Asymmetric Stakes in Antitrust Litigation*

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Abstract

Private antitrust litigation often involves a dominant firm being accused of exclusionary conduct by a smaller rival. In such cases, the defendant generally has a much larger financial stake in the outcome. We explore the implications of this asymmetry in a model of litigation with endogenous effort. Asymmetric stakes lead antitrust defendants to invest systematically more resources into litigation, causing a downward bias in the plaintiff's success probability—a distortion that carries over to ex ante settlements. Enhanced damages cannot prevent this systematic bias. We show that, in most private litigation contexts, asymmetric stakes do not create any distortion, because the prospect of ex post (post-judgment) settlement makes the litigants behave as if the stakes are symmetric. But this does not occur in antitrust, because it proscribes certain ex post settlements. We consider how courts might mitigate the distortion by altering the plaintiff's evidentiary burden.

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1 Introduction

Private antitrust litigation frequently involves a dominant firm being accused of anticompetitive exclusionary conduct by a smaller rival or prospective entrant. A key fact about such disputes, which is independent of the merit of the plaintiff's complaint, is that the defendant typically has a much larger financial stake in the outcome of litigation. The dominant firm is attempting to protect monopoly profits, while the smaller plaintiff is seeking to maintain a modest position in a more competitive market. The result is that the defendant has an incentive to spend significantly more to thwart the plaintiff's efforts than the latter would pay to achieve a viable competitive position.[1]

For example, suppose that, if the dominant defendant's conduct is allowed to persist, the plaintiff-rival will fail and exit the market, resulting in a monopoly profit of $100 for the defendant and no profits for the plaintiff. But if the court issues an injunction to halt the defendant's conduct, the plaintiff will remain operational and earn $15 through ordinary competition, while the defendant will earn $55. As these numbers reflect, monopoly—whether obtained through anticompetitive conduct or a procompetitieve efficiency—typically generates larger total profits than competition. The result is that the defendant *must* have a larger stake in the outcome of litigation. On these numbers, the plaintiff stands to gain $15 if it prevails, whereas the defendant's losses would be $45.

In this paper, we examine the broad implications of asymmetric stakes for antitrust policy and enforcement. We introduce a model of litigation with endogenous effort, meaning that each firm chooses the amount of resources it will invest in litigation in order to influence its chances of prevailing.[2] In the model, a court renders a final decision based on a noisy signal whose distribution depends on both: (a) the underlying merit of the plaintiff's complaint, which can range from very strong to very weak; and (b) the firms' investments in litigation. When the firms invest equal amounts, the signal is unbiased and the plaintiff's winning probability is entirely commensurate with the merit of its complaint. But when the firms invest different amounts the probability will be biased in favor of the firm that spent more.

Consideration of endogenous investment in litigation is particularly apropos in antitrust, where discovery is often very broad-sweeping and complex and the parties generally spend considerable amounts on economic consultants and expert witnesses. Economic evidence often drives the outcome, and hence litigants often spend enormous amounts on econometric

[1] Gilbert and Newbery (1982) explored the impact of this asymmetry on R&D competition.

[2] There are diminishing marginal returns to such investments, however.

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studies, simulation models, and surveys. Judges often rely heavily on such analyses, making their production a very fruitful investment for the litigants.

A key initial result in Section 2 is that the firms' asymmetric stakes leads the dominant defendant to invest significantly more in equilibrium, leading to a downward bias in the plaintiff's probability of success. The result is that litigation outcomes are systematically distorted in defendants' favor. This undermines deterrence of anticompetitive practices. While enhanced damages can help to reduce the extent of the distortion, they cannot eliminate it.[3]

In Section 3, we apply our model to the interplay between asymmetric stakes and settlement. As a benchmark for comparison, we show that in most private litigation contexts, asymmetric stakes will *not* have a biasing effect in equilibrium, provided that the parties can effectively contract around a court's judgment. The prospect of ex post (post-judgment) settlement then influences the parties' incentives at the litigation stage, making them behave as if the stakes were symmetric. This result is an application of the Coase theorem: if the parties will contract around a judgment that fails to maximize their joint-welfare, then the court's decision will merely determine whether one litigant will have to pay the other ex post. But then both parties' stakes reduce to this payment, along with any damages the court might award.

Critically, however, antitrust law generally prohibits otherwise-profitable ex post settlements in which a losing defendant pays the plaintiff for the right to continue a practice that has just been declared anticompetitive. As a result, the prospect of ex post settlement does not prevent the firms' asymmetric stakes from distorting litigation outcomes in equilibrium. We also address ex ante (pre-judgment) settlements wherein the defendant agrees to partially reduce its disputed conduct. The distortion created by asymmetric stakes leads these settlements to be systematically under-competitive. Our analysis further considers the firms' shared incentive to strike ex ante settlements in which the defendant pays cash to continue its disputed conduct in full. We argue that these settlements should be deemed anticompetitive, although their legality is surprisingly unsettled in existing case law.

Section 4 demonstrates that courts could in principle counter the systematic distortion created by asymmetric stakes by reducing the plaintiff's evidentiary burden. We extend our model to accommodate judicial presumptions, which act to predispose the court toward one outcome or the other. The optimal presumption is determined by Bayesian inference; it accounts for not only the distortionary effect of asymmetric stakes, but also a legal author-

[3]This is because damages increase both firms' stakes by the same amount.

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ity's priors about the nature of the defendant's conduct—namely its propensity to cause anticompetitive harm. Relative to a presumption that accounts only for the nature of the defendant's conduct, the optimal presumption will always be more favorable to the plaintiff.

In Section 5 we address several extensions to our baseline analysis. Among other things, we consider whether the distortion created by asymmetric stakes can be avoided in class action litigation by injured consumers, or when there are multiple injured rivals suing the defendant in tandem. However, due to various externality and principal-agent problems, we conclude that the distortion will generally persist in these cases. Similarly, we find that fee shifting does not solve the problem.

Finally, in Section 6, we consider the possibility that some of our results extend beyond the antitrust context. Specifically, we consider how other areas of law may constrain ex post settlement in ways that lead asymmetric stakes to generate a distortionary effect in equilibrium. There are relatively few other areas of private litigation in which it is routinely unlawful to contract around certain types of judgments, although IP law is a notable exception. However, there are many situations in which ex post settlements are lawful, but nevertheless cannot void all consequences of the court's judgment (e.g. its collateral effects on third party suits), in which case asymmetric stakes may still have a distortionary effect.

1.1 Related Literature

The asymmetric stakes in inter-competitor antitrust litigation arise because it is more profitable to preserve monopoly power than to invigorate competition. In their seminal paper, Gilbert and Newbery (1982) considered the same profit disparity in the context of R&D competition. By contrast, we explore its impact on antitrust enforcement via litigation with endogenous effort. This similarly involves a kind of investment game between rivals, although the relevant policy implications are quite distinct.

Our analysis contributes to the literature on the economics of private litigation. Cooter and Rubinfeld (1989) and Spier (2007) discuss some of the major issues commonly addressed in the literature.[4] As in our paper, some articles consider litigation with endogenous effort.[5] A novelty of our model is that the firms' expenditures influence litigation outcome probabilities

[4]One branch of the literature focuses on how asymmetric beliefs or information may result in a failure to settle (e.g. Priest and Klein, 1984; Waldfogel, 1998; Lee and Klerman, 2016). However, our analysis will not consider these possibilities, and will focus instead on the role of asymmetric stakes.

[5]E.g., Choi and Sanchirico (2004); Salkin (2013); Friedman and Wickelgren (2014); Rosenberg and Spier (2014). A related literature studies the economics of contests (e.g. Tullock, 1980; Skaperdas, 1996).

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by altering the distribution of a noisy signal reflecting judicial uncertainty. The model most similar to ours is that of Katz (1988).[6] A few authors have considered how asymmetric stakes may bias litigation outcome probabilities (e.g. Rosenberg, 1984; Salkin, 2013; Rosenberg and Spier, 2014). However, to our knowledge, we are the first to highlight the role of ex post settlement in determining whether asymmetric stakes will have a biasing effect in equilibrium.

There are many papers addressing antitrust restrictions on settlement.[7] Although these articles focus largely on IP settlements, we make analogous arguments in Section 3. Schwartz and Wickelgren (2011) address the efficacy of private antitrust litigation between rivals in curtailing undesirable exclusionary practices. While we discuss deterrence in Section 2.3, our focus is primarily on the problematic bias created by asymmetric stakes when litigation effort is endogenous. As we argue in Section 2.3, enhanced damages will reduce the distortionary effect of asymmetric stakes, although they cannot eliminate it. Choi and Spier (2019) consider the ability of class action litigation to deter anticompetitive behavior (namely collusion), which we address in the context of exclusionary conduct litigation in Section 5. Salop and White (1986) consider the efficacy of treble damages in antitrust disputes between competitors.[8]

Many papers derive optimal legal standards, presumptions, or proof burdens, using a Bayesian approach.[9] In Section 4, we similarly rely on Bayesian inference in considering judicial reliance on presumptions to modify plaintiffs' evidentiary burden. Friedman and Wickelgren (2014) is germane to this analysis, as the authors consider the relevance of endogenous litigation effort to the comparative efficacy of rules versus standards.

2 Model

In this section, we introduce our baseline game of litigation with endogenous effort and derive the equilibrium. There are two competing firms, $i = 1, 2$. Firm 2 (the defendant) is a

[6]Katz (1988) involves a similar signaling structure. In that model, the parties' expenditures (and the merits of the plaintiff's complaint) affect the threshold value that the signal realization must surpass in order for the plaintiff to win. By contrast, in our model the parties' expenditures (and the merits) distort the distribution of the signal, while leaving the relevant threshold value unchanged.

[7]See, e.g., Kaplow (1984); Meurer (1989); Shapiro (2003); Hemphill (2006); Carrier (2014); Edlin et al. (2015); Hovenkamp (2018); Hovenkamp and Lemus (2019). See also Friedman and Wickelgren (2008) for a more general discussion of how private settlements may countervail substantive policy interests.

[8]C.f. Polinsky and Shavell (1998), which discusses the economics of punitive damages generally.

[9]See, e.g., Kaplan (1967); Froeb and Kobayashi (1996); Posner (1998); Bernardo et al. (2000); Friedman and Wickelgren (2006); Ayres and Nalebuff (2015); Salop (2015). See also Kaplow (2011), which considers a non-Bayesian notion of optimal proof burdens.

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dominant firm that is being sued by firm 1, a smaller rival (or a prospective entrant). Firm 1 is alleging that firm 2 is engaging in an exclusionary practice (e.g. exclusive dealing, tying, or acquisitions of critical input suppliers). Firm 2's conduct generates a change w in consumer welfare. The interpretation is that the defendant's conduct is anticompetitive (and therefore unlawful under antitrust's consumer welfare standard) if $w < 0$, but procompetitive if $w \geq 0$. We assume that the value of w is common knowledge as between the firms, but cannot be directly observed by a court.[10]

At the outset of litigation, the two firms make simultaneous choices of litigation expenditures, denoted $x_i \geq 0$ for each firm i.[11] We interpret x_i as firm's i's endogenous effort in litigation. Each litigant must choose the number and quality of attorneys, experts, and consultants it will hire, which will influence the strength of its position in litigation, and x_i captures the total cost of those choices. All else being equal, an increase in x_i will increase firm i's probability of winning (subject to diminishing returns, as described below).

If the court could directly observe the consumer welfare effect w, then there would be no risk of errors in litigation outcomes: the court would correctly condemn every anticompetitive practice, while also correctly condoning every procompetitive one. However, due to imperfect information and the complexities of antitrust subject matter, this is not possible. Instead, we assume that the court observes only a stochastic signal (a noisy estimate) of w, given by

$$y \sim \Phi(\cdot|\mathbf{x}, w).$$

That is, y is drawn from a signal distribution Φ that depends on both the true welfare effect w and the strategy profile $\mathbf{x} = (x_1, x_2)$. However, the court does not observe w or $\mathbf{x}$; it observes only the noisy signal y, which it relies upon as its estimate of w. Accordingly, the court rules in the plaintiff's favor if and only if $y < 0$.

The court thus treats the signal y as if it is unbiased in the sense that $\mathbb{E}[y|\mathbf{x}, w] = w$, although this is not necessarily true.[12] We assume for now that if the signal is biased ($\mathbb{E}[y|\mathbf{x}, w] \neq w$), this is attributable solely to asymmetric litigation expenditures. That is, Φ is in general

[10]This assumption need not be taken literally. In practice, firms will not know w exactly, but they will still have some private information bearing on the likelihood of anticompetitive harm. Our model can be modified so that w is an expected value reflecting private information, but this adds structure without changing our results. Ultimately, what matters is just that the firms are better informed than the judge.

[11]In practice, one expects that there is some bare-minimum cost $c_i > 0$ that a litigant must incur, although it can make an additional discretionary expenditure x_i to improve its chances. However, we normalize $c_i = 0$.

[12]In Section 4, we consider the possibility that the court relies on Bayesian inference to account for a biasing effect of asymmetric litigation expenditures, as well as any underlying predisposition of the defendant's conduct toward pro- or anticompetitive effects.

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biased, but it reduces to an unbiased distribution in the symmetric case $x_1 = x_2$. Further, we assume that such bias always favors the firm that spends more. These points are captured by the following pair of assumptions:

Assumption 1. Φ obeys the relation

$$\Phi(y|\mathbf{x}, w) = \frac{F(y|w)x_1}{F(y|w)x_1 + [1 - F(y|w)]x_2}, \tag{1}$$

where $F(y|w)$ is a cumulative distribution function with density $f(y|w) \equiv \partial F(y|w)/\partial y$ and support $\mathbb{R}$.[13]

Assumption 2. $f(y|w)$ is symmetric about w and depends only on the difference $|y - w|$.[14]

These assumptions lead the signal distribution to exhibit the following properties. (All omitted proofs are in the Appendix.)

Proposition 1. Φ *has the following properties:*

(i) $\mathbb{E}[y|\mathbf{x}, w] = w$ *if and only if* $x_1 = x_2$.

(ii) $\Phi(y|\mathbf{x}', w) < \Phi(y|\mathbf{x}, w)$ *if and only if* $x_2'/x_1' > x_2/x_1$.

(iii) $\Phi(y|\mathbf{x}, w') < \Phi(y|\mathbf{x}, w)$ *if and only if* $w' > w$.

These results capture a number of desirable and intuitive properties, which we now discuss in turn.

Expenditure-driven bias. Condition (i) states that the signal distribution is unbiased if and only if litigation expenditures are symmetric ($x_1 = x_2$). This is because Φ reduces to an unbiased distribution F in this case, whereas Φ skews away from F when expenditures are asymmetric. By condition (ii), this bias always favors the firm who spends more: if firm 2 spends more, then higher values of y become relatively more likely (which benefits firm 2), and vice versa. More concretely, condition (ii) implies that, if $x_2'/x_1' > x_2/x_1$, then $\Phi(\cdot|\mathbf{x}', w)$ is first-order stochastically dominant over $\Phi(\cdot|\mathbf{x}, w)$, and vice versa.

[13]Technically condition (1) is undefined when $x_1 = x_2 = 0$. But note that $\Phi = F$ whenever $x_1 = x_2 > 0$. Thus, we may naturally assume that $\Phi = F$ when $x_1 = x_2 = 0$ as well. But this is ultimately irrelevant, as the firms will always choose $x_1, x_2 > 0$ in equilibrium.

[14]The latter condition means that for any w and w' we have $f(w - a|w) = f(w' - a|w')$ for any scalar a.

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Expenditure offset. Condition (ii) also implies that the firms' litigation expenditures offset one another to some extent. This is because condition (ii) implies that Φ is *homogeneous of degree zero* with respect to $\mathbf{x}$: it obeys $\Phi(\cdot|\lambda\mathbf{x}, w) = \Phi(\cdot|\mathbf{x}, w)$ for any scalar $\lambda > 0$. In words, if both expenditures are scaled up or down by a common factor, the distribution is left unchanged.

Dependence on w. Condition (iii) says that the true welfare effect w affects the signal distribution independently of $\mathbf{x}$, implying that the underlying merit of the plaintiff's complaint always matters. Specifically, if $w' > w$, then $\Phi(\cdot|\mathbf{x}, w')$ first-order stochastically dominates $\Phi(\cdot|\mathbf{x}, w)$.

Diminishing returns. The influence of each firm's expenditure on the signal distribution (and hence the plaintiff's success probability) is subject to diminishing returns. That is, each additional dollar of expenditure has a smaller influence than the previous one. This follows from (1), which implies that Φ (resp. $1 - \Phi$) is strictly concave in x_1 (x_2).[15]

Finally, we note that most of this paper's qualitative results are ultimately driven by a disparity in the firms' equilibrium expenditures (to be proven shortly). As a robustness check, Section 5.4 demonstrates that this disparity continues to arise under much weaker assumptions on the signal distribution.

2.1 Outcome Probabilities and Claim Merit

In a perfect world, the plaintiff's winning probability would be unity if the defendant's conduct is anticompetitive ($w < 0$) and zero otherwise. But this is not a realistic goal, as the court faces uncertainty over the value of w. We will therefore rely on a weaker normative benchmark for the plaintiff's winning probability. Define $\alpha = \alpha(w)$ by

$$\alpha \equiv F(0|w). \tag{2}$$

Conditional on w, α gives the probability that firm 1 will win when the signal distribution is unbiased. (Note that α is always interior.[16]) For now we will assume that any biasing of the signal is socially undesirable. We will thus regard α as the *constrained-optimal* value of the plaintiff's success probability, conditional on w. This reflects that, although we cannot eliminate courts' uncertainty completely, we can at least strive to avoid undue biasing of

[15]This fact will also ensure that each firm's litigation payoff is strictly concave in its expenditure.
[16]This is because F has support $\mathbb{R}$ (Assumption 1).

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their decisions. In Section 4, we consider the possibility that courts might rely on Bayesian presumptions that *deliberately* bias their decisions, in which case the constrained-optimal success probability will take a form analogous to (2).

Because α is strictly decreasing in w and independent of $\mathbf{x}$, it serves the additional useful purpose of providing a compact measure of the underlying *merit* of the plaintiff's antitrust claim. Highly anticompetitive practices ($w \ll 0$) have α close to unity; highly procompetitive practices ($w \gg 0$) have α close to zero; and close calls ($w \approx 0$) have α close to $1/2$.

Of course, the plaintiff's actual winning probability generally differs from α. This probability is given by $p = p(\mathbf{x}, w)$, defined by

$$p \equiv \Phi(0|\mathbf{x}, w) = \frac{\alpha x_1}{\alpha x_1 + (1-\alpha)x_2}, \tag{3}$$

which follows from (1).[17] Note that each firm's expenditure is weighted by the underlying merit of its case, which implies that it is less (resp. more) expensive for a firm to alter the value of p by a small increment when the merits are more (less) favorable to the firm's case.[18] A simple way to see the interplay between the merits and the firms' expenditures is to consider the *litigation odds*—the relative probability that the plaintiff will win, given by

$$\text{Litigation odds} \;\equiv\; \frac{p}{1-p} \;=\; \frac{\alpha x_1}{(1-\alpha)x_2}. \tag{4}$$

Thus, the litigation odds are equal to the product of the relative merits $(\alpha/(1-\alpha))$ and the relative expenditures (x_1/x_2).

[17] In Section 5.4, we consider more general assumptions on the signal distribution, which would give a more general probability function.

[18] To illustrate this, the functional form of p can be interpreted heuristically in terms of random draws from an urn: suppose that each firm chooses to buy some number n_i of balls to put into an urn; the court will then draw a single ball from the urn and enter judgment for the firm who bought it. The "price" of each ball is $\xi_1 = 1/\alpha$ for firm 1 and $\xi_2 = 1/(1-\alpha)$ for firm 2. It follows that p gives the fraction of all balls that were purchased by firm 1. To see this, note that firm i's total expenditure is $x_i = n_i \xi_i$, and hence

$$\frac{n_1}{n_1+n_2} = \frac{x_1/\xi_1}{x_1/\xi_1 \,+\, x_2/\xi_2} = \frac{\alpha x_1}{\alpha x_1 + (1-\alpha)x_2} = p.$$

Thus, by inspection of how the "prices" ξ_i change with α, one gets an intuitive sense of how the merits affect the firms' relative costs of influencing p.

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2.2 Payoffs, Asymmetric Stakes, and Equilibrium

If firm 1 (the plaintiff) wins, we assume that firm 2 will be enjoined from engaging in the challenged practice and will have to pay damages of $\delta \geq 0$ to firm 1. The ensuing market outcome involves duopoly competition with profits of $\pi_i^d > 0$ for each i. By contrast, if firm 1 loses, there is no injunction or damages, and firm 2 will continue engaging in the challenged practice without penalty. Given that firm 2 is dominant, we assume that in this case the resulting market outcome involves firm 2 obtaining a monopoly profit of π^m, whereas firm 1 earns no profits because it goes out of business. However, such exit by firm 1 does not imply that firm 2's conduct is anticompetitive.[19] Finally, we make the standard assumption that monopoly generates larger total profits than duopoly: $\pi^m > \pi_1^d + \pi_2^d$.

Given these profits, the firms' expected payoffs from litigation, denoted $u_i = u_i(\mathbf{x}|w)$, are given by

$$\begin{aligned} u_1 &= p(\pi_1^d + \delta) - x_1 & \qquad u_2 &= p(\pi_2^d - \delta) + (1-p)\pi^m - x_2 \\ &= pv_1 - x_1 & &= \pi^m - pv_2 - x_2, \end{aligned} \tag{5}$$

where we define

$$v_1 \equiv \pi_1^d + \delta, \qquad v_2 \equiv \pi^m - \pi_2^d + \delta. \tag{6}$$

Here v_i gives the incremental value to firm i when it wins rather than loses, which captures the firm's financial stake in the outcome of litigation.[20] Note that $v_2 > v_1$, since $\pi^m > \pi_1^d + \pi_2^d$. This reflects that the firms have *asymmetric stakes*: the defendant must have a greater financial interest on the line, because its challenged conduct enhances total profits. We can now solve for the equilibrium.

Proposition 2. *The antitrust litigation game has a unique Nash equilibrium* $\mathbf{x}^* = \mathbf{x}^*(w)$ *with component strategies*

$$x_i^* = \frac{\alpha(1-\alpha)v_i^2 v_j}{[\alpha v_1 + (1-\alpha)v_2]^2}. \tag{7}$$

[19] A procompetitive practice may a lead smaller rival to lose sales because it creates an efficiency (e.g. a cost reduction) that enables the dominant firm to offer consumers a better deal than the rival can match. Thus, firm 1's exit does not itself reveal whether firm 2's conduct is pro- or anticompetitive.

[20] When firm 1 wins, it avoids losing a duopoly profit of π_1^d and also obtains damages of δ. When firm 2 wins, it avoids a profit reduction of $\pi^m - \pi_2^d$ and also avoids paying damages.

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Equivalently, these strategies can be written as

$$x_i^* = v_i p^*(1-p^*), \tag{8}$$

where $p^* = p^*(w)$ is the equilibrium probability that firm 1 prevails:

$$p^* = \Phi(0|\mathbf{x}^*, w) = \frac{\alpha v_1}{\alpha v_1 + (1-\alpha)v_2}. \tag{9}$$

Since $v_2 > v_1$, it follows from (8) that firm 2 spends strictly more on litigation ($x_2^* > x_1^*$). This leads to the following key result.

Proposition 3. *The plaintiff's equilibrium winning probability is strictly lower than the constrained-optimal level: $p^* < \alpha$ for any w.*

Proof. By (9), $p^* < \alpha \iff v_2 > v_1$. □

Thus, the firms' asymmetric stakes act to skew the equilibrium litigation odds in the defendant's favor, resulting in a suboptimally low win rate for plaintiffs. This undermines deterrence of anticompetitive practices.

The equilibrium has some interesting properties.[21] The factor $p^*(1-p^*)$ in (8) has a useful interpretation: if we think of the outcome of litigation as a binary random variable that equals unity with probability p^* and zero otherwise, then $p^*(1-p^*)$ gives its *variance*. Therefore, $p^*(1-p^*)$ quantifies the uncertainty in the outcome of litigation. It then follows from (8) that the firms make larger expenditures when the outcome of litigation is more uncertain.

Additionally, it follows from (8) that if both firms' litigation stakes are scaled up or down by a common factor, then their expenditures will scale by the same factor, but the plaintiff's winning probability will remain unchanged. Also, the expenditure ratio (x_1^*/x_2^*) is always equal to the ratio of the firms' litigation stakes (v_1/v_2). As such, the equilibrium litigation odds reduce to $\alpha v_1/(1-\alpha)v_2$, deviating below the constrained-optimal odds by a factor of v_1/v_2.

Finally, we note that the litigation game has the property that the firms' expenditures are neither strategic complements nor strategic substitutes; this is evident from the inverted-U

[21] Some of these properties are driven by the functional form specified in Assumptions 1-2. We consider significantly weaker assumptions in Section 5.4.

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shape of the best response functions, which are plotted in Figure 1 below.[22]

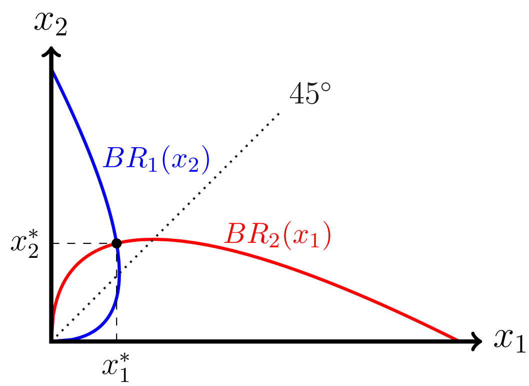

Figure 1: Best response functions and the equilibrium.

2.3 Inadequacy of Enhanced Damages

We now turn to the impact of damages on equilibrium behavior. One might expect that awarding sufficiently large damages could prevent the firms' asymmetric stakes from distorting the litigation odds. In fact, this is not possible, as it would require damages to be infinite.

Proposition 4. *$p^* \to \alpha$ asymptotically as $\delta \to \infty$.*

Proof. Using (9), this follows because $v_2/v_1 \to 1$ asymptotically as $\delta \to \infty$. □

Intuitively, increasing δ raises the litigation stakes for both firms by the same amount, since it is just a transfer from one to the other. Therefore, while larger damages act to reduce the asymmetry in the stakes, bringing v_2/v_1 closer to unity, they will never eliminate it. By contrast, if the stakes were symmetric ($v_1 = v_2$), then plaintiffs would achieve the constrained-optimal win rate ($p^* = \alpha$) for *any* value of δ.

However, enhanced damages may still help to deter potential defendants from engaging in anticompetitive conduct. Larger damages lead firm 2's expected litigation payoff to fall,

[22]For values $x_j > 0$, firm i's best response function is

$$BR_i(x_j) = \xi_i \sqrt{\alpha(1-\alpha)v_i x_j} - \frac{\xi_i}{\xi_j} x_j,$$

where $\xi_1 \equiv 1/\alpha$ and $\xi_2 \equiv 1/(1-\alpha)$. However, $BR_i(0)$ is ill-defined: when $x_j = 0$, firm i wants to set $x_i = \min\{x | x > 0\}$, which is undefined.

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which could potentially dissuade it from undertaking the disputed practice. Larger damages likewise increase the plaintiff's expected payoff, making it less likely that potential plaintiffs would be discouraged from bringing meritorious claims. But these points are not in tension with Proposition 4, which merely says that, if litigation occurs, the odds will be biased in defendants' favor for any δ.[23]

3 Settlement

For several reasons, it is important to consider both ex post (post-judgment) and ex ante (pre-judgment) settlements. First, if litigants anticipate that they would contract around a judgment that fails to maximize their joint-welfare, then the *prospect* of ex post settlement will influence their behavior at the litigation stage. This, in turn, affects ex ante settlement outcomes, as the terms of such agreements are negotiated "in the shadow of litigation." Second, antitrust law imposes certain constraints on settlement that have significant effects on equilibrium outcomes. Third, because the overwhelming majority of cases settle ex ante, it is important to consider how asymmetric stakes affect the terms of these agreements. Throughout this section, we assume transaction costs are non-prohibitive.[24]

3.1 Ex Post Settlements

We first analyze the impact of ex post settlements on equilibrium behavior at the litigation stage. When there are no legal constraints preventing the parties from contracting around a court's judgment, we describe the ensuing ex post settlements as "Coasean." We explain that the prospect of Coasean settlement leads litigants to behave as if the stakes are symmetric, even if they are not. This avoids any distortion in the equilibrium litigation odds. We establish this point using our litigation model and working by backward induction. However, we then explain that the distortion cannot be avoided in antitrust, because antitrust law generally prohibits otherwise-profitable ex post settlements in which a losing defendant pays the plaintiff for the right to continue a practice that has just been declared anticompetitive.

[23]In theory, one way to offset the asymmetry would be for the government "subsidize" successful plaintiffs with a cash rewards. This effectively makes the damages received by the plaintiff larger than those paid by the defendant. However, this is not an approach that would be realistically adopted in practice.

[24]We discuss transaction costs in Section 6.

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3.1.1 Litigation in the Shadow of Coasean Settlement

Consider a generic version of the litigation game involving two private parties $i = 1, 2$ engaged in some (non-antitrust) legal dispute surrounding the conduct of party 2 (the defendant). We assume that the relevant area of law imposes no restrictions on ex post settlements. Consistent with the last section, let v_i denote party i's litigation stakes (its incremental value from winning rather than losing), which includes some damages award $\delta \geq 0$. As before, we suppose that $v_2 > v_1$, so that the parties have asymmetric stakes due to the disparate payoff effects of an injunction.[25] It follows that, if the plaintiff wins, the parties can jointly-benefit from contracting around the injunction ex post.[26] At the margin, the resulting trade surplus would be $v_2 - v_1 > 0$. By default, the entire surplus would accrue to party 2; hence party 2 must pay party 1 in order to secure his assent.[27] To effect a mutually-beneficial result, the payment (denoted τ) must take the form

$$\tau = v_1 - \delta + \beta(v_2 - v_1), \tag{10}$$

where $\beta \in [0, 1]$ denotes the bargaining power of party 1, which specifies its share of the trade surplus.[28] The term $-\delta$ reflects that the settlement payment will not duplicate the damages award, which the defendant pays separately—immediately after the court enters a judgment for the plaintiff and prior to the ex post settlement. Thus, when the plaintiff wins, the overall amount it receives from the defendant is $\tau + \delta = v_1 + \beta(v_2 - v_1)$.

By backward induction, we know that the court's judgment will not influence whether or not the defendant's conduct will persist ex post; it definitely will. Rather, the judgment will merely determine whether the defendant will have to pay for this privilege. This is simply an application of the Coase theorem. We can thus write expected litigation payoffs as

$$u_1 = k_1 + p(\tau + \delta) - x_1, \qquad u_2 = k_2 - p(\tau + \delta) - x_2,$$

where k_1 and k_2 give the parties' terminal payoffs (excluding litigation costs) when the plaintiff loses. (In the antitrust case we had $k_1 = 0$ and $k_2 = \pi^m$.) Given these payoff

[25] If we assume that the stakes are driven entirely by the remedies sought by the plaintiff (damages and/or an injunction), then a pure damages action must involve symmetric stakes, namely $v_1 = v_2 = \delta$. Hence, an asymmetry would have to reflect the disparate payoff effects of an injunction.

[26] For example, in a nuisance claim against a noisy factory, a successful plaintiff may win an injunction ordering the defendant to halt its noisy operations. But the parties may then strike an ex post agreement in which the plaintiff sells the defendant a license to resume its noisy activities.

[27] In the alternative case $v_1 > v_2$, the parties would instead contract around a win for the defendant, so that the payment would run from party 1 to party 2.

[28] If τ is set via Nash bargaining, then $\beta = 1/2$.

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functions, the parties will behave exactly as if they had symmetric stakes. The result is that the plaintiff's success probability will not be biased away from α in equilibrium.

Proposition 5. *Consider the litigation game where there are no restrictions on ex post settlements. There is a unique equilibrium with strategies*

$$x_1^* = x_2^* = (\tau + \delta) \times \alpha(1 - \alpha), \tag{11}$$

and the plaintiff wins with probability $p^* = \alpha$.

Intuitively, the settlement payment τ acts just like a damages award: it makes symmetric contributions to the parties' litigation stakes. Thus, when the litigants can effectively contract around the court's judgment, they will behave as if the stakes are symmetric, even if this is not the case. Put differently, even if an injunction (if enforced) would have disparate effects on the litigants' payoffs, this will not be reflected in equilibrium behavior, for the parties anticipate that the injunction will be lifted (via contract) if the plaintiff wins.

3.1.2 Antitrust Restrictions on Ex Post Settlements

If the plaintiff-rival prevails in court, the antitrust litigants would also be eager to strike a Coasean settlement: an ex post agreement that overrides the injunction and lets the defendant resume its exclusionary conduct in exchange for cash. This enables the firms to restore (and share in) monopoly profits, which exceed total profits under competition.[29] However, antitrust prohibits such ex post settlements.[30] If the court enters a judgment for the plaintiff, declaring the defendant's conduct anticompetitive and issuing an injunction, then the firms cannot lawfully contract around this by agreeing that firm 2 will compensate firm 1 in exchange for continuing its exclusionary practice. The plaintiff does not have the authority to "license" the defendant's anticompetitive behavior in exchange for cash.

This makes sense, because a settlement that effectuates anticompetitive conduct would have third-party effects: it would injure downstream consumers. When exclusionary conduct reduces consumer welfare, it does not cease to be an antitrust violation just because the excluded rival consents to let it happen. On the contrary, such a settlement would amount to a collusive agreement in which a dominant firm pays its rival to exit. Thus, if such ex post

[29] Recall that the stakes are asymmetric ($v_2 > v_1$) only because $\pi^m > \pi_1^d + \pi_2^d$.

[30] It follows that the court's judgment will affect the final (ex post) allocation of rights, even if transaction costs are negligible. The same predicament arises in patent disputes between rivals (Hovenkamp, 2018).

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settlements were not proscribed by antitrust, they would provide a backdoor mechanism for striking anticompetitive horizontal agreements. It follows that the distortion in the litigation odds identified in Proposition 3 will persist in equilibrium due to this relatively unusual constraint on the legality of ex post settlements.[31]

3.2 Ex Ante Settlements

A large majority of antitrust disputes resolve through ex ante (pre-judgment) settlements. Indeed, the firms in our model would settle ex ante, as they do not disagree about the plaintiff's winning probability (p^*), and they could strictly benefit from avoiding costly litigation. A mutually acceptable settlement must give each firm i a payoff of at least u_i^*, where $u_i^* \equiv u_i(\mathbf{x}^*|w)$ denotes firm i's equilibrium litigation payoff.[32] As we explain below, there are two possible ways the firms might settle ex ante.

3.2.1 Cash-for-Exclusion Settlements

The monetary benefit of settling ex ante is ordinarily assumed to be the avoidance of litigation costs. However, in light of the constraint on ex post settlement, an ex ante settlement that effectuates monopoly would offer an additional (and potentially much larger) benefit. Specifically, the joint-benefit of a monopoly-generating settlement (net of expected litigation payoffs) is given by

$$\pi^m - u_1^* - u_2^* = \underbrace{p^*[\pi^m - (\pi_1^d + \pi_2^d)]}_{\text{Expected profit loss}} + \underbrace{x_1^* + x_2^*}_{\text{Litigation costs}}. \tag{12}$$

The bracketed term represents the amount by which total profits would fall if the plaintiff were to win in litigation. Those profits would be gone for good, as the firms could not restore them through ex post contracting. As such, the expected joint-profits lost in litigation constitute a separate possible benefit of ex ante settlement.

This suggests that the firms have an incentive to use an ex ante settlement to generate a monopoly for the defendant, while also providing a payment to the plaintiff, ensuring the deal is mutually-beneficial. Such a "cash-for-exclusion" agreement would look very much like

[31] In Section 6, we consider analogous (often weaker) constraints on ex post settlement that may lead a distortion to arise in other areas of private litigation.

[32] By (5), these equilibrium payoffs are $u_1^* = p^*v_1 - x_1^*$ and $u_2^* = \pi^m - p^*v_2 - x_2^*$.

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the kind of ex post settlement that antitrust forbids. From the firms' perspective, the only significant difference is that the payment would depend in part on the plaintiff's winning probability (p^*), as this influences what size the payment must be in order for the settlement to be mutually preferred to litigation. The larger is p^*, the larger the payment will be.[33]

Although we are not aware of any judicial opinion that speaks directly on this point, this kind of cash-for-exclusion settlement likely would (and certainly *should*) be condemned if challenged on antitrust grounds. Such an arrangement would resemble the "pay-for-delay" patent settlements condemned in the Supreme Court's recent *Actavis* decision.[34] In a pay-for-delay settlement, a monopolist (whose monopoly hinges on a patent) pays off a prospective entrant who is challenging the patent's validity in court. The deal gives the challenger a large "reverse payment" in exchange for abandoning its challenge and staying out of the market until the patent is about to expire.[35] The Court held that this kind of settlement is typically illegal because, in effect, it fully eliminates competition (over the remaining patent term) *with certainty*, whereas a final judgment on the patent's validity had a significant probability of inviting new competition.[36]

Similarly, an antitrust suit has the possibility of engendering greater competition by enjoining an anticompetitive practice. Therefore, an antitrust settlement in which the defendant simply pays the plaintiff-rival to continue its conduct raises the same concerns of anticompetitive harm. It permits the firms to effectuate monopoly and share in its profits, even if the expected result of litigation was much more competitive. Thus, following the logic of *Actavis*, such settlements should be condemned.[37]

3.2.2 Conduct Settlements

If a pure cash-for-exclusion agreement is off-limits, how might the firms settle? An alternative possibility would involve bargaining not over a payment, but rather a mitigation of the defendant's challenged conduct. That is, the defendant agrees to reduce the extent of its

[33] Under Nash bargaining, the payment is $\tau = u_1^* + (\pi^m - u_1^* - u_2^*)/2 = [p^*(2 - p^*)v_2 + (p^*)^2 v_1]/2$.

[34] FTC v. Actavis, Inc., 570 U.S. 136 (2013).

[35] It is a "reverse payment" because in a conventional patent settlement it is the accused infringer who pays the patentee, either to compensate for past infringing sales or to license future ones (or both).

[36] That a final judgment has "significant probability" of invalidating the patent can be inferred when the payment is sufficiently large (e.g. larger than the cost of litigation). See, e.g., Edlin et al. (2015).

[37] The arguments favoring intervention are essentially identical to those favoring a prohibition of pay-for-delay settlements. Hence, for detailed discussion of these arguments, we refer readers to the pay-for-delay literature. E.g. Cotter (2003); Shapiro (2003); Hemphill (2006); Carrier (2014); Edlin et al. (2015).

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potentially-exclusionary conduct, but does not suspend it completely.[38] The settlement thus generates competitive effects that fall somewhere between the two possible outcomes of litigation. In fact, such an arrangement will tend to produce competitive outcomes that are roughly commensurate with the expected result of litigation, which is widely regarded as the normatively appropriate benchmark in the context of horizontal patent settlements.[39]

Consider a concrete example. Suppose that the defendant has just begun engaging in exclusive dealing that prevents N large suppliers of an essential input from selling to the plaintiff-rival. If the plaintiff prevails in court, all N of these deals will be enjoined, although we assume for now that there would not be any damages.[40] If the defendant wins, all of the deals will persist and firm 1 will fail and exit the market. In ex ante settlement negotiations, the firms bargain over a reduction S in the number of exclusive contracts, resulting in $N - S$ agreements remaining in force. Let $\widehat{u}_i(S)$ denote firm i's settlement payoff, where we have $\widehat{u}_1(0) = 0$, $\widehat{u}_2(0) = \pi^m$, $\widehat{u}_1(N) = \pi_1^d$, and $\widehat{u}_2(N) = \pi_2^d$.[41] For simplicity, we will assume that the $\widehat{u}_i$ functions are linear in S, which implies they take the form

$$\widehat{u}_1(S) = \frac{S}{N}\pi_1^d, \qquad \widehat{u}_2(S) = \pi^m - \frac{S}{N}(\pi^m - \pi_2^d). \tag{13}$$

A settlement outcome S is mutually acceptable if $\widehat{u}_i(S) \geq u_i^*$ for both i. For most parameter values, we have $u_1^* + u_2^* > \pi_1^d + \pi_2^d$, implying that a complete abatement of the defendant's conduct ($S = N$) cannot be mutually acceptable, as it would not generate enough total profits to satisfy both firms.[42] This is because the defendant's conduct raises total profits, and a court's judgment might allow it to continue in full. Therefore, a settlement typically must involve the defendant partially continuing its conduct to some extent ($S < N$) in order to be mutually acceptable. However, because $\widehat{u}_1(S)$ is increasing and there is no payment to facilitate profit-sharing, firm 1 will not accept the monopoly-preserving outcome ($S = 0$). Rather, private bargaining will naturally induce a settlement outcome that emulates the expected result of litigation (which would eliminate p^*N deals in expectation).

Proposition 6. *Under Nash bargaining, the agreed-upon settlement outcome is* $S^* = p^*N$.

[38] This is roughly similar to the "behavioral remedies" often imposed by decree in settlements between the FTC/DOJ and antitrust defendants.

[39] Shapiro (2003) proposed that antitrust should require horizontal patent settlements to be no worse for consumers than the outcome of litigation would have been (in expected value). The *Actavis* decision largely embraced this proposal. For discussion of how this standard can be administered outside the pay-for-delay context, see Hovenkamp and Lemus (2019); Hovenkamp (2019).

[40] We discuss the impact of damages on settlement below.

[41] This reflects that $S = 0$ and $S = N$ are equivalent to the two possible outcomes of litigation.

[42] It is straightforward to verify that $u_1^* + u_2^* > \pi_1^d + \pi_2^d \Leftrightarrow p^* < (\pi^m - \pi_2^d - \pi_1^d)/(\pi^m - \pi_2^d + \pi_1^d)$.

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Hence, the conduct settlement will generate competitive effects that line up with the expected result of litigation. Such settlements are much more reasonable than a pure cash-for-exclusion agreement. However, they will be systematically under-competitive as a result of asymmetric stakes, due to the distortion of the plaintiff's winning probability ($p^* < \alpha$).

Corollary 1. *If litigation were unbiased, the settlement outcome would be* $S^{**} = \alpha N > S^*$.

That is, due to asymmetric stakes, the agreed-upon settlement outcome will involve a smaller mitigation of the defendant's conduct than it otherwise would ($S^* < S^{**}$). Thus, the problem is not that the settlement outcome will fail to comport with the expected result of litigation, but rather that the latter benchmark has been distorted by asymmetric stakes. We do not suggest that conduct settlements should be prohibited for this reason. We are merely pointing out that they will generate suboptimal results due to asymmetric stakes.

The conduct settlements contemplated here are analogous to a "pure delay" patent settlement, which differs from pay-for-delay only in that there is no payment.[43] An added wrinkle in the antitrust context is that, even under a conduct settlement, some payment may be necessary to account for damages already sustained by the plaintiff. We discuss that possibility in Section 5. Of course, if a settlement includes a significant payment without any significant mitigation of the defendant's conduct, it should be deemed a cash-for-exclusion agreement and condemned, as argued above.

4 Presumptions and Evidentiary Standards

We have shown that enhanced damages cannot eliminate the distortion created by the firms' asymmetric stakes. In this section we show that courts could address the problem by adjusting the plaintiff's evidentiary burden in order to counteract the distortion. This involves courts' adoption of a *presumption*.

A presumption leads courts to maintain an initial predisposition toward one outcome or the other, although this can be rebutted if countervailing evidence is sufficiently strong. This makes a plaintiff's evidentiary burden either "lighter" or "heavier," depending on which side

[43]That is, the firms bargain over a delay in entry by the patentee's rival, but the patentee cannot pay the rival to accept a longer delay period. For instance, if the patent term has 10 years remaining and the patent is 40% likely to be valid, the expected result of litigation is tantamount to four years of monopoly. Hence the rival (resp. patentee) will not agree to a delay in entry of more (less) than four years, and so they will agree on 4 years of delay. Because these settlements emulate the expected result of litigation, they are lawful under *Actavis*. (See, e.g., Hovenkamp (2019)).

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the presumption favors. We implement this in our model by supposing that the trial court's decision-making process is modified in the following way: rather than entering judgment for the plaintiff whenever it observes a signal value $y < 0$, as assumed previously, we now assume that the plaintiff wins whenever $y < \eta$, where η is some scalar that courts take as given. We interpret a nonzero value of η as a presumption.[44] A presumption with $\eta > 0$ (resp. $\eta < 0$) makes it systematically easier (resp. harder) for plaintiffs to win, all else being the same, and the magnitude of this effect is governed by the absolute value $|\eta|$.

We next solve the litigation game for the case of an arbitrary presumption η and explain how the value of η could be set to counter the systematic distortion created by asymmetric stakes. We also consider the possibility that there are also independent reasons—relating to the nature of the defendant's conduct and its propensity to injure consumers—for using a presumption to modify the plaintiff's evidentiary burden.

4.1 Litigation Equilibrium with a Presumption

Let us fix a presumption $\eta \in \mathbb{R}$, so that the plaintiff wins in litigation if and only if the court observes a signal satisfying $y < \eta$. In this case, the constrained-optimal success probability for the plaintiff is $\alpha_\eta = \alpha_\eta(w)$, defined by

$$\alpha_\eta = F(\eta|w). \tag{14}$$

This is exactly analogous to the definition of α in (2), which would now be denoted by α_0, reflecting that it corresponds to the absence of a presumption ($\eta = 0$). Then, conditional on $\mathbf{x}$ and w, the probability that firm 1 will prevail in litigation is given by $p_\eta = p_\eta(\mathbf{x}, w)$, defined by

$$p_\eta = \Phi(\eta|\mathbf{x}, w) = \frac{\alpha_\eta x_1}{\alpha_\eta x_1 + (1 - \alpha_\eta)x_2}. \tag{15}$$

Adding a presumption affects the firms' payoffs only by influencing the litigation odds. Thus, the firms' payoffs will take the same functional form as before, but with p now replaced by the more general term p_η. It is easy to compute the equilibrium in the litigation game with a presumption.

Proposition 7. *In the antitrust litigation game with a presumption η, there is a unique*

[44] One can alternatively interpret η as a measure of the plaintiff's evidentiary burden. For example, η may govern the amount and quality of evidence that the plaintiff must supply.

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Nash equilibrium $\mathbf{x}_\eta^* = \mathbf{x}_\eta^*(w)$ *with component strategies*

$$x_{i,\eta}^* = \frac{\alpha_\eta(1-\alpha_\eta)v_i^2 v_j}{[\alpha_\eta v_1 + (1-\alpha_\eta)v_2]^2} = v_i p_\eta^*(1-p_\eta^*), \tag{16}$$

where $p_\eta^* = p_\eta^*(w)$ *is the equilibrium probability that the plaintiff will prevail:*

$$p_\eta^* = \Phi(\eta|\mathbf{x}_\eta^*, w) = \frac{\alpha_\eta v_1}{\alpha_\eta v_1 + (1-\alpha_\eta)v_2}. \tag{17}$$

Proof. The result follows from the proof of Proposition 2, but with α and p replaced by α_η and p_η, respectively. □

This result is just a modest generalization of Proposition 2, which can now be viewed as capturing the special case of $\eta = 0$. It is easy to verify that α_η is strictly increasing in η, and therefore p_η^* is likewise increasing in η. Accordingly, if $\eta > 0$, then we have $\alpha_\eta > \alpha_0$ and therefore $p_\eta^* > p_0^*$, so that the presumption improves the plaintiff's litigation odds; the converse occurs when $\eta < 0$.

By inspection of (16), a presumption will not prevent the firms from making asymmetric expenditures in equilibrium; that is, we still have $x_{2,\eta}^* > x_{1,\eta}^*$ for any η. But the presumption can still help to counteract the distortion created by asymmetric stakes, because it nevertheless alters the plaintiff's success probability. The value of η can therefore be adjusted to offset the distortion. For example, we could choose the value $\eta = \widehat{\eta}$ defined by $p_{\widehat{\eta}}^* = \alpha_0$. Using (17), $\widehat{\eta}$ is determined by

$$\alpha_{\widehat{\eta}} = \frac{\alpha_0 v_2}{\alpha_0 v_2 + (1-\alpha_0)v_1}. \tag{18}$$

However, this is not a viable solution, because α_0 is a function of w, which the court does not observe. Instead, we need a different notion of an optimal presumption—one that does not presuppose information about the true welfare effect arising in a given case. We will therefore suppose that a higher legal authority (e.g. Congress or the Supreme Court) chooses an optimal presumption based on *probabilistic* information about the welfare effects generated by the defendant's conduct, as captured by a Bayesian prior. This will enable us to derive a presumption that accounts not only for asymmetric stakes, but also any underlying predisposition of the challenged practice toward pro- or anticompetitive effects. The legal authority then instructs trial courts to employ the presumption in rendering final judgments.

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4.2 Optimizing Presumptions for Specific Practices

In antitrust, presumptions are typically employed when there is a belief among courts that a given type of practice is, in general, usually anticompetitive or usually procompetitive, even though it may be difficult to estimate its welfare effects directly in any given case.[45] Such beliefs can be represented by a Bayesian prior. Explicitly, let $\rho(w)$ be a prior probability density over the welfare effects generated by a particular type of practice (e.g. exclusive dealing or vertical merger).[46] Hence, before any case-specific facts are accounted for, the prior probability that the practice is anticompetitive is given by $\mathrm{P}_\rho\{w < 0\} = \int_{-\infty}^{0} \rho(w)dw$. We make the following assumption on the prior ρ.

Assumption 3. The prior density $\rho(w)$ is symmetric with support $\mathbb{R}$.

Let μ denote the mean welfare effect under ρ, which is also the median in light of the above assumption. The sign of μ captures whether the relevant practice is regarded as usually anticompetitive ($\mu < 0$), usually procompetitive ($\mu > 0$), or neutral on average ($\mu = 0$). In order to derive an optimal presumption, we must consider the posterior probability that a practice is anticompetitive, conditional on the signal observed by the court and the firms' litigation expenditures. Letting $\phi \equiv \partial\Phi/\partial y$ denote the signal density, Bayesian-updating gives the following posterior probability of anticompetitive harm:

$$\mathrm{P}_\rho\{w < 0 \,|\, y, \mathbf{x}\} = \frac{\mathrm{P}_\rho\{w < 0, y \,|\, \mathbf{x}\}}{\mathrm{P}_\rho\{y \,|\, \mathbf{x}\}} = \frac{\int_{-\infty}^{0} \rho(w)\phi(y|\mathbf{x}, w)dw}{\int_{-\infty}^{\infty} \rho(w)\phi(y|\mathbf{x}, w)dw}. \tag{19}$$

We assume that the optimal presumption is that which would perfectly effectuate the preponderance-of-evidence standard. This means that the defendant's conduct should be condemned if and only if the observed signal value y (viewed in light of the prior) suggests that the defendant's conduct is more likely to be anticompetitive than procompetitive—that is, if w is more likely to be negative than nonnegative.[47] It follows that the optimal value of η is that which ensures the above posterior probability is equal to $1/2$ when $y = \eta$.

As (19) indicates, posterior probabilities depend on the firms' expenditures. But recall

[45] For discussion of antitrust presumptions and associated evidentiary burdens, see, e.g., Bernardo et al. (2000); Salop (2015); Gavil and Salop (2020).

[46] As this suggests, our analysis is now conditional on a particular type of restrictive practice.

[47] This is the standard interpretation of the more-likely-than-not standard of proof. In antitrust, it implies that courts focus on the *median* value of the consumer welfare effect, rather than the *expected value* of the consumer welfare effect. Since expected consumer welfare should be the real goal, the median standard will necessarily lead to erroneous outcomes—it will condone some practices that injure consumers in expected value. This is a general problem with focusing on bare probabilities rather than expected values.

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that the court does not observe $\mathbf{x}$ in any given case. Thus, to avoid an ambiguity over $\mathbf{x}$, it is necessary specify a *decision rule* about how firms choose their expenditures; we can then compute posterior probabilities under the assumption that the firms always adhere to this decision rule. There are two such specifications worth considering—namely, symmetric expenditures[48] and equilibrium expenditures. These possibilities give rise to two distinct conceptions of the optimal presumption, which are described below:

Pure Conduct-Based Presumption: The optimal presumption, denoted $\widetilde{\eta}$, under the assumption of symmetric expenditures ($x_1 = x_2$). The value of $\widetilde{\eta}$ is defined implicitly by

$$\mathrm{P}_\rho\{w < 0 \,|\, y = \widetilde{\eta},\, x_1 = x_2\} = \frac{1}{2}. \tag{20}$$

Constrained-Optimal Presumption: The optimal presumption, denoted η^*, under the assumption of equilibrium expenditures ($\mathbf{x} = \mathbf{x}^*_\eta$). The value of η^* is defined implicitly by

$$\mathrm{P}_\rho\{w < 0 \,|\, y = \eta^*,\, \mathbf{x} = \mathbf{x}^*_{\eta^*}\} = \frac{1}{2}. \tag{21}$$

The pure conduct-based presumption $\widetilde{\eta}$ would apply when a court uses a presumption based solely on considerations of the defendant's conduct—that is, without further accounting for the distortion created by asymmetric expenditures. It accomplishes this by conditioning on symmetric expenditures, effectively assuming away any expenditure-related bias. By contrast, the constrained-optimal presumption η^* accounts for *both* the nature of the defendant's conduct and the distortion created by asymmetric stakes.[49] As with α, we describe η^* as "constrained-optimal" because its effectiveness is inherently constrained by the court's uncertainty over w.

It is also useful to consider a special case of the constrained-optimal presumption, denoted η^*_0, corresponding to the case $\mu = 0$. That is, η^*_0 is the constrained-optimal presumption when the prior takes a neutral position toward the welfare consequences of the practice in question. This isolates asymmetric stakes as the sole basis for implementing a presumption. We now present this Section's main result.

Proposition 8. *For any prior $\rho(w)$ satisfying Assumption 3, we have*

[48]The specific value of $x_1 = x_2$ is irrelevant, because $\phi(y|\mathbf{x}, w)$ reduces to $f(y|w)$ whenever expenditures are symmetric (Assumptions 1-2), in which case $\mathbf{x}$ drops out of the posterior in (19).

[49]Note that, as indicated in (21), the constrained-optimal presumption η^* must account for the fact that the firms' equilibrium expenditures themselves depend on the choice of presumption.

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(i) $\text{sign}\{\widetilde{\eta}\} = -\text{sign}\{\mu\}$.[50]

(ii) $\eta^* > \widetilde{\eta}$.

(iii) η_0^* *is pinned down by*

$$F(\eta_0^*|0) = \frac{v_2}{v_1 + v_2}. \tag{22}$$

Part (i) indicates that, as one would expect, if the relevant conduct is predisposed toward anticompetitive effects ($\mu < 0$), then the pure conduct-based presumption must counterbalance this by tilting the scales in plaintiffs' favor ($\widetilde{\eta} > 0$), and vice versa; otherwise, if the prior is neutral, we have $\widetilde{\eta} = \mu = 0$. However, part (ii) states the constrained-optimal presumption will always be strictly more favorable to plaintiffs than the pure conduct-based one, regardless of what value the latter takes. This reflects the fact that asymmetric stakes always skew the litigation odds in defendants' favor. Therefore, countering this distortion always requires shifting the presumption in the plaintiff's favor.

To see how the constrained-optimal presumption addresses the distortion created by asymmetric stakes, it is useful to focus on the special case η_0^* and take advantage of equation (22). Consider first the case where the true welfare effect is exactly $w = 0$. Then, absent a presumption, the strength of the plaintiff's case would be $\alpha_0 = F(0|0) = 1/2$, whereas the plaintiff's equilibrium winning probability would be $p_0^* = v_1/(v_1 + v_2) < 1/2$; this is the usual distortion created by asymmetric stakes. Now consider the effect of implementing the presumption η_0^* defined in (22), while continuing to assume $w = 0$. The presumption reduces the plaintiff's evidentiary burden, so that the strength of its claim increases to

$$\alpha_{\eta_0^*} = F(\eta_0^*|0) = \frac{v_2}{v_1 + v_2} > \frac{1}{2}, \tag{23}$$

which induces the desired winning probability in equilibrium:

$$p_{\eta_0^*}^* = \frac{\alpha_{\eta_0^*} v_1}{\alpha_{\eta_0^*} v_1 + (1 - \alpha_{\eta_0^*}) v_2} = \frac{\frac{v_1 v_2}{v_1 + v_2}}{\frac{v_1 v_2}{v_1 + v_2} + \frac{v_1 v_2}{v_1 + v_2}} = \frac{1}{2} = \alpha_0. \tag{24}$$

However, recalling that p_η^* and α_η are functions of w, it is important to note that the constrained-optimal presumption does not perfectly correct the distortion in all cases. That is, it does not achieve $p_{\eta_0^*}^*(w) = \alpha_0(w)$ for all values of w. Instead, by (globally) shifting the equilibrium probability upward from $p_0^*(w)$ to $p_{\eta_0^*}^*(w)$, the presumption ensures only that

[50] In the special case $\rho(\cdot) = f(\cdot|\mu)$, we have $\widetilde{\eta} = -\mu$ (see the proof of part (i)).

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the latter is everywhere closer to $\alpha_0(w)$.[51] It is not possible to do better than this: to achieve $p^*_{\eta^*_0}(w) = \alpha_0(w)$ globally would require making the presumption a function w, which would be inconsistent with the courts' uncertainty over w.[52] In light of this constraint, we have employed a weaker notion of optimality—namely, that the constrained-optimal presumption is that which perfectly effectuates the preponderance-of-evidence standard, as discussed above.

5 Extensions

5.1 Consumer Class Actions

An excluded rival does not internalize the impact of the defendant's conduct on consumers. This raises the question of whether the problem of asymmetric stakes would vanish (or even reverse direction) if the plaintiff instead were a class composed of all injured consumers.[53] One might think that, if the defendant's conduct reduces *total* welfare (total profits plus consumer surplus), then the asymmetric stakes would be reversed. But, in fact, an injunction's incremental benefit to consumers may or may not exceed the incremental reduction in the defendant's profits. This is because the injunction does not only reduce total profits, but also reallocates some profits from the defendant to the excluded rival.[54]

However, even if an injunction would benefit consumers by more than it reduces the defendant's profits, the defendant is likely to internalize larger litigation stakes than the consumer class for several reasons. First, there are the usual practical difficulties in achieving efficient collective action by a large group of injured parties due to various externality, free-riding, and information problems associated with class actions generally.[55] Second, antitrust standing requirements typically limit potential recovery to those consumers who actually bought the relevant product at a supra-competitive price; consumers who were deterred from buying the product (whose injuries are thus reflected in deadweight loss) are almost never viable

[51] One can verify that $p^*_{\eta^*_0}(w)$ crosses $\alpha_0(w)$ from above at $w = 0$ (and nowhere else). By contrast, $p^*_0(w)$ lies everywhere below both $\alpha_0(w)$ and $p^*_{\eta^*_0}(w)$.

[52] See equation (18) and the discussion that follows.

[53] As Rosenberg and Spier (2014) note, when there are multiple injured parties, they may avoid or mitigate an asymmetric stakes problem if they can efficiently aggregate their interests.

[54] An injunction reduces producer surplus by $\Delta PS \equiv \pi^m - (\pi^d_1 + \pi^d_2)$, which must satisfy $\Delta PS < |w|$ if the injunction would increase total welfare. However, the defendant internalizes a profit change of $\Delta\pi_2 \equiv \pi^m - \pi^d_2 > \Delta PS$. Therefore, we may have $\Delta\pi_2 > |w|$ even if the injunction would increase total surplus.

[55] See, e.g., Spier (2007); Issacharoff (1996); Morawetz (1993).

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plaintiffs.[56] Thus, the class will only partially internalize the consumer welfare benefits of an injunction.

Finally, and most importantly, it is not the consumers but rather their attorneys who make the operative choice of litigation effort in this context.[57] Class action attorneys work on a contingency basis, earning payment only upon winning the case or securing a monetary settlement; their compensation is then given as a percentage of the total monetary award. The consumers themselves do not make out-of-pocket expenses on litigation. Rather, it is the attorneys who choose how much costly effort to invest (including costs of retaining experts, consultants, etc.) in consideration of the likelihood of winning and the expected size of the payment they would receive upon success. As a result, they do not internalize the consumer value from an injunction, and they internalize only a portion of any awarded damages. By contrast, the defendant internalizes both the full damages award and the negative profit effects of an injunction.[58]

5.2 Past Damages in Conduct Settlements

In our discussion of ex ante conduct settlements (Section 3.2.2), we noted that it may be necessary for the settlement to include a payment to the plaintiff in order to account for damages already sustained. This creates an incentive problem: the firms can mutually benefit from trading-off the payment and the mitigation of the defendant's conduct. For instance, if the firms think past damages would be \$100 in expectation, they may nevertheless opt for a payment much larger than \$100 in exchange for a lesser mitigation of the defendant's conduct.[59] This provides greater profits by imposing a smaller limitation on the defendant's conduct. But this also means the settlement's competitive effects will deviate significantly from the expected result of litigation.

[56] This reflects an evidentiary hurdle. If a consumer did not buy the defendant's good, it is hard to prove that she *would* have done so but for the defendant's anticompetitive conduct.

[57] Choi and Sanchirico (2004) similarly highlight the relevance of this principal-agent problem to considerations of endogenous litigation effort.

[58] Other types of enforcement actions are similarly unlikely to resolve the problem of asymmetric stakes. First, parallel (or combined) suits by multiple rivals would tend to exacerbate the problem. Post-injunction competition would be more intense, which would raise the stakes for the defendant while reducing them for each plaintiff. There could also be free-riding problems among the plaintiffs, since any successful suit would benefit them all. Second, public enforcement is unlikely to provide an adequate solution. The agencies face severe budget constraints that limit the number of cases they can bring, and which may constrain their spending within a given lawsuit.

[59] In the extreme case, there will be no mitigation of the defendant's conduct at all, which is just a cash-for-exclusion agreement.

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A possible solution is to require the firms to settle using two independent agreements that are separated in time. An initial contract is limited to the mitigation of future conduct. After that deal is finalized, a second agreement is limited to payment for past damages. This avoids a quid-pro-quo relationship between the payment and the conduct modifier, since the latter is already sunk when the firms begin negotiating the payment. An analogous procedure was recently stipulated in an FTC consent decree concerning a patent settlement.[60] This was previously advocated in the patent context by Hemphill (2009).[61]

5.3 Fee Shifting

By statute, a successful private antitrust plaintiff may recover "a reasonable attorney fee" from the defendant.[62] There is no analogous rule for successful defendants, and hence private antitrust litigation involves one-way fee shifting. However, for several reasons, this is very different from a rule in which a losing defendant must pay the plaintiff's subjectively-chosen litigation expenditure, as given by x_1 in our model.[63]

First, the rule requires the defendant to pay an amount the court deems "reasonable" for the case in question, as opposed to the actual amount paid by the plaintiff to its attorneys.[64] The court will employ one of several objective approaches for determining a "reasonable" fee. Further, such fee shifting does not cover several major components of an antitrust litigant's overall expenditure: the costs of hiring testifying experts, non-testifying experts, and consultants.[65]

For these reasons, a sensible way to capture fee shifting in our model would be to introduce

[60] The decree prohibits the firms from initiating any transaction involving a payment (which could be a settlement of a damages claim) within 30 days before or after they strike a delayed-entry settlement, while also prohibiting any payment (at any date) that is expressly contingent on delayed entry. See www.ftc.gov/system/files/documents/cases/teva_proposed_stipulated_revised_order.pdf

[61] Hemphill (2009) also discusses various steps needed to prevent the firms from cheating by disguising payments in various ways. Such precautions would be important in the antitrust context, too.

[62] Clayton Act §4 (15 U.S.C. §15(a)).

[63] If one modifies our model so that the defendant must pay x_1 to the plaintiff upon losing, then the plaintiff's best-response behavior becomes pathological, prescribing an infinite expenditure in some situations. But this can be avoided by assuming that each firm's probability of losing can never fall below some small lower bound $\varepsilon > 0$ (e.g. the risk of losing on a technicality).

[64] This is intended to avoid a moral hazard problem: plaintiffs might rack up excessive bills if they could expect full reimbursement of whatever amount they choose to spend.

[65] See, e.g., Concord Boat Corp. v. Brunswick Corp., 34 F. Supp. 2d 1125, 1131 (E.D. Ark. 1998) (noting that fees paid to experts and consultants "are not recoverable" by the successful antitrust plaintiff.) This follows a Supreme Court decision that fee shifting statutes exclude expert/consultant fees unless they are explicitly provided for. Crawford Fitting Co. v. J.T. Gibbons, Inc., 482 U.S. 437, 439 (1987).

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some fixed monetary award (i.e. one that is independent of x_1) that reflects the court's assessment of what fees would be "reasonable" for the case in question; the plaintiff would then recover this additional amount in the event that it wins. But then the award would act exactly like an increase in the damages parameter δ. Thus, following our discussion of damages in Section 2.3, we conclude that antitrust's one-way fee shifting acts to reduce the systematic distortion created by asymmetric stakes, but does not eliminate it.

5.4 Generalizing the Signal Distribution

In this section, we drop Assumptions 1-2 and consider more general forms of the signal distribution (and, by extension, the outcome probability function). The proposition below demonstrates that one of our primary results—that the defendant will spend strictly more in equilibrium—obtains under much more general conditions.

Proposition 9. *Consider any differentiable signal distribution $\Phi(y|\mathbf{x}, w)$ satisfying the following conditions:*

(C1) $\dfrac{\partial \Phi}{\partial x_2} < 0 < \dfrac{\partial \Phi}{\partial x_1}$.

(C2) $\left|\dfrac{\partial \Phi}{\partial x_i}\right| > \left|\dfrac{\partial \Phi}{\partial x_j}\right|$ *if and only if* $x_i < x_j$.

Then, for any w, if there exists a Nash equilibrium $\mathbf{x}^*$ of the litigation game with $x_i^* > 0$ for each i, then $x_2^* > x_1^*$.

Condition (C1) ensures that the plaintiff's winning probability is increasing (resp. decreasing) in x_1 (resp. x_2). Condition (C2) says that the marginal effects of x_1 and x_2 upon the plaintiff's winning probability are diminishing at the same rate. One can easily verify that these conditions are met by any signal distribution satisfying

$$\Phi(y|\mathbf{x}, w) = \frac{F(y|w)g(x_1)}{F(y|w)g(x_1) + [1 - F(y|w)]g(x_2)}, \tag{25}$$

where g is strictly increasing and log-concave. This is a generalization of the functional form specified in Assumption 1 (which corresponds to $g(x) = x$). Note that the specification in (25) is not necessarily homogeneous of degree zero in $\mathbf{x}$.[66]

[66] It is homogeneous of degree zero if and only if g is homogeneous of degree k for some value of k.

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As an example, consider the litigation game equilibrium corresponding to a signal distribution taking the form depicted in (25), where we specify $g(x) = x^\gamma$ for some $\gamma > 0$. Following the same approach used in the proof of Proposition 2, we find that

$$x_i^* = v_i \gamma p^*(1 - p^*), \qquad p^* = \frac{\alpha v_1^\gamma}{\alpha v_1^\gamma + (1-\alpha) v_2^\gamma} \tag{26}$$

in any equilibrium in which both expenditures are positive.[67] In this case, the comparative statics are essentially the same as for the case considered throughout most of the main text (which corresponds to $\gamma = 1$). The only difference is that the distortion created by asymmetric stakes is smaller (resp. larger) when $\gamma < 1$ ($\gamma > 1$).

6 Asymmetric Stakes Outside Antitrust

Asymmetric stakes can arise in any area of private litigation. However, our analysis in Section 3.1 demonstrates that the prospect of ex post settlement will typically make the parties behave as if the stakes are symmetric, preventing any distortion from arising in equilibrium. We thus emphasized that the distortion arises in antitrust only because it proscribes certain ex post settlements. This raises the question of whether other areas of private litigation involve similar constraints on ex post settlements, in which case asymmetric stakes could similarly have a distortionary effect. The answer is yes. Here we briefly highlight some examples, although a comprehensive discussion is beyond the scope of this paper.

There appear to be few other areas of private litigation in which it is routinely unlawful for litigants to contract around certain types of judgments. One such example is IP law. If a patent (or copyright) is declared invalid, the parties cannot lawfully strike an agreement in which the accused infringer is nevertheless excluded from using the invention (say, in exchange for cash).[68] Once the patent is invalidated, the patentee has no more lawful basis for excluding anyone from using the relevant invention.[69]

Even if the parties are not prohibited from contracting around a judgment, they may not be

[67] When $\gamma > 1$, a firm may prefer to spend zero in some situations, because the strategy profile in (26) may leave it with a negative payoff for some values of w. But if $\gamma \leq 1$ both expenditures are always positive.

[68] See Hovenkamp (2018). That such an agreement would be unlawful is particularly clear when the patentee is a monopolist and the accused infringer is a potential entrant. With the patent invalidated, such an exclusion agreement would amount to naked market division.

[69] In *Kimble*, the Supreme Court held that a patentee may not lawfully charge royalties after the patent expires. Kimble v. Marvel Entertainment, LLC, 135 S. Ct. 2401 (2015). If even a royalty agreement is unlawful after the patent goes out of force, then surely an exclusion agreement would be unlawful, too.

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able to void or circumvent all of its payoff-relevant consequences. In such situations, asymmetric stakes may still have a distortionary effect in equilibrium. For example, a judgment could have an adverse reputational effect on the losing party that cannot be rectified by any private agreement between the litigants.

A more broadly applicable example surrounds the collateral effects of a judgment on follow-on suits by third parties. When two litigants settle ex post, they may ask the court to vacate its judgment; this would prevent third parties from relying on that judgment (via collateral estoppel) in bringing their own follow-on lawsuits.[70] However, following a significant 1994 Supreme Court decision, courts now routinely refuse to award vacatur for the purpose of accommodating ex post settlement agreements.[71] In such cases, the judgment's collateral effect on third party litigation cannot be undone through ex post settlement. As with antitrust's proscription of certain ex post settlements, this refusal to award vacatur is motivated by a concern for third party interests.

Finally, we note that asymmetric stakes will generally create a distortionary effect in equilibrium if the parties anticipate that ex post contracting would be infeasible due to transaction costs or other frictions. This might suggest that asymmetric stakes will usually have a distortionary effect in the context of class action litigation, as such cases may involve too many parties to permit efficient ex post contracting.

7 Conclusion

When an antitrust defendant is a dominant firm accused of exclusionary conduct by a smaller rival or entrant, the defendant generally has much higher stakes than does the plaintiff. These asymmetric stakes and their effect on litigation effort likely are very important for antitrust litigation involving exclusionary conduct. The loss of monopoly power can reduce the net present value of the dominant firm's profits by billions of dollars, while an injunction generally would provide substantially lower profits to the plaintiff, and damages are unlikely to affect the relative stakes by that much. For example, while it is hard to know what fraction of Windows' profits were at stake in the *Microsoft* litigation, Microsoft's stock price fell from about $52 on Friday March 31 to about $42.5 on April 4, the day after the antitrust

[70] For a detailed discussion, see Fisch (1990).

[71] U.S. Bancorp Mortgage Co. v. Bonner Mall Partnership 513 U.S. 18 (1994).

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opinion was released—-a reduction of about $80 billion.[72] By contrast, the stakes for the private plaintiffs such as RedHat, Netscape, VA Linux, Sun, and Novell were surely much smaller.

This paper has explored the impact of this systematic imbalance on litigation with endogenous effort. Our model shows that asymmetric stakes always lead the plaintiff's winning probability to be distorted below the constrained-optimal level. The problem is not avoided by settling before judgment, for we have also shown that asymmetric stakes lead ex ante conduct-altering settlements to generate too little competition. Enhanced damages can help to reduce the problem, but can never eliminate it. However, we show that one potential solution would involve reducing the plaintiff's evidentiary burden to offset the distortion. Although this result is theoretical, the question of whether antitrust presumptions should be reformed is timely in light of the current concerns that antitrust law is failing sufficiently to constrain the conduct of dominant firms,[73] which has led to legislative proposals[74] as well as academic recommendations for judicial adjustments to legal standards.[75]

While we have focused on antitrust, some of our results have broader applicability. We have shown that asymmetric stakes do not create a distortionary effect in equilibrium if the litigants can effectively contract around a court's judgment; but the distortion persists in antitrust because it proscribes certain ex post settlements. However, as we have explained, similar constraints on ex post settlement arise in other areas of private litigation. Our analysis indicates that such constraints are highly relevant in assessing whether asymmetric stakes will potentially bias litigation outcomes.

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[72] This reduction could be an underestimate because the judge's earlier announced factual findings signaled a substantial likelihood that there would be some liability, and there was a probability of a successful future appeal. Microsoft paid out about $5 billion in damages in private cases and about $4 billion in fines to the European Commission. See Gavil and First (2014) at p. 274.

[73] See, e.g., the Stigler Center's recent report on potentially anticompetitive practices by dominant digital platforms, available at https://research.chicagobooth.edu/stigler/media/news/committee-on-digital-platforms-final-report.

[74] For instance, Senator Amy Klobuchar has recently introduced bill—the "Anticompetitive Exclusionary Conduct Prevention Act of 2020"—which would create anticompetitive presumptions and reduce the enforcement agencies' (but not private plaintiffs') burden of proof in monopolization cases.

[75] See, e.g., Gavil and Salop (2020); Federico et al. (2020).

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Appendix: Proofs

Proof of Proposition 1

Proof. By (1), differentiating Φ yields

$$\frac{\partial \Phi(y|\mathbf{x}, w)}{\partial x_2} < 0 < \frac{\partial \Phi(y|\mathbf{x}, w)}{\partial x_1}, \tag{27}$$

$$\frac{\partial \Phi(y|\mathbf{x}, w)}{\partial w} < 0. \tag{28}$$

Then part (*ii*) follows immediately from (27), while part (*iii*) follows from (28). By Assumption 2, it is clear that the signal is unbiased if $x_1 = x_2$, since f is symmetric about w. But part (*ii*) implies the signal must be biased whenever $x_1 \neq x_2$, since any change in the ratio x_2/x_1 will skew the distribution in one direction or the other. This establishes part (*i*). □

Proof of Proposition 2

Proof. It is easy to verify that each i's payoff function is strictly concave. Hence, a best response for firm 1 is characterized by the first order condition

$$\begin{aligned} & \frac{\partial u_1}{\partial x_1} = 0 \\ \iff \quad & \frac{\alpha[\alpha x_1 + (1-\alpha)x_2] - \alpha^2 x_1}{[\alpha x_1 + (1-\alpha)x_2]^2} v_1 - 1 = 0 \\ \iff \quad & (1-\alpha)\alpha v_1 x_2 = [\alpha x_1 + (1-\alpha)x_2]^2. \end{aligned} \tag{FOC_1}$$

Repeating this for firm 2, we obtain

$$(1-\alpha)\alpha v_2 x_1 = [\alpha x_1 + (1-\alpha)x_2]^2. \tag{FOC_2}$$

Combining these FOCs, an equilibrium must satisfy $v_1 x_2^* = v_2 x_1^*$. Then substituting $x_j^* = (v_j/v_i)x_i^*$ into either FOC and simplifying, we obtain a unique solution

$$x_i^* = \frac{(1-\alpha)\alpha v_i^2 v_j}{[\alpha v_1 + (1-\alpha)v_2]^2}.$$

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With this, the equilibrium probability that the plaintiff wins is

$$\begin{aligned}
p^* &= \frac{\alpha x_1^*}{\alpha x_1^* + (1-\alpha)x_2^*} \\
&= \frac{\alpha \times \frac{(1-\alpha)\alpha v_1^2 v_2}{[\alpha v_1 + (1-\alpha)v_2]^2}}{\alpha \times \frac{(1-\alpha)\alpha v_1^2 v_2}{[\alpha v_1 + (1-\alpha)v_2]^2} \;+\; (1-\alpha) \times \frac{(1-\alpha)\alpha v_1 v_2^2}{[\alpha v_1 + (1-\alpha)v_2]^2}} \\
&= \frac{(1-\alpha)\alpha^2 v_1^2 v_2}{(1-\alpha)\alpha^2 v_1^2 v_2 + (1-\alpha)^2 \alpha v_1 v_2^2} \\
&= \frac{\alpha v_1}{\alpha v_1 + (1-\alpha)v_2}.
\end{aligned}$$

By inspection, we have $x_i^* = v_i p^*(1-p^*)$ for each i, as desired. □

Proof of Proposition 5

Proof. The result follows from the proof of Proposition 2, but with the modification that now impose $v_1 = v_2 = \tau + \delta$, which reflects that the court's decision will only determine whether party 2 has to pay $\tau + \delta$ to party 1. The desired results then follow immediately from the expressions given for x_i^* and p^* in Proposition 2. □

Proof of Proposition 6

Proof. The firms' "disagreement payoffs" are u_i^*. The Nash bargaining solution is the value S^* of S that maximizes the Nash product. Explicitly:

$$S^* = \arg\max_S \Big(\widehat{u}_1(S) - u_1^*\Big)\Big(\widehat{u}_2(S) - u_2^*\Big).$$

Because we are presently assuming $\delta = 0$, it follows that $v_1 = \pi_1^d$ and $v_2 = \pi^m - \pi_2^d$. It is then straightforward to verify that $u_1^* = [p^* - p^*(1-p^*)]\pi_1^d$ and $u_2^* = \pi^m - [p^* + p^*(1-p^*)](\pi^m - \pi_2^d)$. Using these identities (and the definitions of $\widehat{u}_i$ from (13)), the Nash product simplifies to

$$\pi_1^d[\pi^m - \pi_2^d]\left(\frac{S}{N} - p^* + p^*(1-p^*)\right)\left(p^* + p^*(1-p^*) - \frac{S}{N}\right).$$

Taking the first order condition and simplifying yields $S^* = p^* N$, as desired. □

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Proof of Proposition 8

Proof. **Part (i):** When litigation expenditures are symmetric, it follows from Assumptions 1 and 2 that the signal density $\phi(y|\mathbf{x}, w)$ reduces to $f(y|w)$, which is symmetric about w and depends only on $|y-w|$. Then $\tilde{\eta}$ is pinned down by the equation

$$\mathrm{P}_\rho\{w < 0 \,|\, y = \tilde{\eta}, x_1 = x_2\} = \frac{\int_{-\infty}^{0} \rho(w) f(\tilde{\eta}|w) dw}{\int_{-\infty}^{\infty} \rho(w) f(\tilde{\eta}|w) dw} = \frac{1}{2}. \tag{29}$$

Rearranging and simplifying this equation, we obtain

$$\int_{-\infty}^{0} \rho(w) f(\tilde{\eta}|w) dw = \int_{0}^{\infty} \rho(w) f(\tilde{\eta}|w) dw. \tag{30}$$

By the symmetry of ρ and f (Assumptions 2, 3), the product $\rho(w)f(w|\mu) = \rho(w)f(\mu|w)$ is symmetric about μ. Therefore, if $\mu = 0$ then the two sides will be equal iff $\tilde{\eta} = 0$; but if $\mu < 0$ (resp. $\mu > 0$), then equality requires that $\tilde{\eta} > 0$ (resp. $\tilde{\eta} < 0$), as desired. We further note that, in the special case $\rho(w) = f(w|\mu)$, setting $\tilde{\eta} = -\mu$ and using $f(a|b) = f(a-b|0) = f(b-a|0)$, we find

$$\rho(w)f(\tilde{\eta}|w) = f(w|\mu)f(-\mu|w) = f(w-\mu|0)f(-\mu-w|0) = f(w-\mu|0)f(w+\mu|0), \tag{31}$$

which is symmetric about zero. Therefore setting $\tilde{\eta} = -\mu$ satisfies (30) in this case.

Part (ii): Suppose that the firms play equilibrium strategies $\mathbf{x}_\eta^*$, which are themselves conditional on the presumption, as established in Proposition 7. In this case, the optimal presumption η^* is pinned down by the equation

$$\mathrm{P}_\rho\{w < 0 \,|\, y = \eta^*, \, \mathbf{x} = \mathbf{x}_{\eta^*}^*\} = \frac{\int_{-\infty}^{0} \rho(w) \phi(\eta^*|\mathbf{x}_{\eta^*}^*, w) dw}{\int_{-\infty}^{\infty} \rho(w) \phi(\eta^*|\mathbf{x}_{\eta^*}^*, w) dw} = \frac{1}{2}. \tag{32}$$

Rearranging this equation, we obtain

$$\int_{-\infty}^{0} \rho(w) \phi(\eta^*|\mathbf{x}_{\eta^*}^*, w) dw = \int_{0}^{\infty} \rho(w) \phi(\eta^*|\mathbf{x}_{\eta^*}^*, w) dw. \tag{33}$$

Differentiating Φ to obtain ϕ, we find that $\phi(y|\mathbf{x}, w) = \Gamma(y|\mathbf{x}, w) \times f(y|w)$, where

$$\Gamma(y|\mathbf{x}, w) \equiv \frac{x_1 x_2}{\Big(F(y|w)x_1 + [1 - F(y|w)]x_2\Big)^2}. \tag{34}$$

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It is straightforward to verify that

$$\Gamma(y|\mathbf{x},w) \lesseqgtr 1 \quad \Longleftrightarrow \quad \frac{x_2}{x_1} \gtreqless \left(\frac{F(y|w)}{1-F(y|w)}\right)^2.$$

Since $x^*_{2,\eta} > x^*_{1,\eta}$ (for any η), this implies that $\Gamma(\eta|\mathbf{x}^*_\eta, w) < 1$ whenever $\eta < w$, while $\Gamma(\eta|\mathbf{x}^*_\eta, w) \geq 1$ whenever η is sufficiently larger than w. Then, using (30) from Part (i) above, it follows that

$$\int_{-\infty}^{0} \rho(w)\Gamma(\widetilde{\eta}|\mathbf{x}^*_{\widetilde{\eta}}, w) f(\widetilde{\eta}|w)dw > \int_{0}^{\infty} \rho(w)\Gamma(\widetilde{\eta}|\mathbf{x}^*_{\widetilde{\eta}}, w) f(\widetilde{\eta}|w)dw. \tag{35}$$

Here we have inserted $\Gamma(\widetilde{\eta}|\mathbf{x}^*_{\widetilde{\eta}}, w)$ into the integrands on both sides of equation (30). This breaks the equality in (30), because Γ adds weight to the LHS integral while removing weight from the RHS integral. However, if we replaced $\Gamma(\widetilde{\eta}|\mathbf{x}^*_{\widetilde{\eta}}, w)f(\widetilde{\eta}|w)$ with $\Gamma(\eta^*|\mathbf{x}^*_{\eta^*}, w)f(\eta^*|w)$, then the two sides above would have to be equal; this follows immediately from equation (33) and the definition of Γ. Therefore $\widetilde{\eta}$ is not large enough to satisfy (33), ergo $\eta^* > \widetilde{\eta}$.

Part (iii): Now assume $\mu = 0$, so that part (i) implies $\widetilde{\eta} = 0$. In this case, consider the specific case where the true welfare effect is $w = \widetilde{\eta} = 0$. We will show that the median signal (conditional on equilibrium expenditures) in this case coincides with η^*_0. If true, then η^*_0 is pinned down by

$$\Phi(\eta^*|\mathbf{x}^*_{\eta^*_0},\, w = 0) = \frac{1}{2} \tag{36}$$

$$\Longleftrightarrow \qquad \frac{F(\eta^*_0|0)x^*_{1,\eta^*_0}}{F(\eta^*_0|0)x^*_{1,\eta^*_0} + [1-F(\eta^*_0|0)]x^*_{2,\eta^*_0}} = \frac{1}{2} \tag{37}$$

$$\Longleftrightarrow \qquad \frac{F(\eta^*_0|0)v_1}{F(\eta^*_0|0)v_1 + [1-F(\eta^*_0|0)]v_2} = \frac{1}{2} \tag{38}$$

$$\Longleftrightarrow \qquad F(\eta^*_0|0) = \frac{v_2}{v_1+v_2}, \tag{39}$$

which is the desired expression. To confirm that value of η^*_0 must be correct, note that if (and only if) the court observes $y < \eta^*_0$, then we can conclude the true value of w is most likely negative, because: (a) ρ is symmetric about zero; and (b) under equilibrium expenditures, every positive (resp. negative) value of w has a median signal value that is strictly larger (resp. smaller) than η^*_0. □

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Proof of Proposition 9

Proof. Payoffs take the form $u_1 = \Phi(0|\mathbf{x}, w)v_1 - x_1$ and $u_2 = \pi^m - \Phi(0|\mathbf{x}, w)v_2 - x_2$. If an equilibrium has $x_i^* > 0$ for each i, then expenditures must be pinned down by first order conditions. Using condition (C1), these conditions take the form

$$\left|\frac{\partial \Phi(0|\mathbf{x}^*, w)}{\partial x_i}\right| v_i = 1.$$

Combining these equations yields

$$\frac{\partial \Phi(0|\mathbf{x}^*, w)}{\partial x_1} = \frac{v_2}{v_1}\left|\frac{\partial \Phi(0|\mathbf{x}^*, w)}{\partial x_2}\right| > \left|\frac{\partial \Phi(0|\mathbf{x}^*, w)}{\partial x_2}\right|.$$

Thus, by (C2), we must have $x_2^* > x_1^*$. □

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