After	0.0203***	0.0601***	0.0607***	0.0564***	0.0322**	0.0319**
	(2.82)	(3.36)	(3.98)	(2.93)	(2.08)	(2.06)
Fixed effects	None	None	Industry	HQ	Firm	Firm & Time
No. obs.	58078	11052	11052	10760	11052	11052
R^2	0.001	0.002	0.003	0.003	0.010	0.022

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3

The table presents main results in Table III when the data are not winsorized. Increase in market leverage due to treatment, robustness to different fixed effects, and stronger effects for high-tech firms. *Treat* is an indicator for being incorporated in the states with anti-troll laws in place at the time of the U.S. Supreme Court decision in TC Heartland. *After* is an indicator for being after the decision date. Industry fixed effects are based on three-digit SIC codes. HQ fixed effects control for a company's state of headquarter (Compustat item STATE). I use SIC codes 73 and 35 to identify high-tech firms (see Bessen and Meurer, 2013; Cohen et al., 2019). When fixed effects are included, the R^2 displayed is the within R^2. Robust standard errors are clustered by the level of fixed effects.

Dep. var. =	Market leverage					
	All firms	High-tech firms				
	(1)	(2)	(3)	(4)	(5)	(6)
Treat	-0.0221***	-0.0581***	-0.0702**	-0.0962***		
	(-4.79)	(-5.59)	(-2.86)	(-3.21)		
After	-0.0106***	-0.0106**	-0.00965	-0.0107	-0.0158**	
	(-4.24)	(-2.02)	(-1.68)	(-1.64)	(-2.40)	
Treat × After	0.0113*	0.0364**	0.0316**	0.0348**	0.0474***	0.0472***
	(1.68)	(2.41)	(2.16)	(2.54)	(3.03)	(3.02)
Fixed effects	None	None	Industry	HQ	Firm	Firm & Time
No. obs.	57442	10944	10944	10656	10944	10944
R^2	0.001	0.003	0.005	0.009	0.004	0.013

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$