Taking a Financial Position in Your Opponent in Litigation*

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Abstract

Before filing suit, a plaintiff can take a financial position in a defendant firm. A short position benefits the plaintiff by transforming a negative expected-value claim into a positive expected-value one and by enhancing the claim's settlement value. If the capital market is less than strong-form efficient, the plaintiff also benefits directly from the decline in the defendant's stock price. When the defendant is privately informed about the case's merits, bargaining failures can arise. While aggressive short-selling benefits the plaintiff at the expense of the defendant, moderate levels of short-selling can benefit the defendant and raise the settlement rate.

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Introduction

In litigation, the party bringing the lawsuit sometimes has an additional financial interest in his or her opponent, an interest that extends beyond the boundaries of the lawsuit itself. In some situations, plaintiffs maintain a "long" financial position. In securities litigation, for instance, plaintiffs are typically a subset of the firm's current shareholders.[1] In other situations, plaintiffs have a "short" financial position. Recently, a prominent hedge fund manager has brought patent validity challenges against pharmaceutical companies while shorting their stock.[2] Given that the market value of a publicly-traded stock reacts to new information, when the filing of a lawsuit conveys negative information, the defendant's stock price will decline.[3] Furthermore, if a plaintiff holds a financial interest in the defendant's stock, she will have different litigation incentives than a plaintiff who does not. A plaintiff's financial interest in the defendant can radically change the course of litigation.

This paper explores a model of litigation and settlement when a plaintiff can trade the stock of a defendant firm. Before filing suit, the plaintiff may take either a long or a short position against the defendant. With a long position, the plaintiff would benefit if the defendant's stock price goes up, and with a short position, the plaintiff would benefit if the defendant's stock price falls. By selling the stock short, the plaintiff is actively betting against the firm, and will reap higher financial gains when the defendant suffers a greater litigation loss. We show that short selling can make the plaintiff's threat to go to trial more credible, and as a consequence, the defendant will have to pay more in settlement to make the plaintiff go away. Thus, the plaintiff can benefit strategically from shorting the defendant's stock.

The basic idea can be demonstrated with a simple example. Suppose the value of the defendant firm is \$1,000 without any litigation. If a plaintiff brings suit against the firm, the plaintiff can expect to recover \$50, while the cost of litigation is \$60 for the plaintiff and \$60 for the defendant firm. Obviously, the lawsuit has a negative expected value and, without additional incentive, the plaintiff will not bring suit. Now suppose, before filing suit, the plaintiff takes a short position against the defendant at the initial firm value of v_0, so that, if the firm value later becomes v_1, the plaintiff realizes a financial return of 10% of the valuation difference:

[1] For instance, if shareholders file and win in a lawsuit against the corporation, while receiving direct recovery from the firm, the value of their shares will decrease due to the lawsuit.

[2] See Walker and Copeland (2015) and Sidak and Skog (2015) about the short-and-sue tactics used by hedge-fund manager Kyle Bass against publicly-traded pharmaceutical companies. According to Sidak and Skog (2015), Bass has brought 21 IPR challenges against 12 companies, whose market capitalizations range from \$126 million to \$229.8 billion.

[3] Many papers have documented the stock price decline in reaction to filing of lawsuits against corporations. See Cutler and Summers (1988), Bhagat et al. (1994), and Bizjak and Coles (1995).

$(0.1)(v_0 - v_1)$. Suppose the lawsuit gets filed, and the plaintiff now needs to decide whether to proceed to trial or to drop the case. If she were to drop the case, the firm value becomes \$1,000 and she realizes a financial return of $(0.1)(v_0 - \$1{,}000)$. If she were to proceed to trial, on the other hand, firm value becomes \$890 and she realizes $(\$50 - \$60) + (0.1)(v_0 - \$890)$. Comparing the two returns, by proceeding to trial, she realizes an additional financial return of $(0.1)(\$1{,}000 - \$890)$, which is enough to make up for the expected loss of \$10 from trial.[4] By shorting the defendant's stock, the plaintiff has turned a non-credible threat of lawsuit into a credible one. This, in turn, will allow her to extract a positive settlement from the defendant.

We begin by analyzing a benchmark model with symmetric information, where the plaintiff and the defendant know the relevant parameters of the model. As shown in the numerical example, by taking a short position in the defendant's stock, the plaintiff can transform what would otherwise be a negative expected value claim into a positive expected value one. This, in turn, implies that more cases will be filed ex ante. While some of these claims may be meritorious and socially valuable, others may not be. Indeed, through a sufficiently large short position, the plaintiff can credibly threaten to bring any suit to trial, even an entirely frivolous one where everyone agrees that the plaintiff's chances of prevailing in litigation are (near) zero. Short selling improves the plaintiff's bargaining power for positive expected value claims as well, leading to larger settlement payments by the defendant. Conversely, when maintaining a long position in the defendant's stock, the plaintiff's threat to go to trial and bargaining position are compromised.[5]

We then extend the model to allow the defendant to be privately informed about the likely outcome at trial. In a screening protocol of Bebchuk (1984) and Nalebuff (1987), where the plaintiff makes a single take-it-or-leave-it offer, we show that the plaintiff's financial position has two basic effects. First, when credibility is not a concern, taking a short (long) position makes the plaintiff more (less) aggressive in his settlement offer. With a short position, for instance, a larger settlement produces an additional financial return. Thus, a short position will lead to more trials and fewer settlements. Second, when credibility is a concern, the plaintiff's financial position will change the plaintiff's interim incentive to drop the case. A short financial position relaxes the credibility constraint. Interestingly, this allows the plaintiff to become less aggressive and lower the settlement offer. Thus, for moderate amounts of short-selling, the

[4] She will proceed to trial rather than drop the case if $(\$50 - \$60) + (0.1)(v_0 - \$890) \geq (0.1)(v_0 - \$1{,}000)$, which produces $(\$50 - \$60) + (0.1)(\$1{,}000 - \$890) \geq 0$.

[5] For instance, in a shareholder class action, when the lead plaintiff holds a substantial long position, this could substantially reduce the recovery for the entire class. Some courts have recognized this as an issue and recommended dividing the plaintiffs into sub-classes. See the conclusion for more details.

plaintiff's short position may actually benefit the defendant and lower the equilibrium rate of litigation.

The possibility that plaintiffs may short the defendants' stock is relevant in current litigation practice. The America Invents Act went into effect in September 2012.[6] Among other things, the Act provides a streamlined procedure under which just about anyone can challenge the validity of a patent by filing an inter partes review (IPR) petition before the United States Patent and Trademark Office. One of the many IPR petitioners is hedge fund manager Kyle Bass. Through one venture, the Coalition for Affordable Drugs, Mr. Bass has been challenging pharmaceutical patents in an arguably noble attempt to bring down prescription drug prices. His critics maintain that Mr. Bass' motives are mercenary, and that Bass has been "betting against, or shorting, the shares of drug makers and biotechs whose patents he maintains are spurious."[7] At least one pharmaceutical company, Celgene, has argued that Mr. Bass' IPR petitions should be dismissed as a sanction for misconduct (for "abusing the process"),[8] saying that "IPRs were not designed for this purpose" and that these tactics are "nothing more than another nefarious means...to line their own pockets at the expense of public pharmaceutical companies and their shareholders."[9]

This paper contributes to the literature on the economics of litigation in several ways.[10] We provide a new explanation for nuisance litigation, where unscrupulous plaintiffs extort money from otherwise blameless defendants by threatening them with litigation. At first blush,

[6] The Act is also called Leahy-Smith America Invents Act after the lead sponsors, Senator Patrick Leahy and Representative Lamar Smith. The Act was signed into law by President Obama on September 16, 2011.

[7] Silverman (2015). See also Walker and Copeland (2015). Similarly, hedge fund Silver Star Capital challenges patents and holds "various long/short positions in the securities of an assortment of global semiconductor technology enterprises." According to patent holder Power Integrations, Silver Star filed its IPR petition "simply for the purpose of extorting a settlement." see *Patent Owner's Preliminary Response*, Case IPR2016-00736 (Patent 6,212,079). In the securities class action context, Cardinal Investment Company took a short position and then sued Terayon Communications Systems. When the judge discovered Cardinal's short position, Cardinal was disqualified from being the lead plaintiff. See *In re Terayon Commc'ns Sys., Inc.*, No. C 00-01967 MHP, 2004 WL 413277, 7 (N.D. Cal. Feb. 23, 2004). Other cases include lawsuits against Eckerd Drug Stores and Biomatrix. Yahya (2006).

[8] "Abuse of process," similar to "malicious prosecution," is a tort claim, where the claimant argues that the other is misusing the judicial process for an inappropriate motive. This paper argues that the short-sale plaintiff should not be sanctioned, nor the case be dismissed, simply because the plaintiff has taken a short position against the defendant.

[9] See *Patent Owner Motion for Sanctions*, Case IPR2015-01092 (Patent 6,045,501). PTAB denied Celgene's motion in *Coalition for Affordable Drugs v. Celgene* 37 C.F.R. §42.12, stating that "profit is at the heart of nearly every patent and nearly every inter partes review…[and] economic motive for challenging a patent claim does not itself raise abuse of process issues." Celgene's protest notwithstanding, it is possible that allowing a plaintiff to take a short position and to bring a patent validity challenge could actually increase welfare if, without the financial position, there would have been too few patent challenges. If there were too many patent challenges, the opposite could be true. In the current paper, we remain agnostic on the welfare implications.

[10] See Cooter and Rubinfeld (1989), Daughety (2000), Daughety and Reinganum (2005), and Spier (2007) for surveys.

it might appear that a plaintiff with a negative expected value (NEV) claim could not possibly succeed in extracting a settlement offer: since a rational plaintiff would drop the NEV case before trial, a savvy defendant should rebuff the plaintiff's demands. Bebchuk (1988) and Katz (1990) argue that when the plaintiff is privately informed about the strength of his or her case, then extortion may succeed. In a complete information environment, Bebchuk (1996) shows that NEV claims may succeed if the costs are borne gradually over time and negotiations can take place after some but not all of the costs are sunk.[11] None of these papers recognize that financial transactions and short selling can transform a NEV claim into a positive expected value one.

Several papers in the law and economics literature explore how contracts with third parties can strengthen a litigant's bargaining position, leading to a more advantageous settlement. Meurer (1992) argues that an insurance contract can make a defendant tougher in settlement negotiations, and may induce the plaintiff to lower the settlement demand.[12] Spier and Sykes (1998) show that financial leverage can be an advantage to a corporate defendant in a "bet-the-firm" litigation. While small judgments will be borne by the shareholders, a very large judgment might ultimately be borne by debt-holders in the resulting bankruptcy. Similarly, contingent fees can potentially make plaintiffs tougher in negotiations. By paying the lawyer different contingent percentages, depending on whether the case settles or goes to trial, a plaintiff may be able to raise his or her minimum willingness to accept in settlement. This is because the lawyer is bearing the costs of litigation, not the plaintiff, making trial relatively more attractive (Choi (2003); Bebchuk and Guzman (1996)). Spier (2003a, 2003b) and Daughety and Reinganum (2004) show how most favored nations clauses with early litigants can be a strategic advantage in negotiating with later ones.

A small number of papers, primarily in the industrial organization and finance literatures, have examined the possibility of taking a financial position in one's competitors. Gilo (2000) and Gilo, Moshe, and Spiegel (2006) argue that firms taking long financial positions in competitors in the same industry will have a decreased incentive to engage in vigorous competition and an increased incentive to engage in price collusion. Hansen and Lott (1995) argue that an incumbent firm's short position against a potential entrant will allow the incumbent to more successfully engage in costly predation should entry occur. Tookes (2008) shows how informed financial traders have an incentive to make information-based trades in the stocks of

[11] Hubbard (2016) generalizes these results by endogenizing litigation expenditures. See also Rosenberg and Shavell (1985).

[12] Similar in spirit, Bolton and Oehmke (2011) also show how a lender can strengthen its bargaining position against a borrower (in pre-bankruptcy workout negotiations) by entering into credit default swaps agreements which (de facto) insure the lender against borrower bankruptcy. In equilibrium, this can actually help the borrower by decreasing the borrower's incentive to strategically default ex post (solely for the purpose of reducing repayment).

competitors and empirically shows an increase in intra-day transactions over competitors when one company makes an earnings announcement.[13] In a paper more directly related to ours, Kobayashi and Ribstein (2006) present a simple model where a plaintiff's lawyer can short the stock of the defendant and argue that allowing the lawyer, who receives a fraction of the recovery, to short the defendant's stock can mitigate the (litigation effort) incentive problem between the lawyer and the plaintiff.[14]

The paper is organized as follows. Part 1 presents our benchmark model where the plaintiff and firm-defendant are symmetrically informed. Part 2 allows the defendant to be privately informed of the strength of the case (i.e., the probability of losing at trial) and explores the implications of short-selling for the litigation rate. Part 3 discusses several extensions (loser-pays-all litigation costs, risk aversion, and transactions costs of taking short positions) and directions for future research. Proofs that are omitted from the text are presented in the Appendix.

1. The Model

There are two risk-neutral players: a plaintiff (p) and a firm-defendant (d). The plaintiff has a legal claim against the firm-defendant. If the case goes to trial, the plaintiff and the defendant bear the litigation costs of $c_p > 0$ and $c_d > 0$, respectively, and the court finds in favor of the plaintiff with probability $\pi \in [0,1]$. When the plaintiff wins, the defendant pays damages of $D > 0$ and the plaintiff recovers λD where $\lambda \in [0,1]$. The assumption of partial recovery for the plaintiff ($\lambda < 1$) allows for the possibility that the stakes are asymmetric. Revisiting the example from the introduction, when the plaintiff does not own any competing patent, succeeding in an inter partes review (IPR) and invalidating the defendant's patent can impose a heavy loss on the firm-defendant but has no direct benefit for the plaintiff ($\lambda = 0$ while $D > 0$ where D now represents the loss of future profits).

The firm-defendant owns and controls a set of assets that will generate a gross cash flow $R > 0$ where R is fixed and is sufficient to cover the damages award and the litigation cost, $R - D - c_d \geq 0$.[15] So, bankruptcy is not a consideration. We assume that these parameters are known by both the plaintiff and the firm-defendant. In terms of capitalization, the firm has only

[13] Ayres and Choi (2002) call this type of behavior as "outsider trading" and propose giving right to the traded firm to decide whether to allow such outsider trading.
[14] In their model, all the legal decisions are made by the lawyer. They do not consider the issues of credibility or asymmetric information.
[15] Although we assume that the gross valuation R is fixed, in reality, this will be in expectation so that the stock price can move not only due to litigation but for other reasons. In that setting, a risk-neutral plaintiff will attempt to maximize the expected return. The plaintiff can engage in various hedging strategies to reduce or eliminate stock price movement that is unrelated to the litigation.

one class of stock (e.g., common stock) and there is a capital market at which the firm's stock trades. The firm's equity market capitalization at the beginning of a given period t is represented by v_t.[16] We assume that the firm's debt and other financial obligations are all netted out from the analysis. We also assume that the stock market is sufficiently liquid and the volume of trade is sufficiently large so that the plaintiff can fine-tune its financial position in the firm-defendant.

There are four periods in the game with no time discounting: $t \in \{0,1,2,3\}$. At $t = 0$, the plaintiff takes a financial position in the firm-defendant that is equivalent to acquiring a proportion Δ of the firm-defendant's equity at market value v_0, to be determined in equilibrium.[17] We will say more about v_0 after the timing of the game is described. The plaintiff's position can be either long ($\Delta > 0$) or short ($\Delta < 0$) and will be held until the end of the game ($t = 3$).[18] There may be limits on the position that the plaintiff can take: $\Delta_L \leq \Delta \leq \Delta_H$ where $\Delta_L \in (-\infty, 0)$ and $\Delta_H \in (0, \infty)$.[19] If the plaintiff is indifferent between $\Delta = 0$ and other positions, we break indifference by assuming that the plaintiff chooses the neutral position $\Delta = 0$.

At $t = 1$, the plaintiff files suit and approaches the defendant in an attempt to negotiate an out-of-court settlement. At this point in time, the details of the lawsuit—including the plaintiff's financial position Δ—are observed by the defendant and the capital market, so that by $t = 1$, the firm's valuation v_1 fully reflects the expected outcome of the litigation.[20] All negotiations take place under complete information. We adopt the Nash bargaining solution concept where $\theta \in (0,1)$ denotes the defendant's relative bargaining strength, conditional on the plaintiff having a credible lawsuit. That is, θ is the share of the bargaining surplus that is captured by the defendant, when the plaintiff is willing to proceed to trial upon breakdown of settlement negotiations. As θ becomes higher (lower), the settlement amount (s) will tend to

[16] Note that v_t represents the firm's total equity market capitalization rather than its stock price. For instance, if there are 10,000 shares of common stock outstanding, each share will be worth $v_t/10{,}000$ at t.

[17] If the equity market capitalization of the firm is very large, it may be difficult for the plaintiff to take a sizable financial position. The transactions costs of short selling are briefly discussed in the conclusion.

[18] The assumption that the plaintiff always settles its financial position at $t = 3$ (regardless of the case disposition) streamlines the exposition but is not critical to the results.

[19] In addition to direct purchase or short sale, the plaintiff might instead purchase call or put options. Allowing derivative positions would expand the range of feasible financial positions, for instance, by allowing the plaintiff to take a financial position of $\Delta > 1$ or $\Delta < -1$.

[20] In other words, from time $t = 1$ onwards, the capital market is strong-form efficient and fully aware of the plaintiff's tactics. The plaintiff cannot surreptitiously unwind its position, since the market would instantaneously react, dissipating any financial returns for the plaintiff. Implicitly, we are assuming that the counterparties are sufficiently dispersed and cannot collectively renegotiate.

move in the defendant's (plaintiff's) favor.[21] If the settlement negotiations break down, the plaintiff has the option to drop the case and avoid going to trial.

If the parties fail to settle at $t = 1$ and the plaintiff does not drop the case, the case goes to trial at $t = 2$ and the respective litigation costs of c_p and c_d are borne. With probability $\pi \in [0,1]$, the court finds in favor of the plaintiff, the defendant pays damages of D, and the plaintiff receives λD. Thus, in expectation, the defendant would lose $\pi D + c_d$ and the plaintiff would gain $\pi\lambda D - c_p$ (which may be either negative or positive) from the trial.

At $t = 3$, the plaintiff covers its short position (or liquidates its long position) by purchasing (selling) shares at price v_3. Since the capital market observes the progress of the lawsuit in the preceding periods—in particular whether the case was dropped, settled, or litigated—the final market capitalization of the firm v_3 fully reflects the case disposition. If the case was dropped then $v_3 = R$; if the case was settled then $v_3 = R - s$ where s is the settlement amount; and if the case went to trial then $v_3 = R - D - c_d$ if the defendant lost the case and $v_3 = R - c_d$ if the defendant won the case (with an expected value of $R - \pi D - c_d$). The plaintiff's net return from the financial position is $(v_3 - v_0)\Delta$.

The price that the plaintiff pays to acquire the financial position Δ at $t = 0$ depends on the informational efficiency of the stock market. At one extreme, if the market is completely unaware of the potential lawsuit and does not suspect trading by a privately informed trader, then the firm's market capitalization is fixed at $v_0 = R$. In contrast, if the stock market is aware of the lawsuit and observes the plaintiff's trading activities, then the firm's market value would adjust as the plaintiff takes its position, reflecting rational expectations about the future disposition of the lawsuit. If the market is strong-form efficient, then price at which the plaintiff takes its financial position Δ will instantaneously adjust to equal to the expected future stock price in the continuation game, $E(v_3(\Delta))$. We allow for these extremes, as well as partial adjustments, by letting $v_0(\Delta) = (1 - \mu)R + \mu E(v_3(\Delta))$ where $\mu \in [0,1]$ captures the degree of market efficiency.[22]

The plaintiff seeks to maximize its aggregate payoff, which includes any settlement or damages award from litigation and the net return from the financial investment. As is standard

[21] Equivalently, we can (1) interpret θ as the probability that the defendant makes a take-it-or-leave-it offer to the plaintiff and $1 - \theta$ as the probability that the plaintiff makes such an offer; and (2) structure the negotiation process as one party making the offer and, if the offer is not accepted, the plaintiff can decide whether to drop the case.

[22] This is in the spirit of Kyle (1985), who explores the partial market reactions to the market trades of an informed insider and shows that those reactions may follow a simple linear form. With this parameterization, the market's belief about the likelihood that the investor is the plaintiff, μ, does not depend on the size of the short position. In practice, taking a really big short might arouse more suspicion.

in the literature, and in keeping with the fiduciary obligations under the corporate law, the firm seeks to maximize firm profits or, equivalently, its market valuation. The solution concept is subgame-perfect Nash equilibrium.

1.1. The Credibility of Suit

Suppose that the plaintiff and the defendant have reached a bargaining impasse at $t = 1$. Will the case go to trial at $t = 2$, or will the plaintiff drop the case? Since the firm's equity valuation will be $v_3 = R$ if the plaintiff subsequently drops the case, the plaintiff's payoff from dropping the case is $(v_3 - v_0)\Delta = (R - v_0)\Delta$.[23] If the plaintiff takes the firm-defendant to trial instead, the expected value of the firm's equity will be $v_3 = R - \pi D - c_d$, and so the plaintiff's expected payoff from trial is $\pi\lambda D - c_p + (R - \pi D - c_d - v_0)\Delta$, the expected return from trial plus the plaintiff's net expected profit from the financial investment. Comparing these two expressions, the plaintiff will choose to go to trial rather than drop the case when

$$\pi\lambda D - c_p - \Delta\,(\pi D + c_d) \geq 0 \tag{1}$$

The first part of this expression, $\pi\lambda D - c_p$, is the plaintiff's expected return from the trial itself. The second part, $-\Delta\,(\pi D + c_d)$, is the plaintiff's financial gain from the expected decline in the defendant's stock value. Note that this condition does not depend on the firm's initial valuation v_0 or the firm's gross cash flow R. The value v_0 is irrelevant since the plaintiff's financial transactions at $t = 0$ are sunk at the time that the plaintiff is making its drop decision at $t = 1$. The gross cash flow R is irrelevant since credibility is determined by the change in the firm's valuation, which stems from the firm-defendant's expected loss from litigation, $\pi D + c_d$. Rearranging terms gives the following result.

Lemma 1. *The plaintiff has a credible threat to go to trial if and only if the plaintiff's financial position is* $\Delta \leq \tilde{\Delta}$ *where:*

$$\tilde{\Delta} \equiv \frac{\lambda\pi D - c_p}{\pi D + c_d} < 1 \tag{2}$$

From the expression, we can see that credibility is weakened when the plaintiff takes a long position in the defendant's stock.[24] If $\Delta = 1 > \tilde{\Delta}$, so the plaintiff's financial payoff reflects 100% of the firm's equity, the plaintiff would never want to bring the case to court. By suing the

[23] The firm's initial valuation v_0 is a function of Δ but we're using the expression v_0 for expositional simplicity.
[24] Although we say that the credibility is "weakened" or "enhanced," in a complete, symmetric information setting, the more correct statement would be: "the case becomes more (less) likely to be credible as Δ falls (rises)."

defendant, the plaintiff would essentially be transferring money from one pocket to the other, while wasting money on litigation costs. Credibility is enhanced, however, when the plaintiff takes a short position. By shorting the defendant's stock, the plaintiff can augment the damages award with the gain from the reduction in the defendant firm's stock value. Even if the lawsuit itself has a negative expected value, i.e., $\pi\lambda D - c_p < 0$, the plaintiff can gain credibility by taking a sufficiently large short position: $\Delta \leq \tilde{\Delta} < 0$. To take an extreme case, even when the plaintiff has no chance of winning whatsoever, i.e., $\pi = 0$, the plaintiff can establish credibility by setting $\Delta \leq \tilde{\Delta} = -c_p/c_d$. Any lawsuit—even a completely frivolous one with $\pi D = 0$ or one where $\lambda = 0$ so the plaintiff has no legal stake—can become credible if the plaintiff takes a sufficiently short position in the defendant's stock.[25]

1.2. The Bargaining Outcome

Suppose that $\Delta \leq \tilde{\Delta} < 1$ as defined in Lemma 1, so the plaintiff has a credible threat to bring the case to trial. The firm-defendant, seeking to maximize shareholder value, would be willing to accept a settlement offer s that satisfies $R - s \geq R - \pi D - c_d$. Thus, the most that the defendant is willing to pay, $\overline{s}$, is the expected damage award plus the defendant's litigation cost:

$$\overline{s} = \pi D + c_d \tag{3}$$

Now consider the plaintiff. If the case goes to trial, the plaintiff's expected payoff is $\pi\lambda D - c_p + (R - \pi D - c_d - v_0)\Delta$ as above. If the case settles for s then the plaintiff's payoff is $s + (R - s - v_0)\Delta$. Setting these expressions equal to each other and rearranging terms, the least the plaintiff is willing to accept in settlement is:

$$\underline{s}(\Delta) = \pi D + c_d - \left(\frac{1}{1-\Delta}\right)[(1-\lambda)\pi D + (c_p + c_d)] \tag{4}$$

Comparing (3) and (4) shows that $\underline{s}(\Delta) < \overline{s}$, so a positive bargaining range exists.

[25] If the defendant has the losses from litigation fully insured, the plaintiff will no longer be able to enhance credibility (or bargaining leverage) by shorting the defendant's stock. Full insurance is unlikely to be available for all lawsuits. In Kyle Bass's example, for instance, although firms can insure the direct costs (such as legal fees) of fighting patent trolls, the loss of patent protection and market share and other indirect losses (such as management time) are not typically insurable. RPX, a provider of patent risk management services, offers insurance policies that reduce (but do not eliminate) the costs of defending claims. See http://www.rpxinsurance.com/wp-content/uploads/sites/5/2017/07/RPXIS-Summary-of-Coverage-Q2-2017.pdf. Alternatively, the firm-defendant might spin off the contested patent or sell it to RPX or another defensive patent aggregator.

From equation (4) we see that the plaintiff's bargaining position depends critically on the plaintiff's financial stake, Δ. If the plaintiff takes a neutral financial position in the firm, $\Delta = 0$, then the minimum the plaintiff must receive to settle the case is simply $\underline{s}(\Delta) = \pi\lambda D - c_p$ as in the standard model of settlement of litigation. If the plaintiff takes a short position ($\Delta < 0$) then $\underline{s}(\Delta)$ rises above $\pi\lambda D - c_p$ and the plaintiff's bargaining position is enhanced. The reason for this is straightforward. With a short position on the defendant, by going to trial, the plaintiff not only gets the recovery from judgment but also an additional financial return from the short position. The stronger the short position, the more the plaintiff must receive to settle. In the limit as Δ approaches negative infinity, the least that the plaintiff is willing to accept in settlement converges to $\overline{s} = \pi D + c_d$, which is the most that the defendant is willing to pay. Recalling that parameter $\theta \in (0,1)$ is the bargaining power of the defendant, we have the following result.

Proposition 1. *Suppose the plaintiff takes financial position Δ at $t = 0$. If $\Delta > \tilde{\Delta}$, then the case is dropped and $v_3 = R$. If $\Delta \leq \tilde{\Delta}$, then the case settles out of court for $s(\Delta) = \theta\underline{s}(\Delta) + (1 - \theta)\overline{s} > 0$ where $s'(\Delta) < 0$ and $\lim_{\Delta \to -\infty} s(\Delta) = \pi D + c_d$ and $v_3 = R - s(\Delta)$.*

Since $s'(\Delta) < 0$, the plaintiff is better off and the defendant is worse off when the plaintiff takes a shorter financial position. Strikingly, with enough short selling (as $\Delta \to -\infty$), the plaintiff can extract the full value $\pi D + c_d$ from the defendant in settlement even when the plaintiff's private litigation stake is zero ($\lambda = 0$). This demonstrates how a hedge fund might successfully challenge the validity of a defendant's patent even when the expected direct recovery from the litigation is negligible or zero.

1.3. The Plaintiff's Choice of Financial Position

The previous sections showed that taking a short position at time $t = 0$ is strategically valuable to the plaintiff. First, a sufficiently short position, $\Delta \leq \tilde{\Delta}$, can turn a negative expected-value case into a positive expected value one (Lemma 1). This allows the plaintiff to credibly threaten to take the case all the way to trial. Second, since $s'(\Delta) < 0$, a stronger short position will shift the bargaining outcome in the plaintiff's favor (Proposition 1). In this way, the plaintiff enhances its bargaining position vis-à-vis the defendant.

The plaintiff may also enjoy a direct financial benefit from taking a sufficiently short position, $\Delta \leq \tilde{\Delta}$. Recall that the firm's initial market value is $v_0(\Delta) = (1 - \mu)R + \mu E(v_3(\Delta))$ where $\mu \in [0,1]$ parameterizes the degree of market efficiency. If the market is strong-form efficient, then $\mu = 1$ and $v_0(\Delta) = v_3(\Delta) = R - s(\Delta)$. A fully-efficient capital market adjusts instantaneously to reflect the future settlement value, dissipating any financial gain for the plaintiff. In reality, the market is less than strong-form efficient. Plaintiffs can and do trade surreptitiously in the stock of their opponents. When $\mu \in (0,1)$ the defendant's stock price partially adjusts when the plaintiff takes the short position at time $t = 0$, $v_0(\Delta) = R - \mu s(\Delta)$, and drops further when the lawsuit becomes known to the market at time $t = 1$. When the market is less than fully efficient, $v_0(\Delta) > v_3(\Delta)$ and so the plaintiff profits from the decline in the defendant firm's stock price.[26]

Proposition 2. *Suppose $\Delta_L \leq \tilde{\Delta} < 1$. In equilibrium, the plaintiff takes as large a short position as possible against the defendant ($\Delta^E = \Delta_L < 0$). The case settles out of court for $s(\Delta^E) > 0$ and the plaintiff's net payoff is $s(\Delta^E) - (1-\mu)\Delta^E s(\Delta^E) > 0$. If $\Delta_L > \tilde{\Delta}$, then the plaintiff chooses a neutral position ($\Delta^E = 0$) and the lawsuit is not filed.*

Proof of Proposition 2. As argued above, the plaintiff cannot earn any positive return from taking a financial position $\Delta > \tilde{\Delta}$. If $\Delta \leq \tilde{\Delta}$, the case settles for $s(\Delta)$ and the plaintiff's equilibrium return is $s(\Delta) + (v_3(\Delta) - v_0(\Delta))\Delta = s(\Delta) - (1-\mu)s(\Delta)\Delta = s(\Delta)[1-(1-\mu)\Delta]$. Taking the derivative with respect to Δ, we get $s'(\Delta)[1-(1-\mu)\Delta] - s(\Delta)(1-\mu)$. The first term is negative because $s'(\Delta) < 0$ and $1-(1-\mu)\Delta > 0$ since $\Delta \leq \tilde{\Delta} < 1$. The second term is negative as well. Therefore $\Delta^E = \Delta_L \leq \tilde{\Delta}$, the plaintiff takes position Δ_L, and the case settles for $s(\Delta_L)$. ■

Note that the defendant cannot improve its own strategic bargaining position by taking a long financial position in its own stock. To see why, suppose that the defendant took position γ at the beginning of the game. If the defendant were to settle, the defendant's payoff would be $R - s + (R - s - v_0)\gamma$. If the defendant were to proceed to trial, the payoff would be $R - \pi D - c_d + (R - \pi D - c_d - v_0)\gamma$. Comparing these two expressions, the most the defendant is willing to pay to settle the case is $\bar{s} = \pi D + c_d$, which is independent of financial position γ. Hence, taking a long financial position in its own stock cannot benefit the defendant. Why does the financial position create asymmetric effects on the litigants? This is coming from the fact that while the plaintiff earns $\pi\lambda D - c_p$ directly from litigation, the plaintiff's financial return from litigation depends on the defendant's loss, $\Delta(\pi D + c_d)$. Therefore, if the defendant wanted to

[26] Sidak and Skog (2015) found that while the first few IPR challenges by Bass produced statistically significant negative returns (compared to the S&P 500 or NYSE pharmaceutical indices), the later challenges did not. The latter finding is consistent with the financial market incorporating the litigation-related information well before lawsuits are actually filed.

neutralize or mitigate the financial effect, the defendant would need to take a financial position in the plaintiff's stock, if possible, not in its own stock.[27]

2. Asymmetric Information

So far, we have assumed the plaintiff and defendant are symmetrically informed of all relevant aspects of the litigation. With symmetric information, the litigants never actually go to trial—lawsuits either settle out of court or are never filed (Proposition 1). In practice, while most cases are resolved before trial, some are not and the resulting trials often involve significant waste of private and public resources (Spier, 2007).

We now extend the model to include asymmetric information and show that trials occur in equilibrium. We demonstrate that the short-selling activities of the plaintiff will often increase—but may sometimes decrease—the number of cases that go to court. Short selling by the plaintiff harms the defendant if it enables lawsuits that would otherwise not be brought and/or increases the plaintiff's settlement demands. Perhaps surprisingly, the plaintiff's short position helps the defendant if, conditional on the lawsuit being filed, the plaintiff demands less to settle the case.

The timing is as follows. At $t = 0$, the plaintiff takes financial position Δ and the defendant privately observes the probability of being held liable, π, drawn from a commonly-known probability density function $f(\pi)$. We assume that $f(\pi)$ is continuously differentiable, strictly positive on its support $[0,1]$ and, as is standard in the literature, has a monotone hazard rate: $\frac{\partial}{\partial \pi}\left(\frac{f(\pi)}{1-F(\pi)}\right) > 0.$[28] At $t = 1$, the plaintiff approaches the defendant to negotiate a settlement. We follow the standard screening protocol of Bebchuk (1984) and Nalebuff (1987) and assume that the uninformed plaintiff makes a single take-it-or-leave-it offer to the informed defendant. If the offer is rejected, the plaintiff updates its beliefs about the defendant's type and decides whether to drop the case. The trial takes place at $t = 2$ and all financial claims are resolved at $t = 3$. Our solution concept is perfect Bayesian equilibrium.

[27] Even if the defendant were to take a financial position against the plaintiff's stock (when the plaintiff also has a stock that trades on a national exchange, for instance), the plaintiff enjoys the first mover advantage and the defendant may not want to take too strong a position to eliminate the possibility of settlement. The plaintiff's reservation value is $\underline{s}(\Delta)$ in equation (4), which converges to $\pi D + c_d$ as $\Delta \to -\infty$. When the defendant takes a financial position of γ against the plaintiff's stock, the defendant's reservation value may be written as $\overline{s}(\gamma) = \pi D - c_p + \left(\frac{c_p+c_d}{1-\gamma}\right)$, which converges to $\pi D - c_p$ as $\gamma \to -\infty$. Clearly, when γ gets too small, we get $\overline{s}(\gamma) < \underline{s}(\Delta)$, settlement breaks down, and the defendant expects to lose $\pi D + c_d$ at trial.

[28] This is true of many standard distributions, including uniform, normal, and exponential distributions.

The plaintiff's financial position will influence both the plaintiff's choice of settlement offer and the plaintiff's decision to drop the case or go to trial if the settlement offer is rejected. The defendant's decision to accept or reject the settlement offer depends on the defendant's type π and the probability that the plaintiff will drop the case or take it to trial. The credibility of the plaintiff's threat depends on the plaintiff's beliefs about the defendant's type π after the settlement offer is rejected.[29] To succeed in extracting a settlement from the defendant in equilibrium, the plaintiff must maintain a credible threat to litigate the case to judgment.

We proceed in several steps. Lemma 2 characterizes the plaintiff's optimal settlement offer in a simple benchmark scenario where it is impossible for the plaintiff to drop the lawsuit before trial. Lemma 3 characterizes beliefs that render the plaintiff indifferent between going to trial and dropping the case. Next, taking the financial position Δ as fixed, Proposition 3 characterizes the equilibrium of the settlement bargaining game. Finally, Proposition 4 describes the plaintiff's choice of financial position.

To begin, consider a simple benchmark scenario where the plaintiff is fully committed to taking the defendant to trial if the settlement offer is rejected. Suppose that the plaintiff offers to settle for an amount $\hat{s} = \hat{\pi}D + c_d$ where $\hat{\pi} \in [0,1]$. A defendant with threshold type $\pi = \hat{\pi}$ would be exactly indifferent between paying $\hat{s}$ in settlement and going to trial. The settlement offer separates the defendant types into two groups: types below the threshold ($\pi < \hat{\pi}$) reject the plaintiff's offer and go to trial, and types above the threshold ($\pi > \hat{\pi}$) accept it.[30] Given financial position Δ and threshold type $\hat{\pi}$, the plaintiff's expected payoff is:

$$W^p(\hat{\pi}, \Delta) \equiv \int_0^{\hat{\pi}} [\pi\lambda D - c_p + (R - \pi D - c_d - v_0)\Delta] f(\pi) d\pi \\ + \int_{\hat{\pi}}^1 [\hat{\pi}D + c_d + (R - \hat{\pi}D - c_d - v_0)\Delta] f(\pi) d\pi \tag{5}$$

The function $W^p(\hat{\pi}, \Delta)$ represents the plaintiff's payoff in a simple benchmark scenario where the plaintiff is committed to going to trial when offer is rejected. The first integral on the right-hand side is the plaintiff's expected payoff from those defendant types $\pi \in [0, \hat{\pi})$ who reject the settlement offer. For these types, the final market value v_3 will be either $R - D - c_d$ or $R - c_d$, depending on whether the plaintiff wins or loses at trial. So, conditional on the defendant's type π, the firm's expected market value is $R - \pi D - c_d$. The second integral

[29] This credibility issue is particularly important for the plaintiff who recovers only a small (or no) fraction of the damages paid by the defendant (i.e., when λ is small).

[30] Without loss of generality, we assume that when indifferent, the defendant accepts the plaintiff's settlement offer instead of rejecting it.

represents the plaintiff's payoff from those defendant types who accept the settlement offer $\hat{s} = \hat{\pi}D + c_d$. For types $\pi \in [\hat{\pi}, 1]$, the expected market value is $R - \hat{\pi}D - c_d$.

Taking the derivative of $W^p(\hat{\pi}, \Delta)$ with respect to the threshold type $\hat{\pi}$ gives:

$$\frac{\partial W^p(\hat{\pi}, \Delta)}{\partial \hat{\pi}} = -[(1-\lambda)\hat{\pi}D + c_p + c_d]f(\hat{\pi}) + (1-\Delta)D[1 - F(\hat{\pi})] \tag{6}$$

If the plaintiff raises the threshold $\hat{\pi}$ slightly, fewer defendant types accept the settlement offer. Consider the first term on the right-hand side. When a defendant of type $\hat{\pi}$ rejects the offer and goes to trial, the defendant loses $\hat{\pi}D + c_d$ and the plaintiff gains $\hat{\pi}\lambda D - c_p$, a joint cost of $(1-\lambda)\hat{\pi}D + c_p + c_d$. The second term represents the benefit to the plaintiff of raising the threshold, since all infra-marginal defendant types accept the higher settlement offer. The plaintiff benefits directly through the higher settlement received and, when $\Delta < 0$, the plaintiff benefits indirectly because the stock value v_3 is lower in light of the higher settlement amount.

Lemma 2 describes the threshold $\hat{\pi}(\Delta)$ that maximizes the plaintiff's expected payoff when it is impossible for the plaintiff to drop the case before trial.

Lemma 2. *Let* $\Delta_0 = 1 - f(0)(c_p + c_d)/D$. *When* $\Delta \geq \Delta_0$, *then* $W^p(\hat{\pi}, \Delta)$ *is maximized at a corner solution,* $\hat{\pi}(\Delta) = 0$. *When* $\Delta < \Delta_0$, *there exists a unique interior solution* $\hat{\pi}(\Delta) \in (0,1)$ *that maximizes* $W^p(\hat{\pi}, \Delta)$ *with* $\hat{\pi}'(\Delta) < 0$. $\lim_{\Delta \to \Delta_0} \hat{\pi}(\Delta) = 0$, *and* $\lim_{\Delta \to -\infty} \hat{\pi}(\Delta) = 1$.

Lemma 2 has important implications. When the plaintiff's financial position above a threshold, $\Delta \geq \Delta_0$, then the plaintiff prefers to settle with all defendant types and not take any cases to trial, $\hat{\pi}(\Delta) = 0$. When the plaintiff's financial position is below the threshold, $\Delta < \Delta_0$, then the plaintiff will settle with some but not all defendant types, $\hat{\pi}(\Delta) \in (0,1)$. Lemma 2 also tells us that $\hat{\pi}'(\Delta) < 0$ when $\Delta < \Delta_0$. As Δ becomes smaller—so the plaintiff's financial position is shorter—the threshold $\hat{\pi}(\Delta)$ and the corresponding settlement offer $\hat{s}(\Delta) = \hat{\pi}(\Delta)D + c_d$ rise. In our benchmark scenario, short selling leads to more aggressive settlement offers, fewer settlements, and more trials.

The threshold type $\hat{\pi}(\Delta)$ in Lemma 2 was constructed under the strong assumption that the plaintiff cannot drop the lawsuit after the settlement offer is rejected by the defendant. However, on reflection, it is evident that the plaintiff may not have a credible threat to go to trial. In our screening model, high defendant types accept settlement offers and low defendant types reject them. So, after the settlement offer $\hat{s}(\Delta) = \hat{\pi}(\Delta)D + c_d$ is rejected, the plaintiff faces a truncated distribution of defendant types on $[0, \hat{\pi}(\Delta))$. If $\hat{\pi}(\Delta)$ is too small, then the plaintiff would rather drop the case than go to trial. Of course, if the high defendant types anticipated this, they would not be willing to accept the settlement offer to begin with.

Lemma 3 describes the plaintiff's decision to drop the case or litigate when facing a truncated distribution of defendant types. For ease of notation, we let $m(\tilde{\pi}) \equiv E(\pi \,|q \leq \tilde{\pi}) = \int_0^{\tilde{\pi}} \pi \frac{f(\pi)}{F(\tilde{\pi})} d\pi$ be the expected mean probability that the plaintiff will win the case given that the distribution of defendant types $f(\pi)$ is truncated to lie on the interval $[0, \tilde{\pi})$. If all defendants with types $\pi \geq \tilde{\pi}$ accept a settlement offer, then the plaintiff is willing to take the remaining defendant types to trial (instead of dropping the case) when

$$\lambda m(\tilde{\pi})D - c_p - \Delta[m(\tilde{\pi})D + c_d] \geq 0 \tag{7}$$

If $\Delta > \Omega_1 = \frac{\lambda m(1)D - c_p}{m(1)D + c_d}$, the left-hand side is negative when $\tilde{\pi} = 1$ and hence is negative for all $\tilde{\pi} < 1$ as well. In this case, the plaintiff would strictly prefer to drop the case when facing the entire distribution of defendant types, and would therefore drop the case for any truncation. When $\Delta < \Omega_0 = -\frac{c_p}{c_d}$, the left-hand side is strictly positive when $\tilde{\pi} = 0$, and hence is positive for all for all $\tilde{\pi} > 0$. In this case, the plaintiff has a credible threat to go to trial even when facing the very strongest defendant type.

Lemma 3. *When $\Delta \in [\Omega_0, \Omega_1]$ then there exists a unique value $\bar{\pi}(\Delta) \in [0,1]$ where the plaintiff is just indifferent between dropping the case and going to trial when $f(\pi)$ is truncated to the interval $[0, \bar{\pi}(\Delta)]$. Furthermore, $\bar{\pi}(\Omega_0) = 0, \bar{\pi}(\Omega_1) = 1$, and $\bar{\pi}'(\Delta) > 0$.*

The threshold types $\hat{\pi}(\Delta)$ and $\bar{\pi}(\Delta)$ described in Lemmas 2 and 3 are important building blocks for constructing the perfect Bayesian equilibrium of the bargaining game. Suppose that the plaintiff offers to settle for $\hat{s}(\Delta) = \hat{\pi}(\Delta)D + c_d$, where $\hat{\pi}(\Delta)$ is defined in Lemma 2. If $\hat{\pi}(\Delta) > \bar{\pi}(\Delta)$, then the plaintiff's threat to go to trial with the truncated distribution $[0, \hat{\pi}(\Delta))$ is credible. When $\hat{\pi}(\Delta) > \bar{\pi}(\Delta)$, the plaintiff offers $\hat{s}(\Delta) = \hat{\pi}(\Delta)D + c_d$ and defendants with types above $\hat{\pi}(\Delta)$ accept the settlement offer and defendants with types below $\hat{\pi}(\Delta)$ reject the offer and are taken to court. If $\hat{\pi}(\Delta) < \bar{\pi}(\Delta)$, then the plaintiff would rather drop the case than litigate against defendants in the interval $[0, \hat{\pi}(\Delta))$. If the high defendant types anticipated this, they would refuse to accept the settlement offer.[31] When $\hat{\pi}(\Delta) < \bar{\pi}(\Delta)$, the plaintiff can restore credibility by raising the settlement offer from $\hat{s}(\Delta) = \hat{\pi}(\Delta)D + c_d$ to $\bar{s}(\Delta) = \bar{\pi}(\Delta)D + c_d$.

Proposition 3 describes the perfect Bayesian equilibrium of the settlement bargaining game, taking the plaintiff's financial position Δ as fixed. This characterization is facilitated by the facts that the threshold $\hat{\pi}(\Delta)$ is a decreasing function of Δ (Lemma 2) the credibility threshold $\overline{\pi}(\Delta)$ is an increasing function of Δ (Lemma 3). Specifically, given the properties of $\hat{\pi}(\Delta)$ and $\overline{\pi}(\Delta)$, there is a unique value Δ^* where the two thresholds coincide.

Proposition 3. *Suppose the plaintiff has taken a financial position Δ at $t = 0$ and makes a take-it-or-leave-it offer to the privately-informed defendant. There exists unique $\Delta^* \in [\Omega_0, \Omega_1)$ such that $\hat{\pi}(\Delta^*) = \bar{\pi}(\Delta^*)$.*

1. *If $\Delta \le \Delta^*$, then the plaintiff offers to settle for $s^*(\Delta) = \hat{\pi}(\Delta)D + c_d$. The defendant accepts if and only if $\pi \ge \hat{\pi}(\Delta)$ and if the offer is rejected the case goes to trial. If $\Delta < \Delta_0$, then $\hat{\pi}(\Delta) > 0$ and $ds^*(\Delta)/d\Delta < 0$: as Δ rises (falls), the settlement offer falls (rises), the settlement rate rises (falls), and the litigation rate falls (rises). If $\Delta > \Delta_0$, then $\hat{\pi}(\Delta) = 0$ and $ds^*(\Delta)/d\Delta = 0$.*

2. *If $\Delta \in (\Delta^*, \Omega_1]$, then the plaintiff offers to settle for $s^*(\Delta) = \bar{\pi}(\Delta)D + c_d$. The defendant accepts if and only if $\pi \ge \bar{\pi}(\Delta)$, and if the offer is rejected, the case goes to trial. $ds^*(\Delta)/d\Delta > 0$: as Δ rises (falls) the settlement offer rises (falls), the settlement rate falls (rises), and the litigation rate rises (falls).*

3. *If $\Delta > \Omega_1$, then the defendant rejects any positive offer and the plaintiff drops the case.*

When $\Delta \le \Delta^*$, the plaintiff offers to settle for $s^*(\Delta) = \hat{\pi}(\Delta)D + c_d$. This is the same settlement offer that the plaintiff made in the benchmark scenario with full commitment (Lemma 2). Taking a shorter position (a lower Δ) makes the plaintiff more aggressive in negotiations. Although trials are expensive for the plaintiff, the plaintiff also enjoys the silver lining of further reductions in the defendant's stock value. So the plaintiff becomes more willing to take the risk of settlement breakdowns. When the plaintiff takes a shorter position, the defendant is worse off, the settlement rate is lower, and the costs of litigation are higher.

[31] Therefore it is not a continuation equilibrium for the defendant to reject the offer $\hat{s}(\Delta) = \hat{\pi}(\Delta)D + c_d$ if and only if $\pi < \hat{\pi}(\Delta)$. As shown in the proof of Proposition 3 in the appendix, the plaintiff will use a mixed strategy of either proceeding to trial or dropping the case in equilibrium.

In contrast, when $\Delta \in (\Delta^*, \Omega_1]$, the plaintiff offers to settle for $s^*(\Delta) = \bar{\pi}(\Delta)D + c_d$, where $\bar{\pi}(\Delta)$ is defined in Lemma 3. Taking a shorter financial position makes the plaintiff less aggressive in this case. For this range of parameter values, the plaintiff must raise the settlement demand to maintain credibility to take the case to trial following the defendant's rejection of that demand. Taking a shorter position relaxes the plaintiff's credibility constraint, thereby allowing the plaintiff to lower its settlement demand. When $\Delta \in (\Delta^*, \Omega_1]$, taking a shorter position helps the defendant, raises the settlement rate, and reduces the costs of litigation.[32]

Proposition 4 describes the plaintiff's optimal choice of financial position.

Proposition 4. *Suppose the plaintiff makes a take-it-or-leave-it offer to a privately-informed defendant. If $\Delta_L > \Omega_1$, then the plaintiff's threat to go to trial cannot be made credible and so the plaintiff will take a neutral financial position, $\Delta^E = 0$. If $\Delta_L \le \Omega_1$, then the plaintiff's optimal financial position depends on the level of capital market efficiency and satisfies $\Delta^E \in [\Delta_L, min\{0, max\{\Delta^*, \Delta_L\}\}]$. As $\mu \to 1$, $\Delta^E \to min\{0, max\{\Delta^*, \Delta_L\}\}$; as $\mu \to 0$, $\Delta^E \to \Delta_L$.*

When the capital market is completely unaware of the lawsuit, $\mu = 0$, the plaintiff can make a handsome financial return selling the firm-defendant's stock short. In equilibrium, the plaintiff takes the shortest possible financial position. At the other extreme, when the market is strong-form efficient, $\mu = 1$, the plaintiff cannot obtain any financial return from trading the stock of the firm-defendant. Taking a short financial position is advantageous to the plaintiff insofar as it helps to relax the plaintiff's credibility constraint. When $\Delta^* < 0$, the plaintiff will take a short position $\Delta^E = \max\{\Delta^*, \Delta_L\} < 0$. Importantly, the settlement offer is lower with the short position than it would be with a neutral position, $s^*(\Delta^E) < s^*(0)$. This also benefits the defendant and reduces the litigation rate, as illustrated in the following numerical example.

Numerical Example. *Suppose that π is uniformly distributed on the unit interval, so that $f(\pi) = 1$ and $F(\pi) = \pi$, $D = 100$ and $c_p = c_d = 30$. Suppose further that the stakes are symmetric, $\lambda = 1$, the market is strong-form efficient, $\mu = 1$, and that there are no limits on short selling. As shown in Figure 1, $\Omega = [\Omega_0, \Omega_1] = [-1, 1/4]$, $\Delta^* = -1/8$, and*

$$\hat{\pi}(\Delta) = \frac{0.4 - \Delta}{1 - \Delta} \quad \text{and} \quad \bar{\pi}(\Delta) = \frac{0.6(1 + \Delta)}{1 - \Delta} \tag{8}$$

[32] See also Bolton and Oehmke (2011), who show that when a lender enters into a credit default swaps agreement and strengthens its bargaining position against a borrower, it can actually help the borrower by reducing the incentive to strategically default on the loan.

From Proposition 3, when $\Delta \leq \Delta^* = -1/8$, *the plaintiff offers* $s^*(\Delta) = 100\hat{\pi}(\Delta) + 30$; *when* $\Delta \in (-1/8, 1/4]$ *the plaintiff offers* $s^*(\Delta) = 100\overline{\pi}(\Delta) + 30$; *and when* $\Delta > 1/4$ *then the plaintiff drops (or does not file) the case. Using (5), and recognizing that the plaintiff's financial return is zero when* $\mu = 1$, $W^p(\tilde{\pi}(\Delta), \Delta) = \tilde{\pi}(\Delta)(50\tilde{\pi}(\Delta) - 30) + (1 - \tilde{\pi}(\Delta))(100\tilde{\pi}(\Delta) + 30)$ *where* $\tilde{\pi}(\Delta) \in \{\hat{\pi}(\Delta), \overline{\pi}(\Delta)\}$. *Since the market is strong-form efficient, the plaintiff's payoff* $W^p(\tilde{\pi}(\Delta), \Delta)$ *does not depend on* Δ *directly. When* $\Delta = 0$, $\overline{\pi}(0) = 3/5$ *and the plaintiff offers to settle for* $s^*(0) = 100\overline{\pi}(0) + 30 = 90$. *The plaintiff's average payoff is* $(3/5)(30 - 30) + (2/5)(90) = 36$ *and the defendant's average payoff is* $(3/5)(-30 - 30) + (2/5)(-90) = -72$. *When* $\Delta^* = -1/8$, $\overline{\pi}(\Delta^*) = 7/15$ *and the plaintiff offers to settle for* $s^*(\Delta^*) = 100\overline{\pi}(\Delta^*) + 30 = 76.\overline{66}$. *The plaintiff's average payoff is* $(7/15)(23.\overline{33} - 30) + (8/15)(76.\overline{66}) = 37.\overline{77}$ *and the defendant's payoff is* $(7/15)(-23.\overline{33} - 30) + (8/15)(-76.\overline{66}) = -65.\overline{77}$. *Thus, with short selling, the plaintiff and the defendant are both better off and there are fewer trials.*[33]

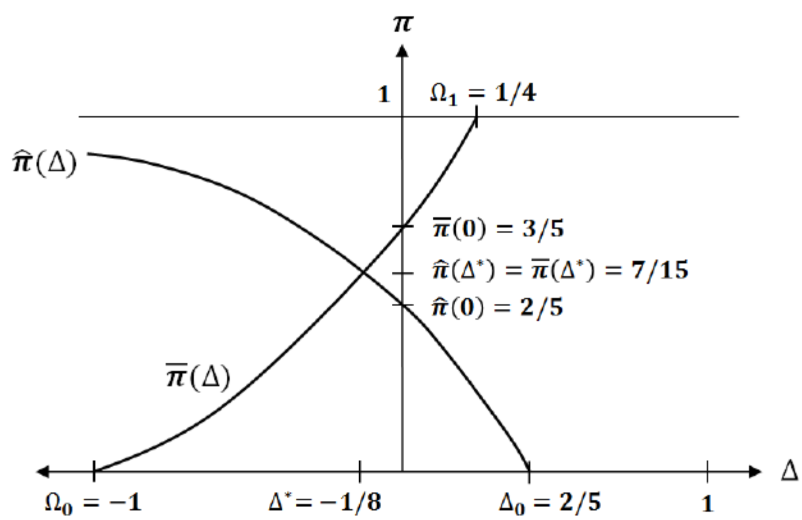

Figure 1: $\pi \sim U[0, 1]$, $D = 100$, $\lambda = 1$, $c_p = c_d = 30$

3. Conclusion

This paper has analyzed a model of litigation where the plaintiff has or can acquire a financial position in the firm-defendant. This issue has become quite salient recently when a hedge fund manager brought numerous patent challenges against pharmaceutical companies

[33] When $\Delta \leq \Delta^* = -1/8$ and the position becomes shorter (as Δ decreases), the settlement offer rises and the defendant becomes worse off.

while shorting their stock. The analysis has shown that the plaintiff gains a strategic advantage by taking a short position in the defendant's stock. This is true even with a fully forward-looking financial market, so that the plaintiff makes no positive return from the financial position. The strategic advantages are two-fold. First, when the lawsuit itself has a negative expected value, taking a short position against the defendant allows the plaintiff to turn the lawsuit into a positive expected value one. Second, the short position raises the minimum amount of settlement that the plaintiff is willing to accept, thereby improving the settlement return for the plaintiff. When the defendant is privately informed about the probability of winning at trial, the plaintiff balances the benefits of relaxing the credibility constraint against the costs of bargaining failure. When credibility is an issue, the paper has shown that short selling can sometimes benefit both the plaintiff and the defendant by making the plaintiff less aggressive in settlement demands and lowering the probability of going to a costly trial.

Our model is very stylized, but can be extended in various ways.[34] We have assumed that each party will bear its own litigation cost regardless of the outcome, as is typical in the United States. Notably, two recent Supreme Court cases have made it easier for the winning party in patent litigation to recover expenses from the losing party.[35] Once such a fee-shifting regime is imposed in our model, it will become more difficult for the plaintiff to pursue the short-and-sue strategy especially when the plaintiff's probability of prevailing at litigation is small. The reason is that when such a "frivolous" claim is filed, the defendant's total expected loss from litigation stays close to zero because the defendant doesn't expect to pay any damages and expects to recover its litigation expenses from the plaintiff. The defendant's stock price will move very little in response to the filing and it becomes more difficult for the plaintiff to realize any financial gain or use the financial position to extract a higher settlement offer. Empirically, we would expect to see less predatory short-selling by plaintiffs and fewer frivolous cases filed under a fee-shifting regime.[36]

Our model assumed that the plaintiff and defendant are risk neutral. When we relax the assumption of risk-neutrality and assume that the plaintiff is risk-averse, the short-and-sue strategy becomes less attractive for the plaintiff. The reason is that the short-and-sue strategy imposes a larger litigation risk on the plaintiff by magnifying the gains and the losses (through the financial position). As the plaintiff becomes more risk-averse, taking a short position against the defendant becomes less attractive and, with sufficient risk aversion, the plaintiff may even

[34] Formal analyses of the extensions are available from the authors upon request.
[35] *Octane Fitness, LLC v. Icon Health & Fitness, Inc.*, 134 S. Ct. 1749 (2014) and *Highmark Inc. v. Allcare Health Management System, Inc.*, 134 S. Ct. 1744 (2014).
[36] Conversely, when the plaintiff's probability of winning at trial is high, credibility is relaxed by both short selling and fee shifting. Empirically, we would expect to see more high-quality cases filed.

take a long financial position to hedge the risk. In contrast, if the defendant is risk averse, this puts the plaintiff in a stronger bargaining position and makes a sue-and-short strategy even more attractive. Empirically, sue-and-short tactics should be more common among plaintiffs who can easily diversify risk (e.g., hedge funds and other financial institutions) and defendants who are sensitive to risk or managed by risk-averse agents.

We assumed that taking a financial position is transactions-cost free. Transactions costs of taking a short position would of course decrease the attractiveness of a short-and-sue strategy. Suppose for example that the plaintiff's total cost of taking a position Δ is proportional to the market capitalization of the firm-defendant, $-\Delta k v_0 > 0$, where $k > 0$.[37] For the plaintiff to create a credible threat to go to trial, the plaintiff would need to pay at least $-\tilde{\Delta} k v_0 > 0$ where $\tilde{\Delta}$ is defined earlier in Lemma 1. Because the plaintiff's cost of shorting is proportional to the market capitalization of the firm-defendant, holding all else equal, plaintiffs should be more likely to bring patent challenges against smaller companies rather than against pharmaceutical behemoths since the relative stock-price impact is larger when the target is small.[38]

In our model, the plaintiff was a unitary actor with a single set of objectives and priorities. In practice, plaintiffs with different objectives often join forces in litigation. Consider securities class action litigation. Pursuant to the Private Securities Litigation Reform Act ("PSLRA"), institutional shareholders with a large bloc-holding are often chosen as the lead plaintiff with the power to manage and control the prosecution. The fact that the lead plaintiff holds a large long position on the defendant,[39] however, creates an intra-class conflict, particularly vis-à-vis plaintiffs who have either divested their shares or even taken a short position on the defendant. The securities class action against Cendant Corporation is exemplary. There, the lead plaintiff, CalPERS, maintained a substantial long position on Cendant, and when a settlement was proposed, other plaintiffs argued that CalPERS could not adequately represent the shareholders as a class due to the long position. Although the Third Circuit Court rejected the plaintiffs' argument, the court recognized the conflict and suggested that, going forward, the plaintiff class be divided into sub-classes to ensure adequate representation of shareholders with different financial positions.[40]

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[37] In practice, transactions costs would include (1) the costs of locating investors who are willing to lend the shares (issues of liquidity); (2) having to pay the "rebate rate" for borrowing the shares; (3) having to post collateral if the price of the shorted stock rises; and (4) being subject to recall by the lender. See Jones and Lamont (2002).
[38] In the Kyle Bass example, most of the pharmaceutical companies Bass targeted were relatively small.
[39] In most securities class actions, individual plaintiffs will be the first to file the claim and institutional investors are unable to divest their shares by the time the suit is filed. Institutional shareholders with diversified, long-term portfolio will also be unable to unload their shares of the defendant firm.
[40] *In re Cendant Corp. Litig.*, 264 F.3d 201 (3d Cir. 2001). See also Webber (2012).

While our paper focused on the implications of taking a financial position in one's opponent in the context of litigation, our insights extend to other competitive and adversarial settings. As described by others, long positions among competitors in the same industry can facilitate collusion while a short position by an incumbent can make predation against an entrant credible. Another type of adversarial behavior that has received much less attention is government lobbying. The recent case of a prominent hedge fund, Pershing Square, lobbying the Federal Trade Commission (FTC) to investigate and to bring an enforcement action against Herbalife, while maintaining a short position on the company, is illustrative (see Goldstein and Stevenson, 2016). While the Herbalife case did not involve a lawsuit and is not directly addressed by the paper, to the extent that a litigation involves spending of resources by private parties to convince a government entity (the court), the main analysis of the paper can be readily extended into such lobbying contexts.

Appendix A: Proofs

Proof of Lemma 2. Taking the derivative of (5) with respect to $\hat{\pi}$ gives the slope:

$$\frac{\partial W^p(\hat{\pi},\Delta)}{\partial \hat{\pi}} = \left[\hat{\pi}\lambda D - c_p + (R - \hat{\pi}D - c_d)\Delta\right]f(\hat{\pi}) \\ -[\hat{\pi}D + c_d + (R - \hat{\pi}D - c_d)\Delta]f(\hat{\pi}) + \int_{\hat{\pi}}^{1} D(1-\Delta)f(\pi)d\pi \quad \text{(A1)}$$

Canceling terms, this slope may be rewritten as

$$\frac{\partial W^p(\hat{\pi},\Delta)}{\partial \hat{\pi}} = -[(1-\lambda)\hat{\pi}D + c_p + c_d]f(\hat{\pi}) + (1-\Delta)D[1 - F(\hat{\pi})] \quad \text{(A2)}$$

which is (6) in the text. Since $(\pi) > 0$ $\forall \pi \in [0,1]$, this slope is negative as $\hat{\pi} \to 1$. Therefore $\hat{\pi}(\Delta) < 1$. Dividing by $1 - F(\hat{\pi}) > 0$ and $(1-\lambda)\hat{\pi}D + c_p + c_d > 0$, the slope is negative (positive) if and only if

$$\frac{(1-\Delta)D}{(1-\lambda)\hat{\pi}D + c_p + c_d} < (>) \frac{f(\hat{\pi})}{1 - F(\hat{\pi})}. \quad \text{(A3)}$$

The left-hand side is positive and weakly decreasing in $\hat{\pi}$ and the monotone hazard rate condition implies that the right-hand side strictly increasing in $\hat{\pi} \in (0,1)$. The right-hand side is equal to $f(0)$ when $\hat{\pi} = 0$ and approaches positive infinity as $\hat{\pi} \to 1$.

Define $\Delta_0 \equiv 1 - f(0)(c_p + c_d)/D$ and suppose $\Delta \geq \Delta_0$. Using the monotone hazard rate condition, $\frac{(1-\Delta)D}{(1-\lambda)\hat{\pi}D+c_p+c_d} \leq \frac{(1-\Delta_0)D}{c_p+c_d} = f(0) < \frac{f(\hat{\pi})}{1-F(\hat{\pi})}$ for all $\hat{\pi} \in (0,1)$. This implies that $\frac{\partial W^p(\hat{\pi},\Delta)}{\partial \hat{\pi}} < 0$ for all $\hat{\pi} \in (0,1)$ and so a corner solution is obtained at $\hat{\pi}(\Delta) = 0$ when $\Delta \geq \Delta_0$.

Now suppose instead that $\Delta < \Delta_0$. In this case, $\frac{(1-\Delta)D}{c_p+c_d} > \frac{(1-\Delta_0)D}{c_p+c_d} = f(0)$. So $\frac{\partial W^p(\hat{\pi},\Delta)}{\partial \hat{\pi}} > 0$ when $\hat{\pi} = 0$ and an interior solution $\hat{\pi}(\Delta) \in (0,1)$ is obtained. Finally, we will show that $\hat{\pi}'(\Delta) < 0$ when an interior solution exists. Letting $\varphi(\hat{\pi}) \equiv \frac{f(\hat{\pi})}{1-F(\hat{\pi})}$ be the monotone likelihood ratio and $(\hat{\pi},\Delta) = \frac{(1-\Delta)D}{(1-\lambda)\hat{\pi}D+c_p+c_d}$, we have that $\hat{\pi}(\Delta)$ is the implicit solution to $\phi(\hat{\pi}(\Delta),\Delta) = \varphi(\hat{\pi}(\Delta))$. Totally differentiating, we have $\frac{\partial\phi(\hat{\pi},\Delta)}{\partial\hat{\pi}}(d\hat{\pi}) + \frac{\partial\phi(\hat{\pi},\Delta)}{\partial\Delta}(d\Delta) = \frac{\partial\varphi(\hat{\pi},\Delta)}{\partial\hat{\pi}}(d\hat{\pi})$, and so the slope $\frac{d\hat{\pi}}{d\Delta} = \frac{\partial\phi(\cdot)/\partial\Delta}{\partial\varphi(\cdot)/\partial\hat{\pi} - \partial\phi(\cdot)/\partial\hat{\pi}}$. Since $\frac{\partial\phi(\cdot)}{\partial\Delta} < 0$, $\frac{\partial\phi(\cdot)}{\partial\hat{\pi}} < 0$, and $\frac{\partial\varphi(\cdot)}{\partial\hat{\pi}} > 0$ we have that $\frac{d\hat{\pi}}{d\Delta} < 0$ and we are done. ■

Proof of Lemma 3. By the definitions of Ω_0 and Ω_1, we have $\Omega_0 < \Omega_1$ and $\bar{\pi}(\Omega_0) = 0$ and $\bar{\pi}(\Omega_1) = 1$. Re-write equation (7) as:

$$(\lambda - \Delta)m(\bar{\pi}(\Delta))D - c_p - \Delta c_d = 0 \quad \text{(A4)}$$

Totally differentiating, we have $-m(\cdot)D(d\Delta) - c_d(d\Delta) + (\lambda - \Delta)D\frac{dm(\cdot)}{d\bar{\pi}}(d\bar{\pi}) = 0$. Rearranging terms, $\frac{d\bar{\pi}}{d\Delta} = \frac{m(\cdot)D + c_d}{(\lambda-\Delta)D\frac{dm(\cdot)}{d\bar{\pi}}}$. The numerator is positive. The denominator is positive because $\frac{dm(\cdot)}{d\bar{\pi}} > 0$ and $\Omega_1 = \frac{\lambda m(1)D - c_p}{m(1)D + c_d} < \frac{\lambda m(1)D + \lambda c_d}{m(1)D + c_d} = \lambda$ assures that $\lambda - \Delta > 0$ for all $\Delta < \Omega_1$. We therefore conclude that $\bar{\pi}(\Delta)$ exists, is unique, and $\bar{\pi}'(\Delta) > 0$ for $\Delta \in [\Omega_0, \Omega_1]$. ∎

Proof of Proposition 3. First, we show that there exists a unique fixed point $\Delta^* \in \Omega$ such that $\hat{\pi}(\Delta^*) = \bar{\pi}(\Delta^*)$. Lemma 2 implies that $\hat{\pi}(\Delta)$ exists, is continuous, and $\hat{\pi}'(\Delta) \leq 0$ for all $\Delta \in [\Omega_0, \Omega_1]$. Since $\bar{\pi}(\Omega_0) = 0$, $\bar{\pi}(\Omega_1) = 1$, and $\bar{\pi}'(\Delta) > 0$ $\forall \Delta \in \{\Omega_0, \Omega_1\}$ from Lemma 3, there must be a fixed point $\Delta^* \in \Omega$ where $\hat{\pi}(\Delta^*) = \bar{\pi}(\Delta^*)$. Further, since $\hat{\pi}'(\Delta) \leq 0 < \bar{\pi}'(\Delta)$ for all $\Delta \in \Omega$, we have that if $\Delta < \Delta^*$ then $\hat{\pi}(\Delta) \geq \bar{\pi}(\Delta)$ and if $\Delta > \Delta^*$ then $\hat{\pi}(\Delta) < \bar{\pi}(\Delta)$.

Case 1: We consider two subcases. Suppose $\Omega_0 \leq \Delta \leq \Delta^*$. We just showed that $\hat{\pi}(\Delta) \geq \bar{\pi}(\Delta)$. Suppose the plaintiff offers $\hat{\pi}(\Delta)D + c_d$ and the defendant accepts if and only if $\pi \geq \hat{\pi}(\Delta)$. Following the rejection of the offer, the plaintiff believes that $\pi < \hat{\pi}(\Delta)$. Since $\hat{\pi}(\Delta) \geq \bar{\pi}(\Delta)$, we have that $m(\hat{\pi}(\Delta)) \geq m(\bar{\pi}(\Delta))$ and so it is credible for the plaintiff to bring the defendant to trial. Suppose $\Delta < \Omega_0$. The plaintiff has a credible threat to litigate even when he believes he is facing the very lowest defendant type with $\pi = 0$. So the credibility constraint is not binding and the plaintiff chooses settlement offer $\hat{s}(\Delta)$ with threshold $\hat{\pi}(\Delta)$.

Case 2: Suppose $\Delta \in (\Delta^*, \Omega_1]$. We proved above that $\hat{\pi}(\Delta) < \bar{\pi}(\Delta)$ and so $m(\hat{\pi}(\Delta)) < m(\bar{\pi}(\Delta))$. We will now show that it is optimal for the plaintiff to offer $\bar{\pi}(\Delta)D + c_d$. To do this, we first prove the following claim.

> ***Claim 1.*** *Suppose $\Delta \in (\Delta^*, \Omega_1)$ and the plaintiff offers $\tilde{s} = \tilde{\pi}D + c_d$ where $\tilde{\pi} < \bar{\pi}(\Delta)$. In equilibrium, the defendant types $\pi < \bar{\pi}(\Delta)$ reject the settlement offer and the plaintiff proceeds to trial with probability $\sigma(\tilde{\pi}) = \frac{\tilde{\pi}D + c_d}{\bar{\pi}(\Delta)D + c_d}$.*
>
> ***Proof of Claim 1.*** The proof follows the analysis in Nalebuff (1987) closely. Since $\Delta > \Delta^*$ (as we are in case 2), we have $\hat{\pi}(\Delta) < \bar{\pi}(\Delta)$ and so $(\lambda - \Delta)m(\hat{\pi}(\Delta))D - c_p - \Delta\, c_d < 0$. We cannot have a continuation equilibrium where the plaintiff always proceeds to trial following the rejection of $\tilde{s} = \tilde{\pi}D + c_d$. If that were true, then $\pi < \tilde{\pi}$ would reject the offer since $(\lambda - \Delta)m(\tilde{\pi})D - c_p - \Delta\, c_d < 0$ and the plaintiff would drop the case, a contradiction. We cannot have a continuation equilibrium where the plaintiff always drops the case following rejection of the offer, $\tilde{s} = \tilde{\pi}D + c_d$. If that were true, then no defendant type would accept the offer. If all defendant types rejected, then since $\Delta < \Omega_1$, we have $(\lambda - \Delta)m(1)D - c_p - \Delta\, c_d > 0$ and so the plaintiff would go to trial rather than drop the case (a contradiction). The equilibrium, therefore, will involve a mixed strategy. For the plaintiff to be indifferent between proceeding to trial and dropping the case after the rejection of settlement offer of $\tilde{\pi} < \bar{\pi}(\Delta)$, it must be that all defendants with types $\pi < \bar{\pi}(\Delta)$ reject the offer, so that, conditional on rejection, we have so $(\lambda - \Delta)m(\bar{\pi}(\Delta))D - c_p - \Delta\, c_d = 0$. Let $\sigma(\tilde{\pi})$ be the probability that the plaintiff proceeds to trial upon rejection of $\tilde{\pi} < \bar{\pi}(\Delta)$. To make the defendant type $\bar{\pi}(\Delta)$ indifferent between

accepting and rejecting the settlement offer $\tilde{\pi}D + c_d$ we need $\sigma(\tilde{\pi})(\bar{\pi}(\Delta)D + c_d) = \tilde{\pi}D + c_d$, from which we get $\sigma(\tilde{\pi}) = \frac{\tilde{\pi}D + c_d}{\bar{\pi}(\Delta)D + c_d}$. This concludes the proof of Claim 1. ■

Coming back to the proof for case 2, now, we can show that the plaintiff's expected return is maximized by offering $\bar{\pi}(\Delta)D + c_d$. If the plaintiff chooses $\tilde{\pi} \le \bar{\pi}(\Delta)$, the plaintiff's expected return can be written as:

$$\int_0^{\bar{\pi}(\Delta)} (R - v_0)\Delta f(\pi)d\pi + \int_{\bar{\pi}(\Delta)}^1 [\tilde{\pi}D + c_d + (R - \tilde{\pi}D - c_d - v_0)\Delta] f(\pi)d\pi \qquad \text{(A5)}$$

The first term in this expression results from the plaintiff's indifference between going to trial and dropping the case following the rejection of the offer. Differentiating with respect to $\tilde{\pi}$, we get

$$D(1 - \Delta)\left(1 - F\left(\bar{\pi}(\Delta)\right)\right) > 0 \qquad \text{(A6)}$$

So the plaintiff would want to raise $\tilde{\pi}$ all the way up to $\bar{\pi}(\Delta)$. Now suppose instead that $\tilde{\pi} > \bar{\pi}(\Delta) > \hat{\pi}(\Delta)$. The plaintiff has a credible threat to litigate following the rejection of the settlement offer, and the plaintiff's payoff is $W^p(\tilde{\pi}, \Delta)$. Since $\tilde{\pi} > \hat{\pi}(\Delta)$, $W^p(\tilde{\pi}, \Delta)$ is decreasing in $\tilde{\pi}$. So the plaintiff would lower $\tilde{\pi}$ all the way down to $\bar{\pi}(\Delta)$.

Case 3: We now show that when $\Delta > \Omega_1$ the plaintiff will never take the defendant to trial. Suppose that this was not true, and that the plaintiff offers $\tilde{\pi}D + c_d$ and takes the defendant to trial with probability $\tilde{\sigma}$ if the offer is rejected. In this case, the defendant would reject the offer if $\tilde{\pi}D + c_d > \tilde{\sigma}(\pi D + c_d)$. Rearranging terms, the defendant rejects the offer if $\pi \in \left[0, \frac{\tilde{\pi}D + c_d(1-\tilde{\sigma})}{\tilde{\sigma}D}\right)$. The expected value of π on this interval is certainly smaller than $m(1)$. Therefore, since $\Delta > \Omega_1$, the plaintiff's threat to go to trial is never credible. Therefore, the plaintiff cannot succeed in extracting a settlement offer. ■

Proof of Proposition 4. When $\Delta_L > \Omega_1$, from Proposition 3, even with the shortest possible position, the plaintiff does not have a credible case against the defendant. Hence, $v_0(\Delta) = v_3(\Delta) = R$ and the plaintiff takes the neutral position against the defendant, $\Delta^E = 0$, and does not bring suit. So we will focus on the case where $\Delta_L \le \Omega_1$.

Take Δ as fixed and let $s^*(\Delta) = \tilde{\pi}(\Delta)D + c_d$ be the equilibrium settlement offer where $\tilde{\pi}(\Delta) \in \{\hat{\pi}(\Delta), \bar{\pi}(\Delta)\}$, as in Proposition 3. Recall that the initial equity market value of the firm defendant is $v_0(\Delta) = (1 - \mu)R + \mu E(v_3(\Delta))$, so that:

$$v_0(\Delta) = (1 - \mu)R + \mu\left(\int_0^{\tilde{\pi}(\Delta)} (R - \pi D - c_d) f(\pi)d\pi + \int_{\tilde{\pi}(\Delta)}^1 (R - \tilde{\pi}(\Delta)D - c_d)\, f(\pi)d\pi\right) \qquad \text{(A7)}$$

and rearranging

$$v_0(\Delta) = R - \mu\left(\int_0^{\tilde{\pi}(\Delta)} (\pi D + c_d) f(\pi) d\pi + \int_{\tilde{\pi}(\Delta)}^1 (\tilde{\pi}(\Delta) D + c_d)\, f(\pi) d\pi\right) \tag{A8}$$

which we may write as

$$v_0(\Delta) = R - \mu\Psi(\tilde{\pi}(\Delta)) \tag{A9}$$

where $\Psi(\tilde{\pi}(\Delta))$ is the defendant's expected loss (either through settlement or litigation). Note that $\Psi(\tilde{\pi}) > c_d > 0$ and is a strictly increasing function of the threshold $\tilde{\pi}$, and

$$\frac{d\Psi(\tilde{\pi}(\Delta))}{d\Delta} = \left[1 - F\left(\tilde{\pi}(\Delta)\right)\right]\tilde{\pi}'(\Delta) D \tag{A10}$$

Next, taking the derivative of $v_0(\Delta)$, we have:

$$v_0'(\Delta) = -\mu \frac{d\Psi(\tilde{\pi}(\Delta))}{d\Delta} = -\mu[1 - F\left(\tilde{\pi}(\Delta)\right)]\tilde{\pi}'(\Delta) D \tag{A11}$$

The sign of $v_0'(\Delta)$ hinges on whether $\tilde{\pi}'(\Delta)$ is positive or negative, which, in turn, depends on whether $\Delta > \Delta^*$ or $\Delta < \Delta^*$.

The plaintiff's expected return is:

$$\begin{aligned} W^p(\tilde{\pi}(\Delta), \Delta) = &\int_0^{\tilde{\pi}(\Delta)} [\pi\lambda D - c_p + (R - \pi D - c_d - v_0(\Delta))\Delta] f(\pi) d\pi \\ &+ \int_{\tilde{\pi}(\Delta)}^1 [\tilde{\pi}(\Delta) D + c_d + (R - \tilde{\pi}(\Delta) D - c_d - v_0(\Delta))\Delta] f(\pi) d\pi \end{aligned} \tag{A12}$$

Which using the expression for $v_0(\Delta)$ in (A8), the expected return can be written as:

$$\begin{aligned} W^p(\tilde{\pi}(\Delta), \Delta) = &\int_0^{\tilde{\pi}(\Delta)} [\pi\lambda D - c_p - (1-\mu)(\pi D + c_d)\Delta] f(\pi) d\pi \\ &+ \int_{\tilde{\pi}(\Delta)}^1 [\tilde{\pi}(\Delta) D + c_d - (1-\mu)(\tilde{\pi}(\Delta) D + c_d)\Delta] f(\pi) d\pi \end{aligned} \tag{A13}$$

Differentiating with respect to Δ, we get:

$$\begin{aligned} \frac{dW^p(\tilde{\pi}(\Delta), \Delta)}{d\Delta} = &-\tilde{\pi}'(\Delta)\left[(1-\lambda)\tilde{\pi}(\Delta) D + \left(c_p + c_d\right)\right] f\left(\tilde{\pi}(\Delta)\right) \\ &+ \tilde{\pi}'(\Delta)(1 - (1-\mu)\Delta) D[1 - F(\tilde{\pi}(\Delta))] \\ &-(1-\mu)\left(\int_0^{\tilde{\pi}(\Delta)} (\pi D + c_d) f(\pi) d\pi + \int_{\tilde{\pi}(\Delta)}^1 (\tilde{\pi}(\Delta) D + c_d)\, f(\pi) d\pi\right) \end{aligned} \tag{A14}$$

Using the definition of $\Psi(\tilde{\pi}(\Delta))$ from above and rearranging terms, we get:

$$\frac{dW^p(\tilde{\pi}(\Delta),\Delta)}{d\Delta} = \tilde{\pi}'(\Delta)\{-[(1-\lambda)\tilde{\pi}(\Delta)D + (c_p + c_d)]f(\tilde{\pi}(\Delta)) + (1-\Delta)D[1-F(\tilde{\pi}(\Delta))]\}$$
$$-(1-\mu)\Psi(\tilde{\pi}(\Delta)) + \mu\Delta D[1-F(\tilde{\pi}(\Delta))]\tilde{\pi}'(\Delta) \qquad \text{(A15)}$$

The first large term in curly brackets on the right hand side is the partial derivative of the plaintiff's expected payoff in (6) in the main text.

We now consider two cases: (1) $\Delta^* > 0$ and (2) $\Delta^* < 0$.

Case 1: $\Delta^* > 0$

In this case, we have $\Omega_0 < \Delta^* < \Delta_0$ and $\hat{\pi}(\Delta^*) = \overline{\pi}(\Delta^*) > 0$.

The firm will not choose $\Delta > \Delta^*$. Suppose it did choose $\Delta > \Delta^* > 0$. Then, using Proposition 3, $s^*(\Delta) = \overline{\pi}(\Delta)D + c_d$ and the firm's profits would be $W^p(\overline{\pi}(\Delta),\Delta)$, as defined above. Since the plaintiff's position is long, $\Delta > 0$, we have $W^p(\overline{\pi}(\Delta),\Delta) \leq W^p(\overline{\pi}(\Delta),0)$. (The plaintiff suffers a financial loss from a long position.) Suppose that the firm chooses a neutral position ($\Delta = 0$) instead. Since $0 < \Delta^*$, the firm subsequently offers $s^*(0) = \hat{\pi}(0)D + c_d$ (Proposition 3). Since $\hat{\pi}(0)$ maximizes $W^p(\hat{\pi},0)$, $W^p(\hat{\pi}(0),0) \geq W^p(\overline{\pi}(\Delta),0)$. Therefore, $W^p(\overline{\pi}(\Delta),\Delta) \leq W^p(\overline{\pi}(\Delta),0) \leq W^p(\hat{\pi}(0),0)$. This proves that the firm (at least weakly) prefers a neutral financial position to any $\Delta > \Delta^* > 0$.

Now consider $\Delta \leq \Delta^*$. Using Proposition 3, $s^*(\Delta) = \hat{\pi}(\Delta)D + c_d$ where $\hat{\pi}(\Delta) \in [0,1)$. Given that $\Delta < \Delta_0$, from Lemma 2, $\hat{\pi}(\Delta)$ is chosen optimally to maximize $W^p(\hat{\pi},\Delta)$ given Δ, so that $[-(1-\lambda)\hat{\pi}(\Delta)D - (c_p + c_d)]f(\hat{\pi}(\Delta)) + (1-\Delta)D\left(1-F(\hat{\pi}(\Delta))\right) = 0$ while $\hat{\pi}'(\Delta) < 0$. (This is simply an application of the envelope theorem.) We, therefore, are left with:

$$\frac{dW^p(\hat{\pi}(\Delta),\Delta)}{d\Delta} = -(1-\mu)\Psi(\hat{\pi}(\Delta)) + \mu\Delta D[1-F(\hat{\pi}(\Delta))]\hat{\pi}'(\Delta) \qquad \text{(A16)}$$

The firm will not choose $\Delta \in (0,\Delta^*]$. To see why, note that $-\Psi(\hat{\pi}(\Delta)) < -c_d < 0$ and since $\hat{\pi}'(\Delta) < 0$ we have $\Delta D[1-F(\hat{\pi}(\Delta))]\hat{\pi}'(\Delta) < 0$. So the weighted average with weights $(1-\mu)$ and μ is negative as well. Hence, $\Delta^E \leq 0 < \Delta^*$.

As $\mu \to 1$ the first term approaches zero for all $\hat{\pi}(\Delta)$ and the second term is positive for all $\Delta < 0$. Therefore, as $\mu \to 1$, the firm will choose $\Delta^E \to 0$. As $\mu \to 0$ the second term approaches zero for all Δ. The first term is strictly negative. Therefore, as $\mu \to 0$, $\Delta^E \to \Delta_L$.

Taken together, when $\Delta^* > 0$ and $\mu \in (0,1)$ we have $\Delta^E \in [\Delta_L, 0)$. As $\mu \to 1$, $\Delta^E \to 0$; and as $\mu \to 0$, $\Delta^E \to \Delta_L$. Also, when $\mu = 1$, $\Delta^E = 0$; and when $\mu = 0$, $\Delta^E = \Delta_L$.

Case 2: $\Delta^* < 0$

In this case, $\Omega_0 < \Delta^* < \Delta_0$ and $\hat{\pi}(\Delta^*) = \overline{\pi}(\Delta^*) > 0$ or $\Delta_0 \leq \Omega_0 = \Delta^*$ and $\hat{\pi}(\Delta^*) = \overline{\pi}(\Delta^*) = 0$.

First, suppose $\Delta > 0 > \Delta^*$. From Proposition 3, we have $s^*(\Delta) = \bar{\pi}(\Delta)D + c_d$. So the firm's profits are $W^p(\bar{\pi}(\Delta), \Delta)$ defined above. Recall, from case 1, that $W^p(\bar{\pi}(\Delta), \Delta) \leq W^p(\bar{\pi}(\Delta), 0)$. Since $\bar{\pi}'(\Delta) > 0$ and $\bar{\pi}(\Delta) > \hat{\pi}(\Delta)$ for all $\Delta > \Delta^*$, we have $\bar{\pi}(\Delta) > \bar{\pi}(0) > \hat{\pi}(0)$. Since $W^p(\pi, 0)$ is decreasing in π when $\pi > \hat{\pi}(0)$, and since $\bar{\pi}(\Delta) > \bar{\pi}(0)$ we have $W^p(\bar{\pi}(\Delta),0) < W^p(\bar{\pi}(0), 0)$. Therefore, $W^p(\bar{\pi}(\Delta), \Delta) < W^p(\bar{\pi}(\Delta),0) < W^p(\bar{\pi}(0), 0)$. So the firm would get higher profits from a neutral position, $\Delta = 0$, than from any $\Delta > 0 > \Delta^*$.

Now suppose that $\Delta \in (\Delta^*, 0]$. From Proposition 3, we have $s^*(\Delta) = \bar{\pi}(\Delta)D + c_d$ and the firm's profits are $W^p(\bar{\pi}(\Delta), \Delta)$. In this case, $\bar{\pi}(\Delta) > 0$. We will show that $\frac{dW^p(\bar{\pi}(\Delta),\Delta)}{d\Delta}$ from above is negative. First, from Lemma 3, we have $\bar{\pi}'(\Delta) > 0$. Second, since $\bar{\pi}(\Delta) > \hat{\pi}(\Delta)$, Lemma 2 and the monotone likelihood ratio property imply that $-\left[(1-\lambda)\bar{\pi}(\Delta)D + \left(c_p + c_d\right)\right] f\left(\bar{\pi}(\Delta)\right) + (1-\Delta)D\left(1 - F\left(\bar{\pi}(\Delta)\right)\right) < 0$. Third, since $\Psi\left(\bar{\pi}(\Delta)\right) > 0$, $-(1-\mu)\Psi\left(\bar{\pi}(\Delta)\right) \leq 0 \ \forall \mu \in [0,1]$. Fourth, when $\Delta \leq 0$, $\mu \Delta D\left(1 - F\left(\bar{\pi}(\Delta)\right)\right)\bar{\pi}'(\Delta) \leq 0$. Therefore, $\frac{dW^p(\bar{\pi}(\Delta),\Delta)}{d\Delta} < 0$.

Finally, suppose that $\Delta \leq \Delta^*$. As we showed in case 1 above, $s^*(\Delta) = \hat{\pi}(\Delta)D + c_d$ and we have

$$\frac{dW^p(\hat{\pi}(\Delta), \Delta)}{d\Delta} = -(1-\mu)\Psi\left(\hat{\pi}(\Delta)\right) + \mu \Delta D\left[1 - F\left(\hat{\pi}(\Delta)\right)\right]\hat{\pi}'(\Delta) \qquad \text{(A17)}$$

This is the same as (A16). This could be negative or positive $\forall \mu \in (0,1)$ since $-(1-\mu)\Psi\left(\hat{\pi}(\Delta)\right) < 0$ and $\mu \Delta D\left[1 - F\left(\hat{\pi}(\Delta)\right)\right]\hat{\pi}'(\Delta) \geq 0$ (since $\hat{\pi}'(\Delta) \leq 0$ and $\Delta \leq \Delta^* < 0$).

Suppose first that $\Omega_0 < \Delta_0$, so that $\Delta^* > \Omega_0$. In this case, $\hat{\pi}(\Delta^*) > 0$ and $\hat{\pi}'(\Delta) < 0$ for all $\Delta < \Delta^*$. When $\mu = 1$ the first term is zero for all $\hat{\pi}(\Delta)$ and the second term is strictly positive for all $\Delta < 0$. Therefore the plaintiff would like to raise the value of Δ. When $\mu = 0$ then the second term is equal to zero and the first term is strictly negative for all $\Delta < \Delta^*$. Now, suppose $\Delta_0 \leq \Omega_0 < 0$ so that $\Delta^* = \Omega_0$ and $\hat{\pi}(\Delta^*) = 0$. If $\Delta < \Delta_0$, we have $\hat{\pi}'(\Delta) < 0$ and the analysis is the same as before. If $\Delta \in [\Delta_0, \Omega_0]$, we get $\hat{\pi}'(\Delta) = 0$ so that the second term disappears while the first term is strictly negative. Therefore, the firm wants to choose the most negative possible position.

Taken together, when $\Delta^* < 0$ we have $\Delta^E \in [\Delta_L, \max\{\Delta^*, \Delta_L\}]$. When $\mu = 1$, $\Delta^E = \max\{\Delta^*, \Delta_L\}$; and when $\mu = 0$, $\Delta^E = \Delta_L$. ■

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Appendix B: Not for Publication

This appendix provides the formal details of several extensions. First, we explore the loser-pays rule for cost allocation, a rule that has gained momentum in patent litigation following two recent Supreme Court rulings.[41] Next, we consider risk aversion and the transactions costs of taking short positions. Fourth, we show how the model can be extended to account for endogenous litigation spending. Finally, we consider asymmetric information with a signaling protocol, where the informed defendant makes a take-it-or-leave-it offer to the plaintiff.

1. Loser-Pays Rule for Allocating the Costs of Litigation

Our model assumed that each side in litigation bears its own litigation cost, regardless of the trial outcome (the American Rule). With the English Rule, the loser of litigation must pay for its own costs as well as the costs of the winner. The plaintiff's expected return from trial is $\pi\lambda D - (1-\pi)(c_p + c_d)$ while the defendant's expected loss is $\pi D + \pi(c_p + c_d)$.

The plaintiff would prefer to go to trial rather than drop the case when the payoff from litigation, $\pi\lambda D - (1-\pi)(c_p + c_d) + [R - \pi(D + c_p + c_d) - v_0]\Delta$, is larger than the payoff from dropping, $(R - v_0)\Delta$, or

$$\Delta \leq \tilde{\Delta} = \frac{\pi\lambda D - (1-\pi)(c_p + c_d)}{\pi D + \pi(c_p + c_d)} \tag{B1}$$

This credibility threshold in (B1) may be either larger or smaller than the corresponding threshold under the American Rule (equation (2) in the main text). When $\pi > c_d/(c_p + c_d)$ then credibility is easier to achieve under the English Rule than the American Rule, and when $\pi < c_d/(c_p + c_d)$ then credibility is more difficult to achieve.[42] Note that if the case is entirely frivolous ($\pi = 0$) then there is no amount of short selling that can make the lawsuit credible.

If the plaintiff has a credible threat to go to trial, $\Delta \leq \tilde{\Delta}$, the most the defendant is willing to pay is

$$\overline{s} = \pi D + \pi(c_p + c_d) \tag{B2}$$

The least that the plaintiff is willing to accept equates the plaintiff's payoff from litigation (above) with the expected return from settling, $s + [R - s - v_0]\Delta$, which gives

$$\underline{s}(\Delta) = \pi D + \pi(c_p + c_d) - \left(\frac{1}{1-\Delta}\right)[(1-\lambda)\pi D + (c_p + c_d)] \tag{B3}$$

The bounds on the bargaining range with the English Rule in (B2) and (B3) are smaller than their American Rule counterparts in (3) and (4) if and only if $\pi < c_d/(c_p + c_d)$. As in the main text, by shorting the defendant's stock, the plaintiff can increase $\underline{s}(\Delta)$, thereby improving its bargaining position. In the limit as Δ approaches negative infinity, $\underline{s}(\Delta)$ converges to $\overline{s}$ and so the plaintiff extracts all the bargaining surplus from the defendant.

We have just shown that when the plaintiff's case is weak (in the sense that $\pi < c_d/(c_p + c_d)$), the credibility will require a more significant short position under the English Rule than the American Rule and the most that the plaintiff can hope to gain in settlement is smaller. When the case is totally frivolous ($\pi = 0$), since the firm will not incur any loss through trial under the English Rule, the firm valuation will remain constant throughout at R. This implies that the plaintiff cannot make any financial return by shorting the defendant's stock and cannot successfully extract a settlement offer. Thus, fee-shifting may be an effective policy instrument in preventing frivolous claims from going forward through financial maneuvering and limiting the amount of the settlements.

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[41] *Octane Fitness, LLC v. Icon Health & Fitness, Inc.*, 134 S. Ct. 1749 (2014) and *Highmark Inc. v. Allcare Health Management System, Inc.*, 134 S. Ct. 1744 (2014).

[42] See Rosenberg and Shavell (1985) for related results in models without financial investing.

2. Plaintiff Risk Aversion

Our baseline model assumed that the plaintiff and defendant are risk neutral, and evaluated the plaintiff's different options (drop, litigate, settle) at their expected value. We now relax that assumption, and show how plaintiff risk aversion will dampen the plaintiff's incentive to bring suit will reduce the plaintiff's bargaining power. We will also illustrate how risk aversion may reduce the benefits of a sue-and-short strategy, and may actually lead the plaintiff to take a long position in the defendant's stock.

For simplicity, we will assume that the stakes are symmetric, $\lambda = 1$, and that the plaintiff's utility has a simple mean-variance form. Given financial position Δ, the plaintiff's certainty equivalent of going to trial is $\pi D - c_p + (R - \pi D - c_d - v_0)\Delta - (1-\Delta)^2\rho$, where ρ is the plaintiff's risk premium from going to trial with a neutral financial position ($\Delta = 0$).[43] Note when $\rho > 0$, the plaintiff's certainty equivalent is an increasing function of Δ. Taking a longer financial position reduces the plaintiff's risk premium, raising the certainty equivalent of trial. The plaintiff has a credible threat to go to trial when the certainty equivalent of trial is larger than the plaintiff's return from dropping the case, $(R - v_0)\Delta$, or

$$\pi D - c_p - \Delta\,(\pi D + c_d) - (1-\Delta)^2\rho \geq 0 \qquad \text{(B4)}$$

Comparing this expression to equation (1) in the text, it is obvious that credibility is harder to achieve than before. The risk premium makes going to trial less attractive for the plaintiff. Note also that when the plaintiff is very risk averse (ρ is large), then there may exist no financial position that achieves credibility. Thus, risk aversion may thwart a sue-and-short strategy.

Even if the plaintiff does have a credible threat to bring the lawsuit to trial, risk aversion will tend to weaken the plaintiff's bargaining position. The least the plaintiff is willing to accept makes the plaintiff indifferent between going to trial (which has an associated risk premium of $(1-\Delta)^2\rho$) and settling out of court (which is safe). Comparing the alternatives, one can easily show that the least the plaintiff is willing to accept is

$$\underline{s}(\Delta) = \pi D + c_d - \left(\frac{1}{1-\Delta}\right)(c_p + c_d) - (1-\Delta)\rho \qquad \text{(B5)}$$

Comparing this expression to equation (4) in the main text when $\lambda = 1$, we see that $\underline{s}(\Delta)$ is lower that it was before, reflecting the riskiness of trial. It follows that when the bargaining parameter $\theta > 0$, a risk averse plaintiff will extract less in settlement than before. Finally, in contrast to our analysis without risk aversion, taking a shorter position is not always better for the plaintiff. There is a tradeoff: taking a shorter position makes the plaintiff tougher through the channel identified earlier, but also weakens the plaintiff through the risk premium. As a consequence, the optimal financial position will tend to be less short and, when the plaintiff is sufficiently risk averse, the optimal position may in fact be long.

3. Transactions Costs of Short Selling

Until this point, we have ignored any transactions costs of establishing and holding a short financial position. The model may be extended to include transactions costs of taking a short position. Suppose the plaintiff's cost of taking a short position is proportional to the magnitude of the short and is given by:

$$-\Delta k v_0(\Delta) > 0 \qquad \text{(B6)}$$

where $k > 0$ is a constant and $\Delta < 0$. These costs can include the foregone opportunity of funds when the plaintiff must hold money in a margin account.[44] Importantly, in this simple framework, it is more costly for the plaintiff to sell short 1% of a firm-defendant that has a large market capitalization than 1% of a firm-defendant with a small market capitalization.

[43] Letting a be the coefficient of absolute risk aversion, we have $\rho = (a/2)D^2\pi(1-\pi)$. See the binary model and discussion in Prescott et al. (2014).

[44] Although we take a reduced form approach on the transaction cost of shorting, there are several components to the cost: (1) cost of locating an investor who is willing to lend the shares (issues of liquidity); (2) having to pay the "rebate rate" for borrowing the shares; (3) having to post collateral if the price of the shorted stock rises; and (4) being subject to recall by the lender. See Jones and Lamont (2002).

This extension is very simple and abstracts away from the costs that would naturally accrue over time and from any nonlinearities in the cost structure. Nevertheless, it gives us the empirical prediction—one that should be robust to more complex environments—that plaintiffs are more likely to strategically establish short financial positions in their opponents when the expected stock price reaction from a trial is large relative to the firm-defendant's market capitalization. Thus, holding all else equal, plaintiffs should be more likely to bring patent challenges against smaller companies rather than against pharmaceutical behemoths since the relative stock-price impact is larger when the target is small.

4. Endogenous Litigation Costs

We now endogenize the parties' litigation spending using a standard Tullock (1980) contest framework.[45] The costs of litigation c_p and c_d are choice variables for the parties at trial and are chosen simultaneously and non-cooperatively. The probability that the plaintiff wins at trial is

$$\pi(c_p, c_d) = \frac{c_p^r}{c_p^r + c_d^r} \tag{B7}$$

where $0 < r \leq 1$.[46] When $r = 1$, this contest is a so-called "lottery contest," where the likelihood that the plaintiff wins, $c_p/(c_p + c_d)$, corresponds to his or her share of the total dollars spent. For simplicity, we will assume that the stakes are symmetric, $\lambda = 1$.

Conditional on financial position Δ, the plaintiff chooses c_p to maximize the net return from litigation and the financial investment, $\pi(c_p, c_d)D - c_p + [R - \pi(c_p, c_d)D - c_d - v_0]\Delta$, taking the defendant's expenditure c_d as fixed. The plaintiff's optimization problem is equivalent to $\max_{c_p} \pi(c_p, c_d)(1-\Delta)D - c_p$. The defendant chooses c_d to maximize $R - \pi(c_p, c_d)D - c_d$, taking c_p as fixed, or equivalently $\max_{c_d} [1 - \pi(c_p, c_d)]D - c_d$. This standard contest model with asymmetric stakes has the following solution:[47]

$$c_p^*(\Delta) = \frac{(1-\Delta)^{1+r}}{[1+(1-\Delta)^r]^2} rD,\ c_d^*(\Delta) = \frac{(1-\Delta)^r}{[1+(1-\Delta)^r]^2} rD, \text{ and } \pi(c_p^*(\Delta), c_d^*(\Delta)) = \frac{(1-\Delta)^r}{1+(1-\Delta)^r} \tag{B8}$$

In equilibrium, $c_p^*(\Delta) = c_d^*(\Delta)(1-\Delta)$. When the plaintiff takes the neutral financial position, $\Delta = 0$, then the plaintiff and defendant spend the same amount and the plaintiff wins half the time, $\pi(c_p^*(0), c_d^*(0)) = 1/2$. The plaintiff and defendant are on a level playing field in this special case. When the plaintiff takes a short position ($\Delta < 0$), the plaintiff has more to gain from litigation than the firm has to lose, since the plaintiff would gain the financial return from the short sale as well as from the litigation expenditure. The probability that the plaintiff wins exceeds one half with short selling. In the limit as Δ approaches negative infinity, the probability that the plaintiff will prevail at trial $\pi(c_p^*(\Delta), c_d^*(\Delta))$ approaches one.

Note that with fully variable litigation expenditures, without any fixed costs, the plaintiff has a credible threat to take the defendant to trial for all values $\Delta < 1$. This is true by revealed preference. Given c_d^*, the plaintiff would achieve the same payoff as dropping the case by spending $c_p = 0$. By spending more than zero, the plaintiff does strictly better.

We now allow the parties to negotiate a settlement before the contest takes place. Given Δ, the most the firm is willing to pay in settlement is:

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[45] Others have also used contest models to study litigation. See Spier (207).

[46] The assumption that $r \leq 1$ is a sufficient condition for the existence and uniqueness of a pure strategy Nash equilibrium for all values of Δ. See the Nti (1999 at 423).

[47] The equilibrium is characterized in the survey of Konrad (2009), page 45, and its proof will not be reproduced here. Letting the plaintiff be contestant 1 and the defendant be contestant 2, c_p and c_d correspond to expenditures x_1 and x_2, respectively, and $\pi(c_p, c_d)$ and $1 - \pi(c_p, c_d)$ correspond to $p_1(x_1, x_2)$ and $p_2(x_1, x_2)$ in the standard notation. The stakes for the plaintiff and defendant, $(1-\Delta)D$ and D correspond to v_1 and v_2 (in the standard notation).

$$\overline{s}(\Delta) = \pi(c_p^*(\Delta), c_d^*(\Delta))D + c_d^*(\Delta) \leq D \tag{B9}$$

This resembles equation (3) in the main text. The defendant's reservation value is now a function of Δ since the equilibrium litigation expenditures, $c_p^*(\Delta)$ and $c_d^*(\Delta)$, depend on Δ. The property that $\overline{s}(\Delta) \leq D$ follows from revealed preference. Since the defendant can guarantee itself an exposure of D by spending nothing at all, the most the defendant is willing to pay is capped at D. The least that the that the plaintiff is willing to accept is

$$\underline{s}(\Delta) = \pi(c_p^*(\Delta), c_d^*(\Delta))D + c_d^*(\Delta) - \left(\frac{1}{1-\Delta}\right)(c_p^*(\Delta) + c_d^*(\Delta)) \tag{B10}$$

This corresponds to equation (4) in the main text. Since $c_p^* = c_d^*(1-\Delta)$, this becomes

$$\underline{s}(\Delta) = \pi(c_p^*(\Delta), c_d^*(\Delta))D - \left(\frac{c_d^*(\Delta)}{1-\Delta}\right) \tag{B11}$$

Comparing the upper and lower bounds of the settlement range in (B9) and (B11), it is clear that $\overline{s}(\Delta) > \underline{s}(\Delta)$ for $\Delta < 1$. Thus, the bargaining range is nonempty for all values of Δ. The Nash bargaining solution gives $s(\Delta) = (1-\theta)\overline{s}(\Delta) + \theta\underline{s}(\Delta)$. Since $\overline{s}(\Delta)$ and $\underline{s}(\Delta)$ are decreasing functions of Δ (please see the proof below) we know that $s(\Delta)$ is also decreasing in Δ. In the limit as $\Delta \to -\infty$, $\pi(c_p^*, c_d^*) \to 1$ and $c_d^* \to 0$. Therefore, as $\Delta \to -\infty$, $\overline{s}(\Delta) \to D$ and $\underline{s}(\Delta) \to D$. By taking a very short position, the plaintiff will be able to extract a settlement arbitrarily cost to D.

<u>Claim:</u> *$d\overline{s}(\Delta)/d\Delta < 0$ and $d\underline{s}(\Delta)/d\Delta < 0$.*

<u>Proof of Claim:</u> Consider first $\overline{s}(\Delta)$ defined in (B9). Since the defendant chooses its litigation expenditure $c_d^*(\Delta)$ to minimize the right hand side of (B9), given its belief about the plaintiff's choice $c_p^*(\Delta)$, we need only consider the effect of Δ on $\overline{s}(\Delta)$ through the plaintiff's equilibrium expenditure, $c_p^*(\Delta)$ (the envelope theorem). We can rewrite $c_p^*(\Delta)$ above as $c_p^*(\Delta) = \frac{(1-\Delta)^{1-r}}{\left[\frac{1}{(1-\Delta)^r}+1\right]^2} rD$ and perform a change in variables where $z = 1-\Delta$ which gives $c_p^*(z) = \frac{z^{1-r}}{\left[\frac{1}{z^r}+1\right]^2} rD$. The numerator is increasing in z and the denominator is decreasing in z, so $c_p^*(z)$ is increasing in z so $c_p^*(\Delta)$ is decreasing in Δ. This concludes the demonstration that $d\overline{s}(\Delta)/d\Delta < 0$.

Now consider $\underline{s}(\Delta)$ defined in (B11). From (B8), we know that $\pi(c_p^*(\Delta), c_d^*(\Delta))$ is decreasing in Δ. We will now show that $-c_d^*(\Delta)/(1-\Delta)$ is decreasing in Δ. Using (B8) above and letting $z = 1-\Delta > 0$,

$$\varphi(z) \equiv \frac{-c_d^*(z)}{z} = \frac{-z^{r-1}}{[1+z^r]^2} rD \tag{B12}$$

Taking the derivative, we get:

$$\frac{\partial\varphi(z)}{\partial z} = \frac{-[1+z^r]^2(r-1)z^{r-2} + z^{r-1}2[1+z^r]rz^{r-1}}{[1+z^r]^4} rD \tag{B13}$$

$$\frac{\partial\varphi(z)}{\partial z} = \frac{[1+z^r]z^{r-2}}{[1+z^r]^4}\{-[1+z^r](r-1) + 2rz^r\} rD \tag{B14}$$

$$\frac{\partial\varphi(z)}{\partial z}=\frac{[1+z^r]z^{r-2}}{[1+z^r]^4}\{(1-r)+(1+r)z^r\}\,rD>0 \qquad \text{(B15)}$$

This last inequality follows from the fact that $z>0$ and $r\in(0,1)$. This implies that $-c_d^*/(1-\Delta)$ is decreasing in Δ, concluding the demonstration $d\underline{s}(\Delta)/d\Delta<0$. ■

5. Asymmetric Information: Signaling

In the main text, Section 2 assumed that the uninformed plaintiff made a single take-it-or-leave-it offer to the firm-defendant. We now adopt a bargaining protocol where the informed defendant makes a single take-it-or-leave-it offer to the uninformed plaintiff. The model closely follows the signaling model of Reinganum and Wilde (1986).[48] We characterize the fully-separating perfect Bayesian equilibrium where the offer fully reveals the defendant's type and makes the plaintiff indifferent between accepting the offer and rejecting the offer and going to trial. The plaintiff subsequently randomizes between accepting the offer and going to trial.[49] As in Reinganum and Wilde (1986), we assume that all cases have positive expected value (absent short selling by the defendant). Specifically, we assume that $f(\pi)$ is distributed on support $[\underline{\pi},1]$ where $\underline{\pi}D-c_p>0$. Although short selling is not necessary for credibility, it will improve the terms of settlement offered by the defendant. For simplicity, we restrict attention to symmetric stakes, $\lambda=1$.

Before analyzing the signaling model, let us briefly revisit the case of *symmetric information* where the defendant could make a take-it-or-leave-it offer to the plaintiff ($\theta=1$). Since $\pi D-c_p>0$ for all $\pi\in[\underline{\pi},1]$, the plaintiff has a credible threat to litigate absent short selling. If $\Delta=0$, then the defendant would offer $s(0)=\pi D-c_p$ and the plaintiff would accept. With short selling, the defendant would need to raise the settlement offer to get the plaintiff to accept. In the limit as $\Delta\to-\infty$, the defendant's settlement offer would converge to $\pi D+c_d$. With *asymmetric information*, the same basic force is at play. By taking a short position in the defendant's stock, the plaintiff can induce the defendant to make a more generous settlement offer. At the same time, short selling will distort the plaintiff's interim incentives, making it more likely that the plaintiff will reject the defendant's offer, and therefore more litigation will occur in equilibrium.

5.1 The Bargaining Outcome

Let the settlement offer made by the defendant of type π to a plaintiff with financial position Δ be denoted by $\sigma(\pi;\Delta)$. In a fully-separating equilibrium, the plaintiff infers the defendant's type from the offer and is indifferent between accepting the offer and going to trial. Thus, the settlement offer must be exactly the same as the lower bound of the settlement range characterized earlier:

$$\sigma(\pi;\Delta)\equiv\underline{s}(\Delta)=\pi D+c_d-\left(\frac{c_p+c_d}{1-\Delta}\right) \qquad \text{(B16)}$$

Note that this settlement offer is increasing in π, so higher offers correspond to higher defendant types. It is also decreasing in Δ, so shorter financial positions induce higher offers. Our earlier assumption that $\underline{\pi}D-c_p>0$ guarantees that the settlement offer $\sigma(\pi;\Delta)$ is strictly positive when $\Delta\le 0$. In the limit as $\Delta\to-\infty$, the entire schedule of offers converges to $\pi D+c_d$.

Let $p(\pi;\Delta)$ denote the equilibrium probability that the plaintiff accepts the offer $\sigma(\pi;\Delta)$. To construct a closed form solution for this probability, suppose the defendant is of type π and makes a settlement offer corresponding to type $\tilde{\pi}$ in the fully-separating equilibrium. After receiving an offer to settle for $\sigma(\tilde{\pi};\Delta)$, the plaintiff believes that the defendant is type $\tilde{\pi}$ and mixes with probability $p(\tilde{\pi};\Delta)$, giving the type π defendant an expected payment of

[48] In Reinganum and Wilde (1986), the plaintiff was privately informed and made an offer to the uninformed defendant.

[49] Pooling equilibria are eliminated with the D1 refinement of Cho and Kreps (1987).

$$p(\tilde{\pi};\Delta)\left[\tilde{\pi}D + c_d - \left(\frac{c_p + c_d}{1-\Delta}\right)\right] + \left(1 - p(\tilde{\pi};\Delta)\right)[\pi D + c_d] \tag{B17}$$

The first term represents the payments made by the defendant if the settlement offer is accepted; the second term represents the payments made if the case goes to trial.

Incentive compatibility requires that a defendant of type π would not want to misrepresent himself and pretend to be type $\tilde{\pi} \neq \pi$. Taking the derivative of (B17) with respect to $\tilde{\pi}$ and setting the slope equal to zero when $\tilde{\pi} = \pi$ gives:

$$p(\pi;\Delta)D - \frac{\partial p(\pi;\Delta)}{\partial\Delta}\left(\frac{c_p + c_d}{1-\Delta}\right) = 0 \tag{B18}$$

This is a first-order differential equation with general solution $p(\pi;\Delta) = \beta e^{\frac{\pi(1-\Delta)D}{c_p+c_d}}$ where β is an arbitrary constant. When $\beta > 0$ this function is increasing in π, so higher defendant types are more likely to accept. It must be the case that $p(1;\Delta) = 1$, so the defendant with the highest type has his offer accepted for sure. If this were not true, i.e., $p(1;\Delta) < 1$, the defendant could raise his offer slightly and the plaintiff would accept regardless of the beliefs held about the defendant's true type. Using this boundary condition of $p(1;\Delta) = 1$, we establish the value for the constant $\beta = e^{\frac{-(1-\Delta)D}{c_p+c_d}}$ and we have the following result.

Proposition 5. *Suppose the informed defendant makes a take-it-or-leave-it offer to the uninformed plaintiff who has taken financial position Δ at time $t = 0$. In the fully-separating Perfect Bayesian Equilibrium, the defendant offers $\sigma(\pi;\Delta)$ where $\frac{\partial\sigma(\pi;\Delta)}{\partial\Delta} < 0$ and $\lim_{\Delta\to-\infty}\sigma(\pi;\Delta) = \pi D + c_d$. The plaintiff accepts with probability*

$$p(\pi;\Delta) = e^{\frac{-(1-\pi)(1-\Delta)D}{c_p+c_d}} \tag{B19}$$

and goes to trial otherwise. $p(\pi;\Delta) > 0$, $p(1;\Delta) = 1$, $\frac{\partial p(\pi;\Delta)}{\partial\pi} > 0$, $\frac{\partial p(\pi;\Delta)}{\partial\Delta} > 0$, *and* $\lim_{\Delta\to-\infty} p(\pi;\Delta) = 0$ $\forall\pi \in [\underline{\pi}, 1)$.

Several observations are in order. First, the defendant's settlement offer $\sigma(\pi;\Delta)$ and the plaintiff's probability of acceptance $p(\pi;\Delta)$ are both increasing in the defendant's type π. To provide the incentive for the defendant to truthfully reveal his type, the plaintiff must be more likely to accept higher settlement offers than lower ones. Second, the settlement offer $\sigma(\pi;\Delta)$ is decreasing, and the probability of acceptance $p(\pi;\Delta)$ is increasing, in the plaintiff's financial position Δ. Thus, when Δ becomes smaller, the settlement offer gets larger and the plaintiff is more likely to reject the settlement offer and go to trial. Short selling by the plaintiff will increase the equilibrium rate of litigation.

5.2 The Plaintiff's Choice of Financial Position when the Market is Unaware

With the continuation equilibrium, we can now explore the plaintiff's optimal choice of Δ at $t = 0$ when the market is unaware of the lawsuit (corresponding to $\mu = 0$). To do this, we first construct the plaintiff's ex ante expected payoff from the game. Initially, suppose the financial market is unaware of the lawsuit so that the plaintiff can take a financial position Δ at $v_0 = R$. When the defendant makes a settlement offer of $\sigma(\pi;\Delta)$ and the plaintiff accepts, we get $v_3 = R - \sigma(\pi;\Delta)$. If the plaintiff rejects the offer, the expected value of the company, conditional on π at $t = 3$ is $R - \pi D - c_d$. In the former case, the plaintiff will make a financial return of $\Delta(R - \sigma(\pi;\Delta) - R) = -\Delta\sigma(\pi;\Delta)$, whereas in the latter case, the plaintiff expects to make a financial return of $\Delta(R - \pi D - c_d - R) = -\Delta(\pi D + c_d)$. When we combine the financial returns with the returns from litigation, the plaintiff's expected return as of $t = 0$ becomes:

$$\int_{\underline{\pi}}^{1} p(\pi;\Delta)\sigma(\pi;\Delta)(1-\Delta)f(\pi)d\pi + \int_{\underline{\pi}}^{1}(1-p(\pi;\Delta))\left((\pi D - c_p) - \Delta(\pi D + c_d)\right)f(\pi)d\pi \quad \text{(B20)}$$

The first part of this expression represents the plaintiff's return from accepting the settlement offer of $\sigma(\pi;\Delta)$ which happens with probability $p(\pi;\Delta)$. The second part of this expression represents the expected return from rejecting the settlement offer and proceeding to trial. Using the expressions for $\sigma(\pi;\Delta)$ and $p(\pi;\Delta)$ in equations (B16) and (B19) above, we can rewrite the plaintiff's ex ante payoff as:

$$V^p(\Delta) = (1-\Delta)\int_{\underline{\pi}}^{1}\left(\pi D + c_d - \left(\frac{c_p + c_d}{1-\Delta}\right)\right)f(\pi)d\pi = (1-\Delta)\int_{\underline{\pi}}^{1}\sigma(\pi;\Delta)\, f(\pi)d\pi \quad \text{(B21)}$$

This is intuitive since the defendant's settlement offer to the plaintiff makes the plaintiff indifferent, in terms of aggregate return, between accepting and rejecting. When we take the derivative with respect to Δ, we see that $V^p(\Delta)$ is strictly decreasing in Δ:

$$\frac{\partial V^p(\Delta)}{\partial \Delta} = \int_{\underline{\pi}}^{1} -(\pi D + c_d)f(\pi)d\pi < 0$$

This leads to the following result:

Proposition 6. *Suppose the informed defendant makes a take-it-or-leave-it offer to the uninformed plaintiff and the financial market is initially unaware of the lawsuit, so that $v_0 = R$. The plaintiff's ex ante payoff is maximized by taking as short a financial position as possible, $\Delta = \Delta_L$.*

5.3 The Plaintiff's Choice of Financial Position when the Market is Fully Aware

When the financial market is strong form efficient ($\mu = 1$), however, it may no longer make sense for the plaintiff to take the largest possible short position. With an informationally efficient capital market, the ex ante market value $v_0(\Delta)$ is equal to the expected future market value of the firm. As a consequence, the plaintiff cannot earn any direct return from its financial investing activities—the plaintiff will just break even on the short selling of the defendant's stock. The plaintiff may benefit from the short position indirectly, however, through its impact on the bargaining outcome.

Since the plaintiff's ex ante return from the financial investment is zero when the capital market is strong-form efficient, the plaintiff's expected ex ante payoff simply becomes:

$$\int_{\underline{\pi}}^{1} p(\pi;\Delta)\sigma(\pi;\Delta)f(\pi)d\pi + \int_{\underline{\pi}}^{1}(1-p(\pi;\Delta))(\pi D - c_p)f(\pi)d\pi \quad \text{(B22)}$$

Note that, compared to (B20), a financial position affects the plaintiff's return only by affecting the settlement offer $\sigma(\pi;\Delta)$ and the probability of acceptance $p(\pi;\Delta)$. Using the expressions for $\sigma(\pi;\Delta)$ and $p(\pi;\Delta)$, we can rewrite the plaintiff's ex ante payoff as:

$$V^p(\Delta) = \int_{\underline{\pi}}^{1}(\pi D - c_p)f(\pi)d\pi - \left(\frac{\Delta}{1-\Delta}\right)(c_p + c_d)\int_{\underline{\pi}}^{1} e^{\frac{-(1-\pi)(1-\Delta)D}{c_p + c_d}} f(\pi)d\pi \quad \text{(B23)}$$

Suppose that $\Delta = 0$ so the plaintiff takes no financial position. In this case, the second term is zero and the defendant will offer to settle for $\sigma(\pi;0) = \pi D - c_p$. The plaintiff's payoff, therefore, is exactly what it would be if the plaintiff went to trial against all defendant types. Suppose instead that the plaintiff takes a long position in the defendant's stock, $\Delta > 0$. In that case, the second term in expression (B23) is negative. Knowing that the plaintiff is in a weak bargaining position, the defendant would offer to settle for $\sigma(\pi;\Delta) < \pi D - c_p$ and the plaintiff is worse off ex ante. It is clear from (B23) that the plaintiff is strictly better off if he shorts the defendant's stock at time $t = 0$. When $\Delta < 0$, the second term is strictly positive. By taking a short position, the plaintiff induces the defendant to make a settlement offer $\sigma(\pi;\Delta) > \pi D - c_p$. At the same time, the probability of accepting the offer $p(\pi;\Delta)$ decreases as Δ falls, thereby making the plaintiff more likely to realize $\pi D - c_p$. When we take these two effects into account, we have the following result.

Proposition 7. *Suppose the informed defendant makes a take-it-or-leave-it offer to the uninformed plaintiff and the financial market is informationally efficient. There exists a* $\Delta^{**} \in (-\infty, 0)$ *that maximizes* $V^p(\Delta)$ *in (B23). The probability of litigation is higher, the plaintiff is better off, the defendant is worse off, and the litigation rate is higher when the plaintiff takes the short position* ($\Delta^{**} < 0$) *than when he does not* ($\Delta = 0$).

Proof of Proposition 7. *From (B23), we have* $V^p(0) = \int_{\underline{\pi}}^{1} (\pi D - c_p) f(\pi) d\pi$ *and*

$$\frac{\partial V^p(\Delta)}{\partial \Delta} = -\frac{c_p + c_d}{1 - \Delta} \int_{\underline{\pi}}^{1} \left(\frac{2 - \Delta}{1 - \Delta} p(\pi;\Delta) + \Delta \frac{\partial p(\pi;\Delta)}{\partial \Delta} \right) f(\pi) d\pi \qquad \text{(B24)}$$

where $\frac{\partial p(\pi;\Delta)}{\partial \Delta} = p(\pi;\Delta) \frac{(1-\pi)D}{c_p + c_d} > 0 \ \forall \pi \in [0,1)$. *From (B24), we see that* $\frac{\partial V^p(\Delta)}{\partial \Delta} < 0 \ \forall \Delta \in [0,1)$. *From (B16), we know that the plaintiff will not want to take a financial position of* $\Delta \geq 1$. *Also, from (B23), as* $\Delta \to -\infty$, $V^p(\Delta) \to \int_{\underline{\pi}}^{1} (\pi D - c_p) f(\pi) d\pi$ *since* $-\frac{\Delta}{1-\Delta} \to 1$ *while* $p(\pi;\Delta) \to 0 \ \forall \pi \in [0,1)$. *Hence, there exists a* $\Delta^{**} \in (-\infty, 0)$ *where* $V^p(\Delta)$ *is maximized. Since* $(\pi;\Delta^{**}) < p(\pi;0) \ \forall \pi \in [\underline{\pi}, 1)$, *the litigation rate is strictly higher for all defendant types except for type 1. Combined with the higher litigation rate, because* $(\pi;\Delta^{**}) > \sigma(\pi;0) \ \forall \pi \in [\underline{\pi}, 1)$, *all defendant types (except for type 1) are strictly worse off.* ■

With a strong form efficient financial market, the plaintiff does not realize a direct financial gain. With respect to the strategic benefit, there are two effects to consider. First, as Δ gets smaller, the schedule of settlement offers $\sigma(\pi;\Delta)$ increases and converges to $\pi D + c_d$. However, to maintain incentive compatibility, the plaintiff has to accept the offer with lower probability: $p(\pi;\Delta)$ falls as Δ gets smaller. In the limit as $\Delta \to -\infty$, the probability $p(\pi;\Delta)$ approaches zero for all $\pi < 1$. (When $\pi = 1$, $p(1;\Delta) = 1$ for all Δ.) The upshot is that while taking a very short position on the defendant's stock has the advantage of raising the defendant's offer, the reduced probability of acceptance at the interim stage mitigates the plaintiff's gain from the ex ante perspective. The plaintiff will, therefore, take a short position ($\Delta^{**} \in (-\infty, 0)$) that optimally balances these two effects.

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