Deterrence and plaintiff incentives*

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Comments welcome

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Abstract

The payoff received by a successful plaintiff in a lawsuit affects a plaintiff's litigation decisions, and so in turn affects the incentives provided to the defendant. This paper characterizes how a change in the plaintiff's award affects the equilibrium litigation expenditures of both the plaintiff and the defendant, and uses this characterization to assess the change in deterrence. The paper gives conditions under which an increase in the plaintiff's award leads to an increase — or alternatively, decrease — in deterrence provided. It identifies two key determinants: (I) Are litigation expenditures substitutes or complements with the underlying merits of the litigating party's case? (II) When pre-trial settlement is possible, does the defendant or plaintiff have greater bargaining power?

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An important topic within law and economics concerns the effects of the award granted to a successful plaintiff in a lawsuit. The size of the plaintiff's award matters because it affects the plaintiff's litigation decisions, which in down affect the social cost of litigation and the incentives provided to the defendant. A natural benchmark for the plaintiff's award is that it should equal the penalty imposed on the defendant. However, and in spite of substantial research on the topic, it remains unclear if and when this benchmark is optimal.

The analysis of the effects of changes in the plaintiff's award is subject to two main complications. First, the plaintiff's litigation decisions are jointly determined with those of the defendant, and a general characterization of the equilibrium of this litigation game has proved hard to obtain. Second, to assess effects on deterrence one must compare the equilibrium litigation outcomes for different underlying defendant actions. Integration of endogenous litigation into primary activity models is challenging because, as Choi and Sanchirico (2004) note, "definitive results on the size of damages' marginal deterrence are elusive ... almost anything can happen." (footnote 23, page 19).

The current paper carries out this analysis, and gives conditions under which an increase in the plaintiff's award leads to an increase — or alternatively, decrease — in deterrence provided. It identifies two key determinants: (I) Are litigation expenditures substitutes or complements with the underlying merits of the litigating party's case? (II) When pre-trial settlement is possible, does the defendant or plaintiff have greater bargaining power? The paper concludes with a discussion of implications for class-action procedure, collateral estoppel, and public versus private enforcement.

Related literature

Polinsky and Rubinfeld (1998) and Hylton (1990) observe that when the plaintiff must decide whether or not to file, strict liability and negligence both fail to provide the defendant with the optimal level of deterrence. Polinsky and Shavell (1989) also consider filing decisions, along with the possibility that the court makes mistakes. They characterize the equilibrium filing decisions and consequent deterrence, but say little about what these conditions imply for the choice of plaintiff awards. Che and Polinsky (1991) argue that in general it is optimal to separate, or *decouple*, the plaintiff's award from the defendant's penalty, since by changing the former one can directly affect the probability that the plaintiff files.

In all of the above papers the only litigation decision modelled is the plaintiff's choice as to whether to file or not — whereas in reality, the plaintiff must also choose the intensity of litigation efforts, as must the defendant. A separate strand of the law and economics literature has studied this problem (see, e.g., Posner 1973, Katz 1988). Closely related is the literature on *contest success functions* — see, e.g., Tullock (1975, 1980), and Hirshleifer (2001). Farmer and Pecorino (1999) and Hirshleifer and Osborne (2001) explicitly apply this framework to analyze legal disputes. However, in general these papers have not related the outcome of the litigation "contest" to deterrence.

The current paper is most closely related to the relatively small number of papers that consider the interaction of litigation intensity with deterrence.[1] Choi and Sanchirico (2004) show how the defendant's litigation intensity can complicate and even overturn Polinsky and Che's argument in favor of decoupling, but restrict attention to cases in which the litigation decision of one of the parties has little impact on the decision of other party — that is, "cross-effects" are negligible. In contrast, the current paper is largely concerned with effects of this kind. Bernardo, Talley and Welch (2000) consider the impact of "legal presumptions" on litigation expenditures and hence deterrence under a particular specification of court decision making in which influence expenditures and the truth are complements; for their specification, they show that when presumptions are shifted to favor the plaintiff this increases deterrence, with the only drawback the increase in litigation costs. In contrast, the current paper focuses on how changes in plaintiff awards can have very different effects in different court systems. It shows that for some plausible specifications of a court system, changes in legal rules that favor the plaintiff (such as awarding him/her a greater fraction of damages) may actually reduce deterrence. Finally, in two recent papers

[1] See also Png (1987) and Spier (1994), who study whether or not settlement occurs.

Sanchirico (2005, 2006) studies how changes to legal procedure impact litigation intensities and deterrence, while holding the plaintiff award and defendant penalty fixed. In contrast, the current paper studies changes in the plaintiff award, while holding legal procedure fixed.

Outline of paper

Section 1 presents the model. Section 2 characterizes equilibrium expenditures. Section 3 analyzes the effect of changes in the plaintiff's award on deterrence. Section 4 considers the important special case in which the court treats the defendant and plaintiff equally. Section 5 introduces the possibility of out-of-court settlement. Section 6 discusses the effects of changing the penalty. Finally, Section 7 applies the results to a range of issues.

1 Basic model

Primary activity

The main focus of the paper is on the incentives the legal system provides to some individual — henceforth, the *defendant* — to take one action in preference to another. Formally, the defendant chooses an action (the "primary activity") $a \in \{G[\text{ood}], B[\text{ad}]\}$. The defendant prefers action B, while action G is socially efficient.

Litigation

The only reason for the plaintiff to take the socially efficient action G is the threat of a penalty, which must be enforced by the legal system. Throughout the paper the penalty is denoted by Z. A necessary condition for the penalty to be imposed is that a second individual — henceforth, the *plaintiff* — initiates the enforcement of the penalty. The penalty is only imposed if a court finds that defendant took action B. The defendant's action $a \in \{G, B\}$ is observed by the plaintiff, but not by the court. The plaintiff is able to initiate a lawsuit after both actions G, B — though his probability of winning the suit differs between the two cases.

The plaintiff's award

In the simplest forms of dispute resolution, the plaintiff's payoff to winning a lawsuit matches the defendant's loss — and as such, the plaintiff's and defendant's incentives to win the case coincide. However, this equality of incentives is impacted by a number of legal rules. To take what is perhaps the clearest example, a number of U.S. states have recently adopted split-award statutes, mandating that a certain fraction of punitive damages be shared with the state. Such rules clearly reduce a plaintiff's payoff from court victory.

A second important example arises when a large number of plaintiffs seek to bring similar lawsuits against a common defendant. Assuming that a court's decision in the first few suits impacts later court rulings, the defendant's incentives to win each case are now greater than those of each individual plaintiff. Equality is restored if plaintiffs can combine their claims, as in class action lawsuits in the U.S. Closely related to the ease with which a class action can be brought is the admissibility of collateral estoppel as a defence — see Section 7.

Arguably the most fundamental determinant of a plaintiff's payoff for prevailing in court is his/her actual identity. In private lawsuits the plaintiff is almost always an injured party, and if successful will receive a payment related to the punishment imposed on the defendant (give or take the factors just described). In sharp contrast, in many instances it is instead a government representative that acts as the plaintiff. For example, a regulatory agency such the Securities and Exchange Commission (SEC) may file a civil lawsuit; and in any criminal case, the role of the plaintiff is occupied by a public prosecutor (in the U.S., typically a District Attorney). Government representatives derive very different payoffs from winning a case than do private plaintiffs — in place of direct monetary compensation, their award, if any, is in the form of future career advancement. Since the location of the boundary between private and public law varies significantly across jurisdictions, so will the incentives of the party who litigates the case against the defendant. For the remainder of the paper, and with some abuse of language, I will refer to whoever argues the case in court against the defendant as the "plaintiff."

Notationally, let R denote the plaintiff's payoff (or monetary equivalent) — henceforth *award* — from winning a case. I will often refer to the benchmark case $R = Z$ as the plaintiff being *fully rewarded*. If damages have been "decoupled," with the state taking some fraction ϕ of the fine, then $R = (1 - \phi) Z$. If the punishment is non-pecuniary and the plaintiff is a private citizen then (at least ignoring vengeance motives) $R = 0$. On the other hand, if the plaintiff is a state representative then the court's decision may be more important than the magnitude of the penalty actually imposed: in the extreme, R may be independent of Z.

Influencing the court

The plaintiff's award to winning a case matters because it affects how many resources the two parties devote to try to win the case. Litigating parties can raise their chances of prevailing in court by undertaking expenditures of various kinds. They can hire more lawyers, and/or better lawyers. They can devote varying amounts of effort to producing evidence of varying qualities. They can also attempt to bribe court officials. The relative importance of these different influence activities varies greatly across legal regimes. In many developing countries outright bribery is probably the most important. In contrast, in the U.S. and other rich countries most observers view court corruption as relatively rare — while at the same time there exists considerable concern about disparities in the quantity and quality of legal representation that different parties have access to.

Let $x_D \geq 0$ and $x_P \geq 0$ denote the influence expenditures of the defendant and the plaintiff respectively, and let the probability that the court rules for the defendant after action a be given by $\pi(x_D, x_P; a)$.[2] Looking ahead, the paper's main results relate general

[2] This formulation includes as a special case the influence game analyzed by Katz (1988), as will be made clear in Example 1 below. The current paper's main focus is on the determinants of deterrence; in contrast, Katz is concerned primarily with court expenditures themselves.

properties of this function π to the optimal level of plaintiff incentives R. Throughout, I assume that the probability π (respectively, $1-\pi$) that the court rules for the defendant (respectively, the plaintiff) is an increasing and strictly concave function of the defendant's expenditure x_D (respectively, the plaintiff's expenditure x_P). I assume moreover that π is twice-differentiable in both x_D and x_P, so that $\pi_D > 0$, $\pi_{DD} \leq 0$, $\pi_P < 0$, $\pi_{PP} \geq 0$.

In this framework, a decision by the plaintiff *not to file* a case is simply represented by $x_P = 0$.

The following example gives a class of parameterizations for π that nests parameterizations used in the existing literature, and will be used to illustrate some of the results that follow.

Example 1. *Following action a, the defendant's expenditure x_D produces evidence $y_D(x_D, a)$, while the plaintiff's expenditure x_P produces evidence $y_P(x_P, a)$. The defendant wins whenever $y_D(x_D, a) + \theta \geq y_P(x_P, a)$, where θ is a random factor reflecting court mistakes, with distribution function F and unimodal density function f with its mode at 0. So*[3]

$$\begin{aligned}
\pi(x_D, x_P; a) &= 1 - F(y_P(x_P, a) - y_D(x_D, a)) \\
\pi_D(x_D, x_P; a) &= y_D'(x_D, a) f(y_P(x_P, a) - y_D(x_D, a)) \\
\pi_P(x_D, x_P; a) &= -y_P'(x_P, a) f(y_P(x_P, a) - y_D(x_D, a)).
\end{aligned}$$

One convenient parameterization of the evidence production functions y_D and y_P is that expenditure x_i by party $i = D, P$ produces evidence according to

$$y_i(x_i, a) = M_{ia} + \gamma_{ia} \ln x, \tag{1}$$

where $\gamma_{ia} > 0$ and $M_{ia} \geq 0$ are constants that may depend both on the identity i of the evidence producing party and on the defendant's action a.[4] *To reflect the fact that evidence production is easier for a party when arguing with the facts (i.e., after $a = G$ for the*

[3]Note that π is concave in x_D and convex in x_P provided that $\frac{y_D''}{(y_D')^2} < \frac{f'}{f}$ and $\frac{y_P''}{(y_P')^2} < -\frac{f'}{f}$. For the logistic distribution ($F(x) = e^{\beta x}(1+e^{\beta x})^{-1}$, some $\beta > 0$), the ratio f'/f lies between $-\beta$ and β.

[4]Note that under this specification, $\frac{y_i''}{(y_i')^2} = -\frac{1}{\gamma_{ia}}$.

defendant and after $a = B$ for the plaintiff), assume

$$M_{DG} \geq M_{DB},\ M_{PB} \geq M_{PG},\ \gamma_{DG} \geq \gamma_{DB} \text{ and } \gamma_{PB} \geq \gamma_{PG}. \tag{2}$$

Economically, M_{ia} can be thought of as either an endowment of evidence available without cost, or as a shift of the mean of the court-specific factor θ. When F is the logistic function, following Katz (1988) the function π is

$$\pi(x_D, x_P; a) = \frac{e^{M_{Da} - M_{Pa}} \frac{x_D^{\gamma_{Da}}}{x_P^{\gamma_{Pa}}}}{e^{M_{Da} - M_{Pa}} \frac{x_D^{\gamma_{Da}}}{x_P^{\gamma_{Pa}}} + 1}.$$

(Note that $\pi = 1$ if $x_P = 0$ and $\pi = 0$ if $x_D = 0$: if the plaintiff spends nothing the defendant wins, and if the defendant spends nothing the plaintiff wins.) When $M_{Da} = M_{Pa}$ and $\gamma_{Pa} = \gamma_{Da}$ this is the widely used power form of the (symmetric) contest success function (see, e.g., Hirshleifer 1989; Skaperdas 1996 gives an axiomatization). Both Hirshleifer and Osborne (2001) and Farmer and Pecorino (1999) use a specification with $\gamma_{Pa} = \gamma_{Da}$ and $M_{Da} \neq M_{Pa}$ in their studies of litigation.

Timing

To recap, events take place according to the following timing:

1. The defendant chooses an action $a \in \{G, B\}$.
2. The defendant and plaintiff simultaneously choose litigation intensities $x_D \geq 0$ and $x_P \geq 0$. A plaintiff's decision not to file a case is represented by $x_P = 0$, i.e., the plaintiff spends nothing on litigation.
3. The court rules for either the defendant or the plaintiff. In the latter case, the defendant pays Z and the plaintiff receives R.

For now out-of-court settlement is assumed impossible — Section 5 analyzes the case in which settlement occurs.

2 Equilibrium expenditures

The plaintiff and defendant simultaneously choose expenditures x_P and x_D. Taking the plaintiff's choice of x_P as given, the defendant chooses $x_D \geq 0$ to maximize his expected payoff,

$$-\left(1-\pi\left(x_D, x_P; a\right)\right) Z - x_D.$$

Similarly the plaintiff takes x_D as given and chooses $x_P \geq 0$ to maximize his expected payoff,

$$\left(1-\pi\left(x_D, x_P; a\right)\right) R - x_P.$$

Given the defendant's choice of action a, define $x_{Da}\left(x_P\right)$ and $x_{Pa}\left(x_D\right)$ to be the defendant's best response to the plaintiff's expenditure x_P, and the plaintiff's best response to the defendant's expenditure x_D, respectively. The first-order conditions (FOC) for $x_{Da}\left(x_P\right)$ and $x_{Pa}\left(x_D\right)$ are

$$\begin{aligned} \pi_D\left(x_{Da}\left(x_P\right), x_P; a\right) &\leq \frac{1}{Z}, \text{ with equality if } x_{Da}\left(x_P\right) > 0 && (3) \\ -\pi_P\left(x_D, x_{Pa}\left(x_D\right); a\right) &\leq \frac{1}{R}, \text{ with equality if } x_{Pa}\left(x_D\right) > 0 && (4) \end{aligned}$$

Note that since π is strictly concave in x_D and convex in x_P, each party has a unique best response to the other's choice of expenditure, and so $x_{Da}\left(x_P\right)$ and $x_{Pa}\left(x_D\right)$ are well-defined. For future reference, note moreover that both best response functions are continuous.[5]

Lemma 1. ***(Equilibrium existence and uniqueness)***
For both defendant actions $a = G, B$, an equilibrium exists and is unique.

In light of Lemma 1, denote the equilibrium expenditures following action a by (x^*_{Da}, x^*_{Pa}).

[5] This is easily shown. For example, for the defendant's best response function this follows from the fact that π_D is strictly decreasing in x_D, and is continuous in x_P.

Deterrence

Let $\zeta(R,Z)$ denote the difference in the defendant's expected court payoff between action choices G and B. That is, $\zeta(R,Z)$ is the *deterrence* provided by the legal system. Formally,

$$\zeta(R,Z) \equiv Z\left(\pi\left(x^*_{DG}, x^*_{PG}; G\right) - \pi\left(x^*_{DB}, x^*_{PB}; B\right)\right) - \left(x^*_{DG} - x^*_{DB}\right).$$

The defendant chooses the good action, $a = G$, if and only if deterrence ζ exceeds his private benefits from taking the bad action B. The remainder of the paper considers the effect of the plaintiff's award R on deterrence.

3 The effect of plaintiff awards on deterrence

The plaintiff's award impacts the amount he/she will spend in court to try to win a case. This affects the plaintiff's expected payoff, and hence the deterrence provided. However, the effect is complicated by the fact that as the plaintiff's court expenditures change, so will the defendant's best response. Consequently it is necessary to characterize the change in equilibrium expenditures, and the ensuing effect on deterrence.

The effect of changing R on equilibrium expenditures

Lowering the plaintiff's award reduces the plaintiff's expenditure $x_{Pa}(x_D)$ for any given defendant expenditure x_D, while leaving the defendant's own best response function unchanged. The effect on equilibrium expenditures depends on the shape of the best response functions. From the FOC (3) and (4), the slopes are given by

$$\begin{aligned} x'_{Da}(x_P) &= \frac{-\pi_{PD}\left(x_{Da}(x_P), x_P; a\right)}{\pi_{DD}\left(x_{Da}(x_P), x_P; a\right)} \text{ if } x_{Da}(x_P) > 0 \\ x'_{Pa}(x_D) &= \frac{-\pi_{PD}\left(x_D, x_{Pa}(x_D); a\right)}{\pi_{PP}\left(x_D, x_{Pa}(x_D); a\right)} \text{ if } x_{Pa}(x_D) > 0. \end{aligned} \tag{5}$$

In the case that the defendant's (respectively, the plaintiff's) expenditure choice is at the zero expenditure corner, $x_{Da}(x_P) = x'_{Da}(x_P) = 0$ (respectively, $x_{Pa}(x_D) = x'_{Pa}(x_D) = 0$). Observe that the only point at which a party's best response function may fail to be

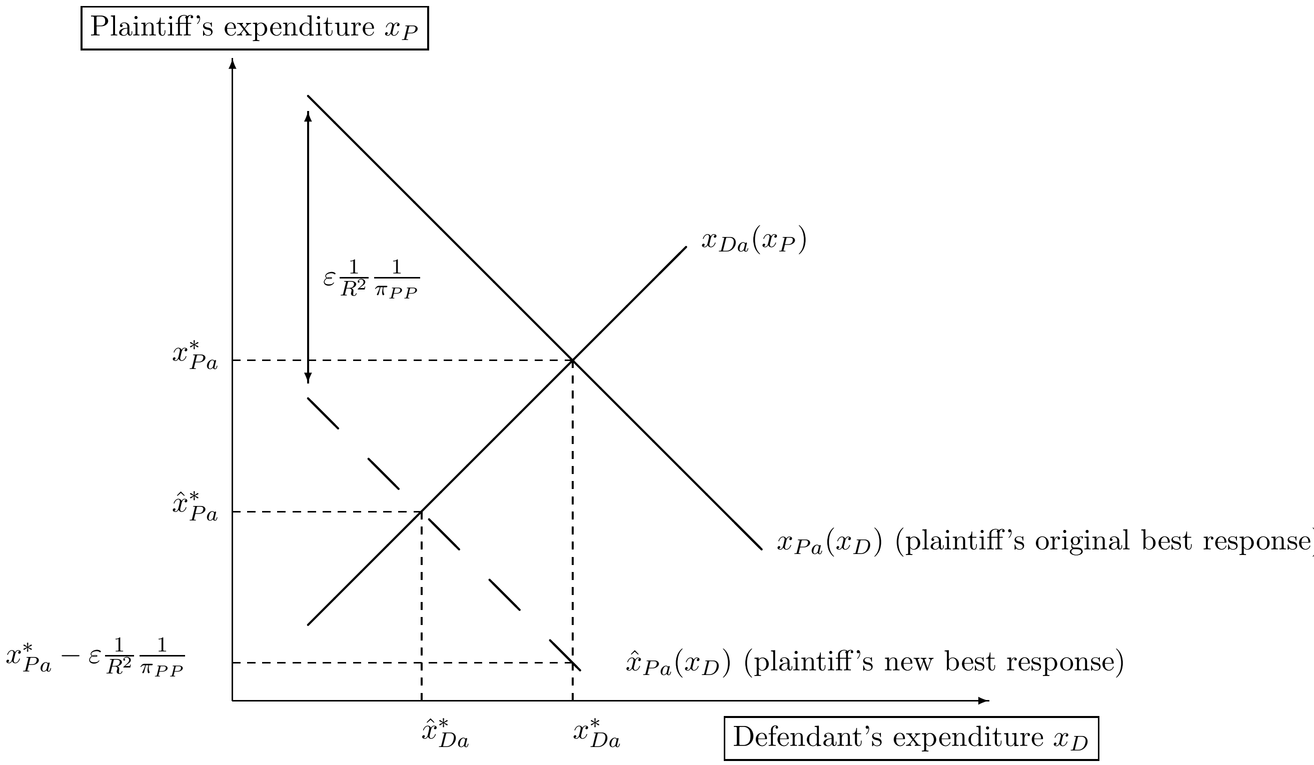

Figure 1: The graph displays the effect of reducing R by ε on equilibrium expenditures. It shows the linear approximations of best response functions $x_{Da}(x_P)$ and $x_{Pa}(x_D)$ in the neighborhood around the equilibrium expenditures (x^*_{Da}, x^*_{Pa}).

differentiable is when the best response function is equal to zero, and the FOC holds at equality. But even here both one-sided derivatives exist.

Consider a small reduction in the plaintiff award, i.e., R to $R - \varepsilon$. As just noted, the plaintiff's best response function is lowered at all points; differentiating the plaintiff's FOC and rearranging, the *amount* by which it is lowered is approximately

$$\varepsilon \frac{\partial x_{Pa}(x_D)}{\partial R} = \varepsilon \frac{1}{R^2} \frac{1}{\pi_{PP}(x_D, x_{Pa}(x_D); a)}.$$

The new equilibrium is determined by the intersection of the plaintiff's new best response function and the defendant's best response function, the latter of which is of course unaffected by the change in the plaintiff's award. Let $\hat{x}^*_{Pa}$ and $\hat{x}^*_{Da}$ denote the plaintiff's and defendant's new equilibrium expenditures. From Figure 3, we can see that on the one hand the change in the change in the defendant's expenditure satisfies

$$x^*_{Da} - \hat{x}^*_{Da} = \left(x^*_{Pa} - \hat{x}^*_{Pa}\right) x'_{Da},$$

while on the other hand the change in the defendant's expenditure satisfies

$$\left(x^*_{Da} - \hat{x}^*_{Da}\right)\left(-x'_{Pa}\right) = \hat{x}^*_{Pa} - \left(x^*_{Pa} - \frac{\varepsilon}{R^2 \pi_{PP}}\right).$$

It follows that

$$\frac{x^*_{Pa} - \hat{x}^*_{Pa}}{\varepsilon} = \frac{1}{1 - x'_{Da} x'_{Pa}} \frac{1}{R^2 \pi_{PP}}.$$

Stated more formally, and taking care of cases where one or more parties is at the zero expenditure corner and so the FOC do not hold at equality, we have:

Proposition 1. ***(Change in plaintiff's equilibrium choice of legal expenditure)*** *The left-hand side derivative of x^*_{Pa} with respect to R exists, and is given by*

$$\frac{\partial x^*_{Pa}}{\partial R_-} = \begin{cases} \frac{1}{1 - x'_{Da}\left(x^*_{Pa}\right) x'_{Pa}\left(x^*_{Da}\right)} \frac{1}{R^2 \pi_{PP}\left(x^*_{Da}, x^*_{Pa}; a\right)} \geq 0 & \text{if } x^*_{Pa} > 0 \\ 0 & \text{if } x^*_{Pa} = 0 \end{cases}.$$

(If $x_{Da}(\cdot)$ is not differentiable at x^*_{Pa}, then $x'_{Da}\left(x^*_{Pa}\right)$ is understood to denote the left-hand side derivative.)

Effect of changing R on deterrence

Given Proposition 1's characterization of how a reduction in plaintiff awards affects equilibrium expenditures, one can assess the impact on deterrence. First, taking the plaintiff's choice of expenditure x_P as given, the defendant's expected payoff after taking action a is

$$V_D\left(x_P; a\right) \equiv \max_{x_D} - \left(1 - \pi\left(x_D, x_P; a\right)\right) Z - x_D \tag{6}$$

Deterrence ζ can then be expressed in terms of $V_D(x_P; a)$ as

$$\zeta = V_D(x_{PG}^*; G) - V_D(x_{PB}^*; B).$$

By the envelope theorem, the derivative of V_D with respect to a change in the plaintiff's influence expenditure is[6]

$$\frac{\partial V_D(x_P; a)}{\partial x_P} = \pi_P(x_{Da}(x_P), x_P; a) Z. \tag{7}$$

If the plaintiff's equilibrium expenditure is $x_{Pa}^* > 0$, then from the FOC $\pi_P(x_{Da}^*, x_{Pa}^*; a) = -1/R$. On the other hand, if $x_{Pa}^* = 0$ then from Proposition 1, $\partial x_{Pa}^* / \partial R_- = 0$. Combined, these statements imply:

Proposition 2. ***(Change in deterrence)***
A change in the plaintiff's award R changes deterrence according to

$$\frac{\partial \zeta}{\partial R_-} = -\frac{Z}{R}\frac{\partial x_{PG}^*}{\partial R_-} - \frac{Z}{R}\frac{\partial x_{PB}^*}{\partial R_-} = \frac{Z}{R}\left(\frac{\partial x_{PB}^*}{\partial R_-} - \frac{\partial x_{PG}^*}{\partial R_-}\right).$$

In words, Proposition 2 says that a reduction in the plaintiff's award R will reduce deterrence if and only if it generates a bigger reduction in the plaintiff's equilibrium legal expenditures after the defendant has taken action B than G.

4 When is deterrence maximized by fully rewarding the plaintiff?

Together, Propositions 1 and 2 fully characterize how a change in the plaintiff's award will affect the deterrence provided. That is, for any specification of the court π and the plaintiff's award R, one can compute the equilibrium expenditures x_{DG}^*, x_{PG}^*, x_{DB}^*, x_{PB}^*,

[6] The application of the envelope theorem is immediate when $x_{Da}(x_P) > 0$. If $x_{Da}(x_P) = 0$ over some open neighborhood around x_P, then clearly $\partial V_D(x_P; a) / \partial R = \pi_P(0, x_P; a) Z = \pi_P(x_{Da}(x_P), x_P; a) Z$. Thus the only potential difficulty arises at a point x_P such that $x_{Da}(\cdot) = 0$ to one side, but $x_{Da}(\cdot) > 0$ to the other. But in this case the limits of the derivative from either side both equal $\pi_P(0, x_P; a) Z$, and so V_D is indeed differentiable at this point, with its derivative equal to $\pi_P(x_{Da}(x_P), x_P; a) Z$.

evaluate the second derivatives of π at these expenditures, and thus establish how a small change in the plaintiff's award affects deterrence.

In order to gain additional insight into the determinants of the deterrence-maximizing plaintiff award, this section studies the important benchmark case in which the court treats the defendant and plaintiff equally, in the following sense: an innocent defendant's ability to influence the court matches that of a plaintiff arguing against a guilty defendant. In other words, a party's influence ability depends only on whether or not he is arguing for or against the truth, and not on his identity. Formally, there exists a constant κ such that for all x_D, x_P,

$$\pi\left(x_D, x_P; G\right) = 1 - \pi\left(x_P, x_D; B\right) + \kappa \tag{ANON}$$

Note that this assumption does not rule out the possibility that the court systematically favors one party over the other, since it says nothing about the *level* of π — which is determined by the constant κ.

When property (ANON) holds, and the plaintiff is fully rewarded ($R = Z$) the court game played between the plaintiff and the defendant after $a = G$ is the same as that played between the defendant and the plaintiff after $a = B$. As such, the equilibrium expenditures following $a = G, B$ are just mirror images of one another, i.e., $\left(x^*_{DG}, x^*_{PG}\right) = \left(x^*_{PB}, x^*_{DB}\right)$. This consequence of (ANON) allows a considerable simplification of Proposition 2, and delivers the following conclusion for when a local reduction in plaintiff incentives from the benchmark $R = Z$ improves incentives:

Proposition 3. ***(Change in deterrence)***
If (ANON) holds, and equilibrium expenditures by both parties are strictly positive after $a = B, G$, then a local increase in the plaintiff's award around $R = Z$ increases deterrence if and only if

$$\pi_{DD}\left(x^*_{DB}, x^*_{PB}; B\right) \leq -\pi_{PP}\left(x^*_{DB}, x^*_{PB}; B\right) \tag{8}$$

To interpret Proposition 3, note that after the defendant chooses action B the defendant is arguing against the facts, while the plaintiff is arguing with them. Thus

$$
\begin{aligned}
\pi_{DD}\left(x_{DB}^{*}, x_{PB}^{*}; B\right) &= \frac{\partial\left(\text{marginal impact of spending \$1 for party arguing \textit{against} the facts}\right)}{\partial\left(\text{total influence expenditure of party arguing \textit{against} the facts }\right)} \\
-\pi_{PP}\left(x_{DB}^{*}, x_{PB}^{*}; B\right) &= \frac{\partial\left(\text{marginal impact of spending \$1 for party arguing \textit{with} the facts}\right)}{\partial\left(\text{total influence expenditure of party arguing \textit{with} the facts }\right)}.
\end{aligned}
$$

So inequality (8) is equivalent to the condition

$$
\frac{\partial^{2}\left(\text{marginal impact of spending \$1}\right)}{\partial\left(\text{total influence expenditure}\right)\partial\left(\text{increase in merits of case}\right)} \geq 0.
$$

Proposition 3 says that increasing plaintiff incentives increases deterrence if and only if expenditures and the truth are complements in their determination of the marginal value of litigation expenditure.

If instead the truth and influence expenditures are substitutes in this sense, then Proposition 3 implies that fully rewarding the plaintiff is suboptimal. Consequently, deterrence would be increased if the plaintiff's award were decreased.[7,8]

Example 2. *Consider again Example 1, with evidence production given by (1) and at least one of the relations in (2) strict. Using the fact that* $y_D'\left(x_{DB}^{*}; B\right) = y_P'\left(x_{PB}^{*}; B\right)$ *when* $R = Z$*, inequality (8) is equivalent to*

$$
\frac{y_D''\left(x_{DB}^{*}; B\right)}{\left(y_D\left(x_{DB}^{*}; B\right)\right)^{2}} - \frac{y_P''\left(x_{PB}^{*}; B\right)}{\left(y_P\left(x_{PB}^{*}; B\right)\right)^{2}} - 2\frac{f'\left(y_P\left(x_{PB}^{*}; B\right) - y_D\left(x_{DB}^{*}; B\right)\right)}{f\left(y_P\left(x_{PB}^{*}; B\right) - y_D\left(x_{DB}^{*}; B\right)\right)} \leq 0.
$$

Substituting in for (1)'s specification of y_D *and* y_P*, this inequality becomes*

$$
\frac{1}{\gamma_{PB}} - \frac{1}{\gamma_{DB}} - 2\frac{f'\left(y_P\left(x_{PB}^{*}; B\right) - y_D\left(x_{DB}^{*}; B\right)\right)}{f\left(y_P\left(x_{PB}^{*}; B\right) - y_D\left(x_{DB}^{*}; B\right)\right)} \leq 0.
$$

[7] It is important to note that the complementarity/substitutability of the truth and influence expenditures is unrelated to the complementarity/substitutability of the influence expenditures of the two parties, that is, π_{DP}.

[8] Proposition 3 relates the *local* effect of an increase in plaintiff incentives to the complementarity/substitutability of the truth and influence expenditures in the determination of the marginal effect of influence expenditures. It is also possible to obtain a parallel result relating the incentives provided by a fully incentivized ($R = Z$) and completely unincentivized plaintif to the complementarity/substitutability of the truth and influence expenditures in determining the probability of court victory. For space reasons this result is omitted, but is available from the author upon request.

It is straightforward to show that $y_P(x^*_{PB};B) - y_D(x^*_{DB};B) > y_P(x^*_{PB};G) - y_D(x^*_{DB};G)$ *(see appendix for details), while property (ANON) implies* $y_P(x^*_{PB};B) - y_D(x^*_{DB};B) = -(y_P(x^*_{PB};G) - y_D(x^*_{DB};G))$. *It follows that* $y_P(x^*_{PB};B) - y_D(x^*_{DB};B) > 0$, *and so* $f'(y_P(x^*_{PB};B) - y_D(x^*_{DB};B)) < 0$.

Given this, if $M_{PB} > M_{DB}$ *but* $\gamma_{PB} = \gamma_{DB}$ *truth and expenditures are substitutes. Economically, this case arises if the main effect of the defendant's action* B *is to increase the court's propensity to rule for the plaintiff. In this case, it is suboptimal to fully reward the plaintiff.*

In contrast, if γ_{PB} *exceeds* γ_{DB} *by a large enough amount, truth and expenditures are complements. Economically, this case arises if the marginal product of influence expenditures is much higher for a party arguing with the facts. In this case, it is at least locally optimal to fully reward the plaintiff.*

5 Settlement

So far the analysis has dealt with the case in which all litigation ends in court. However, given that once in court the litigating parties expend resources, the parties have the incentive to reach a settlement before the trial. Empirically, the vast majority of lawsuits do indeed settle out of court.

To model settlement, let $\bar{V}_D(a)$ and $\bar{V}_P(a)$ denote the settlement payoffs of the defendant and plaintiff respectively, given defendant action a. Given the zero-sum nature of settlement, $\bar{V}_D + \bar{V}_P = 0$. The distribution of bargaining power between the two parties has a very large impact on how changes in plaintiff awards affect deterrence. To make this point in the most transparent way, this section will consider the two extreme cases in which the plaintiff (respectively, defendant) has all the bargaining power.

Plaintiff has all the bargaining power

When the plaintiff has all the bargaining power, the defendant's settlement payoff equals his expected payoff in court, $\bar{V}_D(a) = V_D(x^*_{Pa}; a)$. In this case, the deterrence provided to the defendant is the same with and without the possibility of settlement, and the analysis of prior sections applies unchanged. In particular, when property (ANON) holds it is suboptimal to fully reward the plaintiff if the truth and influence expenditures are substitutes.

Defendant has all the bargaining power

If instead the defendant has all the bargaining power, the defendant's expected payoff from settlement after action a is given by: $\bar{V}_D(a) = -\bar{V}_P(a) = -V_P(x^*_{Da}; a)$. As such, the effect of a change in the plaintiff's award R on deterrence ζ is

$$\frac{\partial \zeta}{\partial R} = -\left(\frac{\partial V_P(x^*_{DG}; G)}{\partial R} - \frac{\partial V_P(x^*_{DG}; B)}{\partial R}\right). \tag{9}$$

By the envelope theorem, a change in the plaintiff's award R affects $V_P(x^*_{Da}; a)$ according to

$$\frac{\partial V_P(x^*_{Da}; a)}{\partial R} = (1 - \pi(x^*_{Da}, x^*_{Pa}; a)) - R\pi_D(x^*_{Da}, x^*_{Pa}; a)\frac{\partial x^*_{Da}}{\partial R}. \tag{10}$$

The defendant's expenditure x^*_{Da} satisfies the FOC $Z\pi_D(x^*_{Da}, x^*_{Pa}; a) = 1$, while the effect of a change in plaintiff awards on the defendant's expenditure is given by $\partial x^*_{Da}/\partial R = x'_{Da}(x^*_{Pa})\,\partial x^*_{Pa}/\partial R$. Hence (10) rewrites as[9]

$$\frac{\partial V_P(x^*_{Da}; a)}{\partial R} = (1 - \pi(x^*_{Da}, x^*_{Pa}; a)) - \frac{R}{Z}x'_{Da}(x^*_{Pa})\frac{\partial x^*_{Pa}}{\partial R}. \tag{11}$$

So if settlement is possible and the defendant has all the bargaining power, substituting (11) into (9) implies that changing the plaintiff's award affects deterrence according to

$$\frac{\partial \zeta}{\partial R} = \pi(x^*_{DG}, x^*_{PG}; G) - \pi(x^*_{DB}, x^*_{PB}; B) + \frac{R}{Z}\left(x'_{DG}(x^*_{PG})\frac{\partial x^*_{PG}}{\partial R} - x'_{DB}(x^*_{PB})\frac{\partial x^*_{PB}}{\partial R}\right). \tag{12}$$

[9] If the defendant's expenditure is at the zero corner, then $\partial x^*_{Da}/\partial R = x'_{Da}(x^*_{Pa}) = 0$ and so (10) still holds.

The first two terms reflect the difference between the defendant's equilibrium probabilities of winning in court after actions G and B. Under any economically sensible specification of π this difference is non-negative. (It is readily verified that this is indeed the case for the parameterization of Example 1 — see appendix for details.)

From Proposition 1, an increase in the plaintiff's award increases the plaintiff's equilibrium expenditure. So the net effect of the last two terms in (12) depends critically on how the defendant responds to an increase in plaintiff expenditures, as measured by $x'_{DG}(x^*_{PG})$ and $x'_{DB}(x^*_{PB})$. That is, when the plaintiff increases his expenditure, does the defendant respond by spending more or less? As noted by Katz (1988), regardless of the specification of the court function π, one of the defendant and the plaintiff must increase his expenditure in response to an increase in the other's expenditures. From (12), an increase in the plaintiff's award increases deterrence if

$$x'_{DG}(x^*_{PG}) \geq 0 \geq x'_{DB}(x^*_{PB}) \tag{13}$$

or equivalently (in terms of the court function π)

$$\pi_{DP}(x^*_{DG}, x^*_{PG}; G) \geq 0 \geq \pi_{DP}(x^*_{DB}, x^*_{PB}; B). \tag{14}$$

Condition (14) says that at the equilibrium expenditures, a small increase in the plaintiff's expenditure raises the value of the defendant's expenditures and causes him to "fight back" if he took the good action, with the opposite true if the agent took the bad action. This condition seems likely to be satisfied. It holds in the parameterization of Example 1 provided the defendant produces more evidence than the plaintiff after action $a = G$, with the opposite true after $a = B$ (and condition (ANON) guarantees this is indeed the case).

Summarizing:

Proposition 4. ***(Change in deterrence under settlement and defendant bargaining power)***

If settlement is possible; the defendant has all the bargaining power; the defendant's equilibrium success rate is higher after action G than B; and condition (14) holds, then an increase in the plaintiff's award increases deterrence.

Note that Proposition 4 holds independent of whether or not (ANON) holds.

The difference between the two settlement cases can be understood as follows. An increase in the plaintiff's award induces the plaintiff to increase his litigation expenditures. When the plaintiff has all the bargaining power, deterrence is increased when the defendant is impacted more by this change when he has taken the bad action $a = B$ — that is, if the plaintiff's expenditure increases by more after action $a = B$. As the analysis earlier in this paper establishes, whether this happens depends on whether influence expenditures are complements or substitutes with the truth.

In contrast, when the defendant has all the bargaining power, deterrence is increased when the plaintiff's expected court payoff rises by more when $a = B$. This condition is likely to hold. The plaintiff's equilibrium probability of court victory is higher when $a = B$ so the direct effect of an increase in R is bigger, and additionally, (14) implies that the defendant drops his expenditure when $a = B$.

6 Robustness: raising the penalty Z

The focus of the analysis in on the deterrence provided by a given penalty Z. Of course, deterrence is also affected by the level of Z itself. Given this, is it not possible to implement any deterrence level simply by changing Z?

In practice, raising the penalty Z may not be possible. If Z is a fine, then it is clearly bounded above by the plaintiff's wealth. "Fairness" considerations might also prevent Z from being too high. Moreover, and perhaps less obviously, raising Z might not actually lead to greater deterrence at all. Loosely speaking, the reason is that as Z is raised the two litigating parties will respond by increasing their legal expenditures. In the extreme, the two parties may fight themselves to a draw in court, and the probability that the plaintiff wins the case may be exactly the same after he behaves and diverts. In this case, the size of the actual punishment Z has no effect on deterrence at all. (A formal analysis is available from the author's webpage.)

7 Discussion

The paper establishes that it is generally desirable to curb plaintiff awards when courts are highly susceptible to influence-activities by a party arguing against the facts — i.e., when the truth and influence expenditures are substitutes. Conversely, when courts are resistant to influence activities of this sort, then fully rewarding the plaintiff is preferable.

Split-recovery statutes

The most immediate application of this result is to the division of damages between a successful plaintiff and the state. As discussed in the introduction, a significant number of U.S. states have adopted "split-recovery" statutes stipulating that plaintiffs share punitive damages with the state. The paper's analysis suggests that such statutes are desirable if the truth and legal expenditures are substitutes. While there is no easy way to evaluate whether courts in those states adopting split-recovery statutes satisfy this condition, it is suggestive that at least one state (Alaska) explicitly cited a desire to reduce frivolous litigation as a reason for introducing legislation of this type.[10]

Class action lawsuits

In the United States plaintiffs with similar claims against a common defendant often combine their claims into a class action lawsuit. The combination of claims in this manner is substantially harder in most European legal systems, including even the English legal system from which much of the U.S. legal system is derived.[11] Even in the U.S., the common use of class actions in litigation is a relatively recent phenomenon, often attributed to a 1966 change civil procedure rules. There have been repeated attempts at further reform, often with the aim of reducing the prevalence of class actions.[12] U.S.-style class actions are often

[10] See Sharkey (2003) on this and other details relating to split-recovery statutes. Finch (2002) discusses split-recovery statutes in the context of more general tort-related concerns.

[11] See, e.g., Sherman (2002).

[12] See, e.g., Hensler *et al* (2000).

viewed with horror in other jurisdictions: Hodges' (2001) judgement that

> Europe neither needs nor wishes to import U.S.-style class action litigation, representing huge, avoidable, and unnecessary cost which distorts the economy by siphoning transactional costs towards service suppliers who are enabled significantly to influence demand for their services.

is both representative and comparatively sober.

From the perspective of this paper, the key property of class action lawsuits is that they affect the plaintiff reward to winning a lawsuit, as the following (extremely stylized) model demonstrates.

There are N plaintiffs, each with a claim of Z/N against a common defendant. Absent class action suits, one of the plaintiffs must litigate first. Assume that the success/failure of this first suit influences courts deciding the case brought by the remaining plaintiffs. To make the analysis as transparent as possible, I focus on the extreme case in which (a) if the first plaintiff wins her case, all the remaining plaintiffs will win their cases, while (b) if the first plaintiff loses her case, all the remaining plaintiffs will lose their cases. So the first plaintiff gains Z/N if she wins her case, while the defendant loses the much greater amount Z.

In contrast, if class action cases are allowed, then the plaintiffs can combine their claims. The combined class of plaintiffs gains Z if they win their case, which is now equal to the defendant's loss.

Given the paper's main results, it follows immediately that class action suits will be good for deterrence whenever courts are unresponsive to the influence activities of the party arguing against the facts, and bad for deterrence when the reverse is true. Although I have focused on the extreme case in which the ruling in the first plaintiff's lawsuit sets a binding precedent for all future lawsuits, one would clearly reach the same qualitative conclusions even if the first court's ruling influences later courts only to a much weaker extent.

Many commentators have voiced concern that class action suits in the U.S. make possible highly "speculative" lawsuits against corporations, and in doing so impose large costs without enhancing deterrence.[13] If courts are responsive to the influence activities of the party arguing against the facts, such criticisms are consistent with the analysis of this paper. Moreover, such criticisms are very much in line with the results of Section 5, which show that high plaintiff awards are a problem primarily when the plaintiff has a lot of bargaining power.

Conversely, Rosenberg (2000) has argued that class action lawsuits improve deterrence by equating the plaintiff's and defendant's stakes. The current paper formally confirms this argument, and makes clear that it depends the particular assumptions one makes about a court's responsiveness to influence attempts by the litigating parties.

Collateral estoppel

Suppose a court has ruled against a plaintiff in one lawsuit, and that the *same plaintiff* subsequently sues a *different defendant* on similar grounds. Can this second defendant derive any advantage from the first court's ruling against the common plaintiff? In a 1971 decision the U.S. Supreme Court extended the common law concept of collateral estoppel[14] to cover just such a circumstance, and ruled that the second defendant can indeed benefit from the plaintiff's failure in a previous case.[15]

The possibility of defensive collateral estoppel of this sort clearly serves to increase the plaintiff's payoff to winning a lawsuit — for if she loses, she is deprived of future litigation opportunities. As such, defensive collateral estoppel will increase deterrence whenever courts are unresponsive to expenditures by the party arguing against the facts; and will decrease deterrence if the reverse if true.

[13] See, e.g., *The Economist*, March 24 2001, "Tort on stilts"; and the sources cited by Posner in *Rhone-Poulenc Rorer, Inc.*, 51 F. 3d 1293.

[14] The same concept is often referred to as issue preclusion.

[15] See, e.g., Spurr (1991).

Public enforcement

Plaintiffs who are acting on behalf of the state are rewarded very differently from private plaintiffs. Examples of the former include public prosecutors (District Attorneys in the U.S.) and employees of state regulatory agencies (the SEC, for example). Certain categories of judges in many civil law countries also act at times like public prosecutors, and fall within this category. In none of these cases does the state employee acting as a plaintiff receive a direct monetary reward for winning a court case. Instead, if he or she is awarded at all it is via future career advancement and/or salary increases.[16] In many instances these employees are protected by lifetime employment, further reducing the incentives they face.

Given the apparent lack of incentives of public plaintiffs, one might ask (as do Becker and Stigler, 1974) why public enforcement is used at all. The analysis presented here suggests an answer: it is precisely the *lack* of incentives that makes public enforcement valuable. Moreover, the analysis suggests that this advantage arises only in legal systems which work badly, in the sense of allowing the party arguing against the facts a substantial ability to influence the court's decision.

This has implications for the comparative design of legal systems: if, for example, private litigation is viewed as providing sufficient deterrence against various activities in the U.S., this does not imply that it will do so in other countries. Instead, it may be necessary for the state to play a much more activist role in the enforcement of laws. For example, a regulatory agency can be endowed with stronger enforcement powers; or actions labeled as grossly negligent in private tort cases, which in the U.S. often attract punitive damages, can instead be dealt with in criminal courts.[17]

Empirically, the paper's analysis suggests that the welfare effects of many legal features will be vary widely across jurisdictions. For example, studies such as those of La Porta *et al* (2003) and Beck *et al* (2003) attempt to measure the economic impact of regulatory

[16] For evidence on the career advancement actually enjoyed by successful public plaintiffs, see, for example, Boylan (2003).

[17] Merryman (1985) suggests that it is indeed the case that criminal sanctions replace the absence of punitive damages in many civil law jurisdictions.

agencies. To the extent to which regulatory agencies have lower incentives to win a case than private plaintiffs, the results of this paper suggest that granting enforcement powers to regulatory agencies will have a positive welfare impact *only in* jurisdictions in which courts are highly responsive to the influence activities of the party arguing against the facts.

Since in practice only laws are publicly enforced, while private contracts are privately enforced, this comparison also has implications for when laws themselves will be most useful.[18] That is, while the traditional Coasian view[19] stresses the role of *ex ante* transaction costs in determining when laws and regulations achieve something private contracts alone cannot, the analysis here suggests that *ex post* enforcement costs are also important. As such, it offers an explanation of why laws matter even in domains such a financial markets where transactions costs are often argued to be low.[20] As with the case of public versus private enforcement, the implication is that laws and regulations are of most value exactly when the truth and influence expenditures are substitutes.

Common law and civil law

The preceding discussion suggests that a relatively heavy reliance on private law, the admissibility of class action lawsuits, and collateral estoppel all act to increase a plaintiff's payoff to winning a case. Overall, the paper has emphasized the relation between, on the one hand, the susceptibility of a court to the influence activities of the party arguing against the facts, and on the other, the optimal level of plaintiff awards. Proposition 3 characterizes in general terms the level of responsiveness of a court to expenditures by litigating parties that is needed to rationalize restricting plaintiff awards. Whether these general properties are satisfied by a specific court system is ultimately an empirical matter.

That said, it is worth noting that the plaintiff award-enhancing features discussed above

[18]The paper has nothing to say on why the mode of enforcement is correlated with whether the state or private parties write the law/contract/regulation that is to be enforced.

[19]Asides from Coase (1960), see, for example, Posner (1998).

[20]See, e.g., La Porta *et al* (1997) for an empirical analysis of the impact of laws governing creditor and shareholder rights.

are all present in the U.S. legal system, and are generally absent from civil law jurisdictions. To the extent to which one believes legal rules are approximately optimal, a possible interpretation is that in U.S. courts the truth and influence expenditures are complements, while in European courts they are substitutes;[21] and legal rules have evolved to reflect this difference.

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[21]Moreover, Example 2 is suggestive in this regard. There, truth and expenditures are substitutes when the defendant's action a affects the court outcome through shifts in the mean of the court specific factor θ. This would be the case in legal systems in which the judge plays a large and active role. Conversely, truth and expenditures are complements when the defendant's action a affects the court outcome primarily through shifts in the marginal product of influence expenditures, as might be the case in more adversarial systems.

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A Omitted proofs

Proof of Lemma 1

An expenditure pair (x^*_{Da}, x^*_{Pa}) is an equilibrium if and only if x^*_{Pa} is a fixed point of the function $x_{Pa} \circ x_{Da}$, and $x^*_{Da} = x_{Da}(x^*_{Pa})$. As we have noted, both x_{Da} and x_{Pa} are continuous functions. Moreover, $x_{Da}(x_P) \in [0, Z]$ and $x_{Pa}(x_D) \in [0, Z]$ for any x_P and x_D, since certainly neither party will ever spend more than Z in order to win Z. Brouwer's fixed point theorem then implies that the function $x_{Pa} \circ x_{Da}$ must have a fixed point in $[0, Z]$. For uniqueness, note from the characterization of the best response functions (5) and text immediately following (see page 10) that $x_{Pa} \circ x_{Da}$ is a weakly decreasing function. Consequently the fixed point x^*_{Pa} is unique, and x^*_{Da} is unique given x^*_{Pa}. ∎

Proof of Proposition 1

As in the main text, consider a discrete decrease in R to $\hat{R} \equiv R - \varepsilon$. Let $\hat{x}_{Pa}(x_D)$ denote the plaintiff's reaction function under this new level of R. Clearly the plaintiff's new best response is lowered for all the plaintiff expenditures, i.e., $\hat{x}_{Pa}(x_D) \leq x_{Pa}(x_D)$ for all x_D.

First, consider the case in which $x^*_{Pa} = 0$. Since $x_{Pa}(x^*_{Da}) = 0$ then $\hat{x}_{Pa}(x^*_{Da}) = 0$. So the expenditures x^*_{Da} and x^*_{Pa} still constitute an equilibrium under the new plaintiff award $\hat{R}$. Thus $\partial x^*_{Pa}/\partial R_{-}$ exists, and equals 0.

Second, consider the case in which $x^*_{Pa} > 0$. In this case $\hat{x}_{Pa}(x^*_D) > 0$ for ε small enough, and so $\hat{x}_{Pa}$ is differentiable at x^*_{Da}. Taking the Taylor expansion of $\hat{x}_{Pa}$ around x^*_{Da},

$$\hat{x}_{Pa}(x_D) = \hat{x}_{Pa}(x^*_{Da}) + (x_D - x^*_{Da})\,\hat{x}'_{Pa}(x^*_{Da}) + O\left((x_D - x^*_{Da})^2\right)$$

where $O(\delta)$ denotes a term that tends to zero at least as fast as δ. So for $|x_D - x^*_{Da}| < \varepsilon$,

$$\begin{aligned}\hat{x}_{Pa}(x_D) &= x_{Pa}(x^*_{Da}) - \frac{\varepsilon}{R^2\pi_{PP}\left(x^*_{Da}, x_{Pa}(x^*_{Da}); a\right)} + (x_D - x^*_{Da})\,x'_{Pa}(x^*_{Da}) \\ &\quad + (x_D - x^*_{Da})\left(\hat{x}'_{Pa}(x^*_{Da}) - x'_{Pa}(x^*_{Da})\right) + O\left(\varepsilon^2\right) \qquad (15)\end{aligned}$$

From (5) it is clear that the slope of the plaintiff's reaction function under $\hat{R}$ (i.e. $\hat{x}'_{Pa}(x^*_{Da})$) differs from the slope under R (i.e. $x'_{Pa}(x^*_{Da})$) only to the extent that the level of the reaction function itself is different. Since the change in the level of the reaction function is itself of order ε, the change in the slope must also be of order ε. So substituting in also $x^*_{Pa} = x_{Pa}(x^*_{Da})$, (15) rewrites to

$$\hat{x}_{Pa}(x_D) = x^*_{Pa} - \frac{\varepsilon}{R^2\pi_{PP}\left(x^*_{Da}, x^*_{Pa}; a\right)} + (x_D - x^*_{Da})\,x'_{Pa}(x^*_{Da}) + O\left(\varepsilon^2\right)$$

For the plaintiff's reaction function, the local linear approximation for $x_P \in [x^*_{Pa} - \varepsilon, x^*_{Pa}]$ is simply

$$x_{Da}(x_P) = x^*_{Da} + (x_P - x^*_{Pa})\,x'_{Da}(x^*_{Pa}) + O\left(\varepsilon^2\right). \qquad (16)$$

(As in the statement of the Lemma, $x'_{Da}(x^*_{Pa})$ denotes the left-hand side derivative in the case that x_{Da} is not differentiable at x^*_{Pa}.) The new equilibrium level of plaintiff's expenditure, $\hat{x}^*_{Pa}$ must solve

$$\hat{x}^*_{Pa} = x^*_{Pa} - \frac{\varepsilon}{R^2 \pi_{PP}\left(x^*_{Da}, x^*_{Pa}; a\right)} + \left(x^*_{Da} + \left(\hat{x}^*_{Pa} - x^*_{Pa}\right) x'_{Da}\left(x^*_{Pa}\right) - x^*_{Da}\right) x'_{Pa}\left(x^*_{Da}\right) + O\left(\varepsilon^2\right)$$

i.e.,

$$\left(\hat{x}^*_{Pa} - x^*_{Pa}\right)\left(1 - x'_{Da}\left(x^*_{Pa}\right) x'_{Pa}\left(x^*_{Da}\right)\right) = \frac{-\varepsilon}{R^2 \pi_{PP}\left(x^*_{Da}, x^*_{Pa}; a\right)} + O\left(\varepsilon^2\right)$$

From (5), $x'_{Da}\left(x^*_{Pa}\right) x'_{Pa}\left(x^*_{Da}\right) \leq 0$. This establishes that the linear approximation (16) is valid even in the case where x_{Da} is not differentiable at x^*_{Pa}, and so completes the proof. ∎

Proof of Proposition 3

The proof consists of showing that, under the conditions stated,

$$\left.\frac{\partial \zeta}{\partial R_-}\right|_{R=Z} = \frac{1}{1 - x'_{DB}\left(x^*_{PB}\right) x'_{PB}\left(x^*_{DB}\right)} \frac{1}{Z^2} \left(\frac{1}{\pi_{PP}\left(x^*_{DB}, x^*_{PB}; B\right)} + \frac{1}{\pi_{DD}\left(x^*_{DB}, x^*_{PB}; B\right)}\right). \tag{17}$$

The result following immediately from (17).

To establish (17), note first that (ANON) implies that, for any x_P and x_D, $\pi_{PD}\left(x_D, x_P; G\right) = -\pi_{PD}\left(x_P, x_D; B\right)$, $\pi_{PP}\left(x_D, x_P; G\right) = -\pi_{DD}\left(x_P, x_D; B\right)$, and $\pi_{DD}\left(x_D, x_P; G\right) = -\pi_{PP}\left(x_P, x_D; B\right)$. Substituting $\left(x^*_{DG}, x^*_{PG}\right) = \left(x^*_{PB}, x^*_{DB}\right)$ (see main text) into the explicit formula (5) for the best response slopes then implies that when x^*_{Pa} and x^*_{Da} are both positive,

$$\begin{aligned} x'_{DG}\left(x^*_{PG}\right) x'_{PG}\left(x^*_{DG}\right) &= \frac{\pi_{PD}\left(x^*_{DG}, x^*_{PG}; G\right)}{\pi_{DD}\left(x^*_{DG}, x^*_{PG}; G\right)} \frac{\pi_{PD}\left(x^*_{DG}, x^*_{PG}; G\right)}{\pi_{PP}\left(x^*_{DG}, x^*_{PG}; G\right)} \\ &= \frac{\pi_{PD}\left(x^*_{PB}, x^*_{DB}; G\right)}{\pi_{DD}\left(x^*_{PB}, x^*_{DB}; G\right)} \frac{\pi_{PD}\left(x^*_{PB}, x^*_{DB}; G\right)}{\pi_{PP}\left(x^*_{PB}, x^*_{DB}; G\right)} \\ &= \frac{\pi_{PD}\left(x^*_{DB}, x^*_{PB}; B\right)}{\pi_{DD}\left(x^*_{DB}, x^*_{PB}; B\right)} \frac{\pi_{PD}\left(x^*_{DB}, x^*_{PB}; B\right)}{\pi_{PP}\left(x^*_{DB}, x^*_{PB}; B\right)} \\ &= x'_{DB}\left(x^*_{PB}\right) x'_{PB}\left(x^*_{DB}\right). \end{aligned} \tag{18}$$

Additionally, property (ANON) implies that

$$\pi_{PP}\left(x^*_{DG}, x^*_{PG}; G\right) = -\pi_{DD}\left(x^*_{DB}, x^*_{PB}; B\right). \tag{19}$$

Equalities (18) and (19) combine with Propositions 1 and 2 to deliver (17). ∎

Comparison of equilibrium court outcomes in Example 1

From the first-order conditions for the defendant and plaintiff, for actions $a = G, B$

$$Z\frac{\gamma_{Da}}{x^*_{Da}} = R\frac{\gamma_{Pa}}{x^*_{Pa}}.$$

So

$$\frac{x^*_{PB}}{x^*_{DB}} \geq \frac{x^*_{PG}}{x^*_{DG}},$$

and hence (recalling $\gamma_{DG} \geq \gamma_{DB}$ and $\gamma_{PB} \geq \gamma_{PG}$)

$$e^{\gamma_{PB}-\gamma_{DB}}\frac{x^*_{PB}}{x^*_{DB}} \geq e^{\gamma_{PG}-\gamma_{DG}}\frac{x^*_{PG}}{x^*_{DG}},$$

i.e,

$$\gamma_{PB}\ln x^*_{PB} + \gamma_{DG}\ln x^*_{DG} \geq \gamma_{PG}\ln x^*_{PG} + \gamma_{DB}\ln x^*_{DB}.$$

Recalling $M_{DG} \geq M_{DB}$ and $M_{PB} \geq M_{PG}$,

$$\begin{aligned} & M_{DG} + \gamma_{DG}\ln x^*_{DG} - M_{PG} - \gamma_{PG}\ln x^*_{PG} \\ \geq \quad & M_{DB} + \gamma_{DB}\ln x^*_{DB} - M_{PB} - \gamma_{PB}\ln x^*_{PB}, \end{aligned}$$

which implies that $\pi\left(x^*_{DG}, x^*_{PG}; G\right) \geq \pi\left(x^*_{DB}, x^*_{PB}; B\right)$.