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RESEARCH ARTICLE

# The Appeal Decision and Settlement Bargaining

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**Abstract**
This paper analyses settlement bargaining under incomplete information when an appeal is possible. Litigants may engage in pretrial and, before reaching the appeals court, posttrial settlement bargaining. In the latter, both litigants utilise the information revealed at earlier stages, introducing the following effects: First, a defendant rejecting the pretrial settlement reveals having a strong case. Hence, a higher pretrial settlement rate weakens the plaintiff's average case, thereby reducing her posttrial equilibrium payoff (*strategic effect*). Second, the trial judgment is a noisy public signal of the appeals judgment. Hence, winning at trial makes a litigant stronger in posttrial settlement bargaining (*information effect*). Unlike in the standard single-stage model of settlement bargaining, I find that lower legal costs may not always reduce settlement incentives and that the allocation of legal costs between litigants may matter. Additionally, a stronger correlation between judgments on both court levels weakens the strategic effect.

**Keywords** Appeals · Litigation · Settlement · Bargaining

**JEL Classification:** K41 · K13 · D82

## 1 Introduction

One of the hallmarks of the rule of law is the possibility to appeal adverse judicial outcomes, and a significant number of litigants take advantage of this opportunity.

The analysis in this paper is based on a model I have developed in an unpublished working paper 'The Appeals Process and Incentives to Settle', MPRA Working Paper 59424. I would like to thank the Editor, Nicholas Yannelis, an anonymous Associate Editor and two anonymous referees, as well as Eberhard Feess, Daniel Göller, Michael Hewer, Thomas Kittsteiner, Gerd Mühlheußer, Lars Nesheim, Elisabeth Schulte, Urs Schweizer, Petros Sekeris, Alessia Testa, Bastian Westbrock and participants at seminars in Aachen, Bamberg, Bonn, Christchurch, Marburg, Paris and Oslo, and at conferences of the Econometric Society, Verein für Socialpolitik, Association Française de Science Economique and the German Law & Economics Association for invaluable comments and discussions on this and previous versions of the paper.

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In the US, about 20% of judgments for one of the litigants are appealed (Eisenberg (2004)).[1] However, even in cases where no appeal is filed eventually, earlier decisions by litigants are made in anticipation of this possibility.[2]

Among the decisions that might be affected by the possibility to appeal, the decision whether to settle the case out of court has received particular attention in the public discussion of civil justice reform. Higher settlement rates can relieve the burden on the civil justice system and save litigants and the taxpayer some of the costs of running it. However, an economic analysis of settlement bargaining in the context of potential appeals is lacking so far.

The relevance of a possible appeal for settlement bargaining is intuitively plausible: In the existing literature, the dominant economic explanation for the breakdown of settlement bargaining is asymmetric information (e.g. Bebchuk (1984)). Similar to how a monopolist reduces quantity below the efficient level to increase profit margins for the sold items, the less informed litigant (assumed to be the plaintiff) foregoes settlement with some probability to secure a more favourable settlement in the cases where an agreement is reached. The nature of this trade-off and, crucially, how it depends on characteristics of the judicial system such as court fees, may be very different if the trial judgment can be appealed: Posttrial settlement bargaining may then depend on information revealed by the trial judgment and the defendant's pretrial decisions. Therefore, the plaintiff may take into account how her pretrial negotiation strategy will affect her posttrial bargaining position. However, we cannot know how this affects the model's conclusions without analysing this extended model.

This paper seeks to fill this gap by studying how the characteristics of the appeals process influence litigants' incentives to settle the case out of court. I extend the standard model of pretrial settlement bargaining with incomplete information pioneered by Bebchuk (1984) to include the possibility for a litigant who lost at trial to file appeal. If an appeal is pursued, another round of settlement bargaining follows and, if unsuccessful, the appeals court conclusively determines liability.[3] In equilibrium, some cases are settled pretrial, some may go to trial without an appeal, in some cases appeal is filed and settled posttrial, and some cases go all the way to the appeals court.

From a theoretical perspective, the model deviates from the canonical model of sequential bargaining with incomplete information in two important ways: First, the trial judgment serves as a public signal on the eventual appeal judgment during posttrial settlement bargaining. This introduces another strategic layer to the choice of pretrial settlement offer due to that additional public signal's impact on litigants' posttrial bargaining positions under either possible trial outcome. Second, if the litigant with less bargaining power (here assumed to be the defendant) has lost at trial, this public signal makes him even worse off in the equilibrium of posttrial settlement bargaining than he was ex-ante, which may make it optimal for him to pull out of the negotiation

[1] Other countries exhibit similar patterns. For instance, in Korea, the total appeal rate in civil cases is 5%, but this figure increases to over 25% when restricting attention to high-stake cases (Kim and Min (2017)).

[2] Friehe and Wohlschlegel (2019) show how litigation effort incentives at trial change when the possibility of an appeal is introduced.

[3] While the model is quite stylised, I will demonstrate in Section 7 how to accommodate and discuss features of the appeals process in different legal systems within the model, such as the question whether or not appellate courts may consider new facts.

even without any agreement (i.e., to accept the trial judgment rather than filing appeal). The paper shows how this novel effect puts an upper bound on the victorious plaintiff's ability to extract rents in posttrial bargaining.

I identify two complementary ways how decisions in pretrial bargaining affect posttrial settlement bargaining payoff and, therefore, how anticipating this impact affects the plaintiff's benefit of being tough in pretrial settlement bargaining. First, there is a *Strategic Effect*: As defendants with weak cases are most eager to settle pretrial, the fact that the case has even reached trial signals that the defendant's case must have been sufficiently strong to reject the pretrial settlement offer. Therefore, increasing the settlement demand discourages more types of defendant from settling and, *ceteris paribus*, makes the plaintiff's expected posttrial case stronger, which increases her payoff in posttrial settlement bargaining.

Second, there is an *Information Effect*: Assuming that the trial judgment is a noisy public signal of the appeals judgment, a litigant who wins at trial is, *ceteris paribus*, more likely to prevail at the appeals stage compared to one who loses at trial. Therefore, a plaintiff who has won at trial will negotiate more aggressively posttrial, resulting in higher equilibrium payoff. Increasing the pretrial settlement demand discourages some of the weakest types of defendant from settling and, therefore, makes the plaintiff's average case at trial stronger. Therefore, the plaintiff is more likely to win at trial, increasing her payoff in posttrial settlement bargaining.

The losing litigant's decision to file appeal plays an important role in the analysis. I show that the victorious plaintiff's equilibrium posttrial settlement demand will make all types of defendant who settle posttrial indifferent between accepting the trial judgment and filing appeal, similar to the construction of a mixed strategy equilibrium. This requirement places an upper bound on the plaintiff's equilibrium posttrial settlement demand.

This boundary solution, which always occurs in the realistic scenario where the losing litigant's decision to file appeal is non-trivial, drives several insights that are relevant for the debate on legal reform but cannot be obtained in the single-stage model. First, there may be a parameter range where pretrial settlement incentives are constant in the legal costs at trial. Intuitively, at the lowest pretrial settlement demand that triggers the aforementioned boundary solution, being tougher in pretrial settlement bargaining will no longer enhance the plaintiff's posttrial equilibrium payoff in this boundary solution. Therefore, the marginal effect of being tougher pretrial drops discontinuously, so that this threshold settlement demand is optimal for a whole range of pretrial costs.

Second, contrary to the established wisdom, the allocation of legal costs in appeal between both litigants may matter for pretrial settlement incentives. Intuitively, at the aforementioned boundary solution, apportioning more of these costs to the defendant requires the plaintiff to settle with more types of defendant posttrial in order to keep the defendant indifferent between accepting the trial judgment and filing appeal. This makes the plaintiff's marginal case that is not settled posttrial weaker and, therefore, increases her incentives to settle pretrial. While the exact nature of this effect is driven by my specific assumptions on the plaintiff's bargaining and commitment powers, the general insight that the allocation of appeals court costs matters for equilibrium pretrial settlement incentives just rests on the plausible feature that some losing litigant sometimes refrains from filing appeal. Hence, this result contributes to the debate on civil justice reform as it demonstrates how settlement can be encouraged without increasing the sum of litigants' legal costs.

Third, an example illustrates how the correlation of judgments at both levels of jurisdiction can be incorporated in the analysis. In this example, a higher correlation of judgments at both court levels implies that the probability of success on appeal depends more on the trial result and less on the defendant's private information. This weakens the strategic effect explained earlier. As a result, it may be possible to improve settlement incentives by reducing this correlation. Applied to the debate on civil justice reform, arbitration may be interpreted in this model as a first stage that provides a very noisy signal of the final outcome at low cost. In this context, my analysis demonstrates that replacing a full trial stage by arbitration while retaining the possibility of an appeal may improve settlement incentives at lower costs of the judicial system.

Most of the existing economic literature on appeals has focused on how the possibility of an appeal affects judges' incentives who prefer their decisions not to be reversed by a higher instance. First, the threat of appeals serves as a disciplining device preventing opportunistic (Shavell (2006, 2007) and Iossa and Palumbo (2007)) or politically motivated (Spitzer and Talley (2000)) judges from deviating too much from the socially preferred outcome. Second, imperfectly informed judges learn from the available information (such as previous judgments) when they aim to make the correct decision (Daughety and Reinganum (1999)), to avoid reversal by a higher level of jurisdiction (Daughety and Reinganum (2000)) or to impress an expert relevant for their career development (Levy (2005)). Last, the possibility of an appeal may induce trial judges to increase their judicial effort (Feess and Sarel (2018)). My paper takes the opposite approach by modelling judgments as random variables and focusing on litigants' settlement decisions. In this sense, my paper is complementary to this line of literature.

Those papers that do analyse litigants' decisions in the context of appeals focus on litigation effort incentives (Friehe and Wohlschlegel (2019)), the decision to file appeal (Shavell (1995, 2010)), and settlement incentives of *symmetrically* informed litigants (Bütler and Hauser (2000)). None of these existing papers have studied pretrial settlement incentives of asymmetrically informed litigants when an appeal is possible.

Another line of related literature studies settlement bargaining in dynamic contexts. In Robson and Skaperdas (2008), symmetrically informed litigants may engage in posttrial Coasean bargaining over the use of the disputed property rights. Briggs III et al. (1996) consider antitrust suits in which the defendant can perfectly anticipate court judgments and the first judgment perfectly predicts the second so that no case will ever be tried at both stages.

The most closely related models in this line of literature are those in Spier (1992, 2003), which both consider repeated settlement bargaining. While the aforementioned strategic effect of weaker litigants settling early on is also present in these papers, there is no public signal on the final outcome like the trial judgment in my model,[4] so that the information effect and the decision to file appeal cannot be analysed within

[4] Vasserman and Yildiz (2019) do consider the advent of public information between rounds of settlement bargaining, but they assume optimism rather than asymmetric information as the source for delay of agreement.

these models. Special cases of these models could be analysed in my model when considering the limit case where both courts' judgments are drawn independently and when restricting attention to parameter ranges where the losing litigant always appeals.

This paper also contributes to a recent literature on bargaining games in which new information emerges over the course of the negotiation. For instance, the less informed player observes signals on the informed player's private information in Daley and Green (2020), whereas Ortner (2023) assumes that the informed player learns more about their own type. By contrast, the trial verdict in my model is a public signal on both litigants' payoffs *given* any realisation of the informed player's private information.

After defining the model in Section 2, I will start the analysis with the final stage of posttrial settlement bargaining (Section 4), followed by the decision of a litigant who has lost at trial whether to file appeal (Section 5), and pretrial settlement bargaining (Section 6). Section 7 analyses the impact of some parameters on the incentives to settle pretrial and discusses implications for civil justice reform. All proofs of lemmas and propositions can be found in Appendix C.

## 2 The Model

**Overall Structure** Consider a case in which a plaintiff ('she') sues a defendant ('he') for damages of an undisputed size $D$.[5] The lawsuit involves up to two levels of jurisdiction, which I label the trial and the appeals stage, and settlement bargaining before each of these stages. As this paper focuses on litigants' strategic interaction between each other, I do not model courts as strategic players. Therefore, court decisions at each stage are modelled as random moves denoted $\tau \in \{0, 1\}$ for the trial stage and $\alpha \in \{0, 1\}$ for the appeals stage. Let the judgment that the defendant is liable to pay the plaintiff $D$ be denoted by $\tau = 1$ or $\alpha = 1$, respectively. Litigants are asymmetrically informed about the probability of the plaintiff to prevail in the appeals court.

In order to distinguish between both levels of jurisdiction, and between litigants, many variables and parameters need subscripts and superscripts. The notation will be defined in the following way: Subscripts denote the level of jurisdiction that the variable or parameter refers to, where $T$ corresponds to the trial and $A$ to the appeals stage. Superscripts indicate whether it refers to the plaintiff ($p$) or the defendant ($d$). Furthermore, strategies and posterior beliefs in post-trial settlement bargaining may depend on the trial court's judgment $\tau$. This will be denoted by superscript 1 if the trial court has found the defendant liable, and 0 otherwise, or by superscript $\tau$ when referring to either possible judgment by the trial court.

**Actions, Payoffs and Timing** As I assume that both court decisions $\tau$ and $\alpha$ are random moves, the only strategic players in this game are the plaintiff and the defendant. After filing suit and before trial, the plaintiff makes a take-it-or-leave-it pretrial settlement demand $S_T$. The defendant then observes some private information $x$ on the probability that the appeals court will eventually judge in favor of the plaintiff ($\alpha = 1$), and chooses whether to accept the demand. If the defendant accepts the

[5] For instance, in an accident case, the size of the victim's harm and the injurer's negligence may be undisputed, and the case is about finding out whether the plaintiff's negligence was causal for the accident.

pretrial settlement demand, he pays $S_T$ to the plaintiff, and the game ends. Hence, in this case the plaintiff's and the defendant's payoffs are $\pi^p = S_T$ and $\pi^d = -S_T$, respectively.

If the defendant rejects the pretrial settlement demand, the case goes to trial court, which imposes litigation costs $c_T^p$ on the plaintiff and $c_T^d$ on the defendant.[6] The trial court's judgment $\tau \in \{0, 1\}$ is drawn, where $\tau = 1$ means that damages $D$ are awarded.

Next, the litigant who lost at trial may file appeal. If the losing litigant does not appeal, the game ends, and payoffs are $\pi^p = \tau D - c_T^p$ for the plaintiff and $\pi^d = -\tau D - c_T^d$ for the defendant.

If appeal has been filed, the plaintiff makes a posttrial settlement demand $S_A$, which the defendant may accept or reject. If he accepts, the game ends, and payoffs are $\pi^p = S_A - c_T^p$ for the plaintiff and $\pi^d = -S_A - c_T^d$ for the defendant.

If the defendant rejects the plaintiff's posttrial settlement demand, the case goes to the appeals court, which imposes additional litigation costs $c_A^p$ on the plaintiff and $c_A^d$ on the defendant, and after which the game ends. Depending on the appeal court's judgment $\alpha \in \{0, 1\}$, where $\alpha = 1$ means that damages $D$ are awarded, payoffs are $\pi^p = \alpha D - c_T^p - c_A^p$ for the plaintiff and $\pi^d = -\alpha D - c_T^d - c_A^d$ for the defendant. The plaintiff's overall expected payoff will be denoted by capital $\Pi$, and that in the posttrial stage following a trial judgment $\tau$ by $\Pi_A^\tau$.

To sum up, all that matters for litigants is whether the defendant is held liable to pay damages $D$ to the plaintiff, and the legal costs on each level of jurisdiction. In particular, this model does not consider decisions outside the litigation game such as potential injurers' choices of care level, so that it is irrelevant in this model whether the final judgment accurately reflects true fault.

**Information** Just like in the standard model with only one court level, litigants make decisions in the shadow of the final judgment, which in this model is the appeals court's judgment $\alpha$. Two noisy signals on the probability of $\alpha = 1$ may be observed in the course of the game. First, the defendant observes a private signal $x \in [0, 1]$ before deciding whether to accept the pretrial settlement demand. I assume that conditional on the signal $x$ being observed, the defendant can update the probability of $\alpha = 1$ to $x$.[7] Furthermore, let the ex-ante probability that the defendant observes signal $x \in [0, 1]$ be distributed continuously with a full-range distribution function $F(x)$ with density $f(x)$ and monotonically increasing hazard rate $\frac{f(x)}{1-F(x)}$, and assume that this distribution is known to the plaintiff when the game starts. Consistency requires that the plaintiff initially believes that the probability of $\alpha = 1$ is $\int_0^1 xf(x)dx$.

Second, it is plausible to assume that the judgments at both levels of jurisdiction, $\tau$ and $\alpha$, are correlated with each other. Therefore, the trial court's verdict $\tau \in \{0, 1\}$

[6] In reality, the plaintiff may choose whether to indeed go to trial or to back down if her demand has been rejected. This raises credibility issues of settlement demands discussed in Nalebuff (1987), which are known to result in a lower bound to settlement demands. In order to avoid the case distinctions associated with the possible boundary solutions, I make this simplifying assumption.

[7] For convenience, I will sometimes refer to a defendant who has observed the private signal $x$ as a 'type-$x$ defendant'.

is a noisy public signal on $\alpha$, and both litigants can use it to update their beliefs on $\alpha$, and the plaintiff to update her beliefs on the defendant's type $x$.[8]

We can think of the judgments $\tau$ and $\alpha$ as being deterministic in any given state of nature $z \in Z$. In Appendix A I formally analyse the joint distribution of $\tau$, $\alpha$ and $x$ and argue that any event $\omega \subseteq Z$ is characterised by the probabilities $\omega_{ij}$ that $\tau = i$ and $\alpha = j$ in this event. According to this definition of the event space, the defendant's private signal $x$, which is defined as the ex-ante probability that the defendant will be found liable by the appeals court, indicates that the state of nature is in an event where $\omega_{01} + \omega_{11} = x$.

I assume that all events in which the defendant observes the same $x$ are also identical with regards to how $x$ can be split into $\omega_{01}$ and $\omega_{11}$ (and $1 - x$ into $\omega_{00}$ and $\omega_{10}$). In Appendix A, I show that this assumption allows me to define

$$p^\tau(x) := Prob(\tau \mid x) = \omega_{\tau 0} + \omega_{\tau 1} \tag{1}$$

as the probability that the trial court verdict is $\tau$ in an event with the defendant's private information $x$, but unconditional on $\alpha$. Conditional on observing the public signal $\tau$, Bayes' Rule implies that the plaintiff's updated belief on the defendant's private signal $x$ has density

$$\mu^\tau(x) = \frac{p^\tau(x) f(x)}{\int_0^1 p^\tau(x') f(x') dx'} \tag{2}$$

Furthermore, due to the correlation of $\tau$ and $\alpha$, both litigants can use the observed $\tau$ to update the probability of $\alpha$ for any given $x$. Let this correlation of $\tau$ and $\alpha$ be represented by

$$d^\tau(x) := Prob(\alpha = 1 \mid x, \tau) = \frac{\omega_{\tau 1}}{\omega_{\tau 0} + \omega_{\tau 1}}, \tag{3}$$

defined as the probability of $\alpha = 1$ conditional on the realizations of the private signal $x$ and the public signal $\tau$, where the second equality holds whenever the denominator $p^\tau(x) = \omega_{\tau 0} + \omega_{\tau 1}$ is positive.

In order to keep the following analysis tractable, I am further restricting generality in several respects: First, for simplicity, I will focus on signal technologies for which the functions $p^\tau(\cdot)$ and $d^\tau(\cdot)$ are continuous and differentiable. Second, the following plausible properties of the signal technology are assumed throughout the paper:

**Assumption 1** (a) $p^1(\cdot)$ is non-decreasing.
(b) $d^\tau(\cdot)$ strictly increasing, $\tau = 0, 1$.
(c) $d^0(x) \leq d^1(x)$ for all $x$.

Part (a) assumes that defendants who observed lower $x$ are no more likely to win in the trial court than those who observed higher $x$. According to part (b), given any verdict of the trial court, defendants who observed higher $x$ are strictly more likely to

[8] Grenadier and Grenadier (2024) suggest the real options approach as an alternative and model the advent of new public information over time via its effect on the volatility in the litigation value. While the analysis in that paper focuses on litigants' decisions to file suit and continue with the lawsuit, extending their model to include settlement bargaining might be an alternative approach to addressing the present paper's research question.

win in the appeals court than those who observed lower $x$. Last, part (c) assumes that, given the defendant's *private* signal, the *public* signal is informative in the sense that a defendant who has lost in trial court can never expect to be more likely to win in the appeals court than if he had won in trial court.

Third, the comparative statics analysis of the equilibrium in pretrial bargaining is much simplified if there is a unique equilibrium in posttrial bargaining. As I will show in the analysis, the following assumption is sufficient to guarantee this uniqueness:

**Assumption 2** (a) For any pair $x, y \in [0, 1]$, $d^0(x) < d^1(y)$.
(b) The distributions with densities $\mu^\tau(x)$ have an increasing hazard rate.
(c) The functions $d^\tau(x)$ are weakly concave.

Assumptions 1 and 2 will be sufficient to guarantee the existence of equilibria in the class that I will study.

***Example*** I am now introducing an example for a class of signal technologies that satisfies Assumptions 1 and 2 in order to demonstrate how the functions $p^\tau(x)$ and $d^\tau(x)$ can be determined based on assumptions on the relationship between $x$, $\tau$ and $\alpha$. The diagrams that I will use in Section 6 to illustrate how pretrial settlement depends on various model parameters are based on this example. Furthermore, as the example will parameterise the accuracy with which $\tau$ predicts the probability that $\alpha = 1$, I will use it when discussing the impact of this accuracy on pretrial settlement incentives in Subsection 7.3.

The example plausibly assumes that the trial outcome is based on information derived from sources similar to the defendant's private information, ensuring that the probability of each trial outcome, given the defendant's type $x$, matches the probability of the same outcome at the appeals stage. Formally, this assumption means that $p^1(x) = x = 1 - p^0(x)$. There are two polar cases satisfying this assumption: First, the trial court may perfectly anticipate the appeals court's judgment ($\tau = \alpha$ with certainty). Second, the trial outcome $\tau$ may be drawn independently of the appeals outcome but with the 'correct' probability $x$ coinciding with the defendant's type. In the example, I will mix these cases by assuming that the former case occurs with probability $\rho \in (0, 1)$ and the latter with probability $1 - \rho$.

The parameter $\rho$ captures the trial court's accuracy in predicting the appeals outcome in a natural way: For high values of $\rho$, the appeals court is very unlikely to overturn the trial court's decision. If, on the other hand, $\rho$ is low, the trial court's judgment remains useful for the plaintiff to update her beliefs on the defendant's private information, whereas litigants gain little new insight into the appeals court's judgment for given $x$. Hence, the example allows me to analyse comparative statics of equilibrium choices with respect to this accuracy.

In Appendix A, I show that these assumptions imply

$$\begin{aligned} d^1(x) =& \rho + (1-\rho)x \\ d^0(x) =& (1-\rho)x. \end{aligned} \tag{4}$$

With probability $\rho$, $\tau = \alpha$, which means that the probability of $\alpha = 1$ ($\alpha = 0$), conditional on $\tau = 1$ ($\tau = 0$), is $d^1(x) \equiv 1 \equiv 1 - d^0(x)$. On the other hand, with probability $1-\rho$, $\tau = 1$ is drawn with probability $x$ independent of the eventual appeal outcome. Then, the litigants do not gain any insight from the trial outcome beyond the defendant's type $x$, so that the probability of $\alpha = 1$, conditional on $\tau = 1$ and the defendant's type $x$, is still $x$. Taking expectations over both of these cases yields (4).

This example satisfies part (a) of Assumption 2 for a sufficiently high accuracy $\rho > \frac{1}{2}$ of the trial judgment, so that I will assume $\rho > \frac{1}{2}$ throughout the paper whenever discussing the example. Furthermore, I show in Appendix B that part (b) is satisfied in that example for a range of probability distributions including the uniform distribution. Last, the functions $d^\tau(x)$ in (4) are linear, thus also satisfying part (c).

In the remainder of this paper, I will refer to this special case simply as *The Example*.

**Equilibrium Concept** I am using the concept of weak Perfect Bayesian Equilibrium with the additional requirement of a weak Perfect Bayesian Equilibrium to be played in every proper subgame.

The timeline of the model implies that, when the plaintiff makes the pretrial settlement demand, information is still symmetric. Hence, there is a proper subgame following each possible choice of $S_T$. As subgame perfection is not necessarily implied in a weak Perfect Bayesian Equilibrium (e.g. Watson (2025)), I am explicitly requiring this. Proposition 4 below will show that such an equilibrium always exists under Assumptions 1 and 2, and that there are no relevant information sets reached with zero probability in that equilibrium. Hence, imposing restrictions on off-equilibrium beliefs is irrelevant, which means the equilibrium characterised in this paper would also satisfy any stronger version of the Perfect Bayesian Equilibrium that imposes such restrictions.

## 3 Preview of Equilibrium and Discussion of Assumptions

In the remainder of the paper, I will show that the following course of play is an equilibrium: The plaintiff starts with making a take-it-or-leave-it pretrial settlement demand, which all types $x \geq x_T$ of defendant accept. If the case goes to court, this reveals to the plaintiff that the defendant's type must be $x \in [0, x_T)$. The trial verdict $\tau \in \{0, 1\}$ allows the defendant to update his probability of losing at appeal ($\alpha = 1$) from $x$ to $d^\tau(x)$. The plaintiff can make the same inference for every type $x \in [0, x_T)$ of defendant who is still in the game. In addition to that, the trial outcome $x$ reveals to the plaintiff something about the defendant's type as each type $x$ was going to lose at trial with probability $p^1(x)$. Therefore, following the trial outcome, the plaintiff will use Bayesian updating to reflect this information, and truncate her beliefs to the support $[0, x_T)$ of types of defendant who have not settled pretrial.

Due to the assumption that the plaintiff has full bargaining power, it is always optimal for a losing plaintiff to appeal a trial outcome $\tau = 0$. The plaintiff then makes a take-it-or-leave-it posttrial settlement demand, which all types $x \in [x_A^0, x_T)$ of defendant accept. Types $x < x_A^0$ reject the posttrial settlement demand, whereafter the case proceeds to the appeals court where the outcome $\alpha \in \{0, 1\}$ is announced and the game ends.

If the defendant has lost at trial ($\tau = 1$), her lack of bargaining power may cause her anticipated posttrial payoff to fall below her payoff when just accepting the trial

**Table 1** Equilibrium actions by type of defendant

<table>
<tr><th colspan="4">Defendant wins at trial</th></tr>
<tr><td>Types</td><td>$[0, x_A^0)$</td><td>$[x_A^0, x_T)$</td><td>$[x_T, 1]$</td></tr>
<tr><td>Pretrial Settlement</td><td colspan="2">D rejects</td><td>D accepts</td></tr>
<tr><td>Appeal</td><td colspan="2">P appeals</td><td></td></tr>
<tr><td>Posttrial Settlement</td><td>D rejects</td><td>D accepts</td><td></td></tr>
</table>

<table>
<tr><th colspan="5">Defendant loses at trial</th></tr>
<tr><td>Types</td><td>$[0, x_A^1)$</td><td>$[x_A^1, \overline{x}_T)$</td><td>$[\overline{x}_T, x_T)$</td><td>$[x_T, 1]$</td></tr>
<tr><td>Pretrial Settlement</td><td colspan="3">D rejects</td><td>D accepts</td></tr>
<tr><td>Appeal</td><td colspan="2">D appeals</td><td>no appeal</td><td></td></tr>
<tr><td>Posttrial Settlement</td><td>D rejects</td><td>D accepts</td><td></td><td></td></tr>
</table>

outcome and paying the plaintiff damages $D$. In this case, only defendants of types $x < \overline{x}_T (< x_T)$ appeal the trial outcome, where $\overline{x}_T$ is determined such that the plaintiff's optimal posttrial settlement demand is exactly equal to $D$. In any case, once appeal has been filed, the plaintiff will make another posttrial settlement demand, which all remaining types of defendant above $x_A^1$ accept and the game ends, whereas types $x < x_A^1$ reject the posttrial settlement demand, the case proceeds to the appeals court, the outcome $\alpha \in \{0, 1\}$ is announced and the game ends.

The equilibrium actions of all types of defendant are summarised in Table 1 for the case where some types of losing defendant chose not to appeal.

Note that there is some asymmetry in the equilibrium after the trial judgment: It is only a losing *defendant* who might choose to not appeal, which only imposes an *upper* bound on the plaintiff's posttrial settlement demand. This asymmetry is driven by two assumptions: First, my assumption to assign all the bargaining power to the plaintiff implies that only the defendant may ever anticipate a payoff in the posttrial game that is below his payoff when paying the damages imposed at trial. Second, the assumption that the plaintiff can commit to proceeding to trial whenever a settlement demand has been rejected means that very low settlement demands can be supported in equilibrium. As Nalebuff (1987) shows, relaxing this assumption introduces a lower bound to the plaintiff's equilibrium settlement demand. Hence, in a model without commitment, there would also be a lower bound imposed on the plaintiff's posttrial settlement demand. However, for the sake of simplicity, this paper focuses on the impact of the upper bound alone.

## 4 Posttrial Settlement Bargaining

Following backward induction, I start the analysis with the posttrial settlement. This stage is only reached if the defendant has rejected the plaintiff's pretrial settlement demand and the losing litigant at trial has filed appeal. In this section, I will first use Bayes' Rule to derive the plaintiff's beliefs (5) on the distribution of the defendant's type, consistent with equilibrium strategies and with the trial outcome $\tau \in \{0, 1\}$.

Based on these updated beliefs, I will then solve the posttrial settlement bargaining game (Proposition 1), which Lemma 1 will show to be equivalent to finding the optimal threshold type of defendant above which the plaintiff finds it optimal to settle posttrial.

Consider an equilibrium where the game proceeds to this stage of posttrial settlement bargaining if and only if the defendant's type is $x < \hat{x}_T$.[9] Then, depending on the trial outcome $\tau$, the plaintiff's beliefs are consistent with such an equilibrium if they have density

$$m^\tau(x; \hat{x}_T) = \frac{\mu^\tau(x)}{\int_0^{\hat{x}_T} \mu^\tau(x')dx'} = \frac{p^\tau(x) f(x)}{\int_0^{\hat{x}_T} p^\tau(x') f(x')dx'}. \tag{5}$$

The plaintiff's beliefs on the defendant's type in (5) have been updated using the information of the trial outcome $\tau$, the probability of which, $p^\tau(x)$, depends on the defendant's type, and the supposed equilibrium strategies.

The posttrial settlement bargaining game is similar to the well-known single-stage model (e.g. Bebchuk, 1984) when assuming that a type-$x$ defendant's probability of being held liable to pay $D$ is $d^\tau(x)$ (instead of $x$ in the single-stage model) and that the defendant's types are distributed with density $m^\tau(x; \hat{x}_T)$ (instead of $f(x)$). Part (b) of Assumption 2 ensures that the increasing hazard rate of the ex-ante distribution carries over to the plaintiff's ex-post beliefs, which implies that the result typically obtained in the single-stage model, that the first-order condition can be satisfied by at most one choice of $S_A$, carries over to posttrial settlement bargaining.

Suppose that the plaintiff makes a posttrial settlement demand $S_A$. As the defendant's expected loss from proceeding to the appeals court, $d^\tau(x)D + c_A^d$, is increasing in $x$ due to the monotonicity of $d^\tau(x)$ (Assumption 1 (b)), it is higher types $x$ of defendant who will accept $S_A$. As a consequence, Lemma 1 shows that the plaintiff's choice of posttrial settlement demand $S_A$ is equivalent to finding an optimal threshold type $x_A$ of defendant who is indifferent between accepting and rejecting $S_A$, just like in the standard single-stage model.

**Lemma 1** *Suppose that the plaintiff's posttrial beliefs on the defendant's type have density $m^\tau(x; \hat{x}_T)$ and support $[0, \hat{x}_T)$, where $\hat{x}_T < 1$. For the plaintiff's optimal posttrial settlement demand $S_A^\tau$, there is a unique threshold type of defendant $x_A^\tau \in [0, \hat{x}_T)$ such that all types $x \geq x_A^\tau$ ($x < x_A^\tau$) accept (reject) the offer.*

The plaintiff's optimal choice of $x_A^\tau$ following a trial outcome $\tau$ maximises her objective function given by

$$\Pi_A^\tau(x_A) = \int_0^{x_A} (d^\tau(x)D - c_A^p)m^\tau(x; \hat{x}_T)dx + (d^\tau(x_A)D + c_A^d) \int_{x_A}^{\hat{x}_T} m^\tau(x; \hat{x}_T)dx. \tag{6}$$

If the defendant has a weak case (types $x \geq x_A$), he will settle and pay the plaintiff $S_A = d^\tau(x_A)D + c_A^d$. On the other hand, if the defendant has a strong case (types $x < x_A$), the case will go to the appeals court, where the plaintiff will be awarded damages $D$ with probability $d^\tau(x)$ but incur legal costs $c_A^p$.

[9] In Sections 5 and 6, I will show that Assumption 2 guarantees that such an equilibrium exists.

The plaintiff's optimal choice of $x_A^\tau$ can be derived in a similar way as in the single-stage model:

**Proposition 1** *Suppose that the trial judgment was $\tau$ and the losing litigant has filed appeal, and consider an equilibrium in which the plaintiff's posttrial beliefs on the defendant's type have density $m^\tau(x; \hat{x}_T)$ and support $[0, \hat{x}_T]$, where $\hat{x}_T < 1$. In such an equilibrium, the case goes to the appeals court if and only if the defendant's type is $x < x_A^\tau(\hat{x}_T)$ implicitly given by*

[*Definition of* $x_A^\tau(\hat{x}_T)$]

$$\begin{cases} d^{\tau\prime}(x_A^\tau(\hat{x}_T))D \\ \quad = \frac{p^\tau(x_A^\tau(\hat{x}_T))f(x_A^\tau(\hat{x}_T))}{\int_{x_A^\tau(\hat{x}_T)}^{\hat{x}_T} p^\tau(x)f(x)dx}(c_A^p + c_A^d), & \text{if } d^{\tau\prime}(0)D > \frac{p^\tau(0)f(0)}{\int_0^{\hat{x}_T} p^\tau(x)f(x)dx}(c_A^p + c_A^d); \\ x_A^\tau(\hat{x}_T) = 0, & \text{otherwise.} \end{cases} \tag{7}$$

An intuitively plausible observation immediately implied by Proposition 1 is that the plaintiff's optimal posttrial settlement demands following each trial outcome $\tau$,

$$S_A^\tau(\hat{x}_T) = d^\tau(x_A^\tau(\hat{x}_T))D + c_A^d, \tag{8}$$

are weakly increasing in the threshold type $\hat{x}_T$. That is to say, the stronger the plaintiff's average case, the tougher she will be in the posttrial settlement bargaining.

## 5 Appeal Decision

When deciding upon appeal, the losing litigant will compare the trial outcome with the anticipated outcome of the posttrial settlement bargaining game just discussed. Suppose first that the defendant has won at trial ($\tau = 0$). As the plaintiff has full bargaining power and the case proceeds directly to the appeals court when the defendant rejects a posttrial settlement demand,[10] the plaintiff can appropriate at least the defendant's legal costs on the appeals stage $c_A^d$ in the posttrial settlement bargaining game. Consequently, a losing plaintiff will always file appeal.

Suppose now that the plaintiff has won at trial ($\tau = 1$). Intuitively, an appeal by the defendant reduces both players' disagreement payoffs in the posttrial settlement negotiation by their respective legal costs $c_A^p$ and $c_A^d$. Again, due to the assumption that the plaintiff has full bargaining power, this will exclusively harm the defendant's bargaining position, so that the defendant's anticipated payoff in the posttrial bargaining game may even be lower than his payoff when accepting the trial outcome. In the following, I will argue that a posttrial settlement demand $S_A > D$, which makes the defendant worse off when settling posttrial than when accepting the trial outcome, cannot be part of an equilibrium. Proposition 2 (b) shows that in this case, the equilibrium posttrial settlement demand is the boundary solution $S_A = D$. This makes all

[10] See Section 8 for a discussion of these assumptions.

types of defendant who settle posttrial indifferent between appealing and not appealing. In equilibrium, the types who appeal and do not appeal are then determined such that $S_A = D$ is indeed the plaintiff's optimal choice. In a way, the construction of the equilibrium somewhat resembles mixed strategies where the aim is to make the other player indifferent between pure strategies.

Consider an equilibrium in which the defendant has settled pretrial if and only if $x \geq x_T$. Furthermore, recall that for every $\hat{x}_T \leq x_T$, $x_A^1(\hat{x}_T)$ denotes the plaintiff's equilibrium choice in posttrial bargaining given by Proposition 1 if her beliefs are $m^1(x; \hat{x}_T)$. If

$$d^1(\min\{x, x_A^1(x_T)\})D + c_A^d \leq D, \tag{9}$$

a type $x$ defendant will be better off when filing appeal rather than accepting the trial outcome, even if the plaintiff is anticipated to believe that all types of defendant would have appealed an adverse trial outcome. If (9) is satisfied for all types $x < x_T$, then there is an equilibrium in which indeed all types of defendant appeal against a losing trial outcome.

However, if $c_A^d$ is sufficiently large, the plaintiff's optimal $x_A^1(x_T)$ might violate (9) for some $x$, i.e., some types of defendants might prefer accepting the trial outcome. If any types of defendant won't file appeal, it will be those with the lowest posttrial payoff, including all types $x \geq x_A^1$ who anticipate to settle posttrial in equilibrium. In other words, (9) is violated for some types of defendants if and only if $S_A > D$, i.e., the plaintiff is anticipated to demand more than the originally claimed damages $D$ in the posttrial settlement bargaining.

But if defendant types $x \in [x_A^1(x_T), x_T]$ don't file appeal, the beliefs $m^1(x; x_T)$ are no longer consistent with the defendant's equilibrium play, and the plaintiff's choice $x_A^1(x_T)$ is no longer optimal. On the other hand, if the plaintiff is anticipated to choose a lower, optimal $S_A$ and $x_A$ in the posttrial negotiation, so that all types of defendant $x \leq x_T$ prefer settling again, the originally anticipated $S_A^1$ and $x_A^1$ will be the plaintiff's optimal choice again, and so forth.

Therefore, the equilibrium $x_A^1$ in this case must make those types of defendant who anticipate to settle posttrial indifferent between accepting the trial judgment and filing appeal, i.e., $S_A = D$. The following Proposition characterises the defendant's appeals decisions and posttrial settlement bargaining in equilibrium.

**Proposition 2** *Consider an equilibrium in which the defendant settles pretrial if and only if $x \geq x_T$, and define $\tilde{x}_A$ such that*[11]

$$[\textit{Definition of } \tilde{x}_A] \qquad D(1 - d^1(\tilde{x}_A)) = c_A^d. \tag{10}$$

*(a) If the plaintiff's optimal $x_A^1(x_T) \leq \tilde{x}_A$, then a losing defendant will always file appeal. The equilibrium posttrial settlement demand is $S_A^1(x_T) < D$.*
*(b) If the plaintiff's optimal $x_A^1(x_T) > \tilde{x}_A$, then there is a $\overline{x}_T < x_T$ given by*

$$[\textit{Definition of } \overline{x}_T] \qquad x_A^1(\overline{x}_T) = \tilde{x}_A \tag{11}$$

[11] In the remainder of the paper, I am assuming that $d^1(0) \leq 1 - \frac{c_A^d}{D}$ in order to guarantee that $\tilde{x}_A$ is well defined and avoid tedious case distinctions.

*such that a losing defendant will file appeal if and only if $x \leq \overline{x}_T$. The equilibrium posttrial settlement demand is $S_A^1(\overline{x}_T) = D$.*

In case (b) of Proposition 2, Lemma 1 implies that $x_A^1(\overline{x}_T) < \overline{x}_T < x_T$. By definition, type $\tilde{x}_A$ is indifferent between (i) accepting the trial verdict and (ii) appealing and not settling posttrial. By construction of $\overline{x}_T$, $S_A = D$ is optimal for the plaintiff, so that $\tilde{x}_A$ is also indifferent between these two actions and appealing while settling posttrial (i.e., $x_A^1(\overline{x}_T) = \tilde{x}_A$). As all types $x \geq x_A^1(\overline{x}_T)$ anticipate to be settling posttrial when appealing the trial outcome, all of them will be indifferent between appealing and not appealing. Some of these types will file appeal ($x \in [x_A^1(\overline{x}_T), \overline{x}_T)$) and some won't ($x \in [\overline{x}_T, x_T)$).

To sum up, a winning plaintiff's equilibrium choice in posttrial settlement bargaining is $x_A^1 = \min\{x_A^1(x_T), \tilde{x}_A\}$. Furthermore, let $\widetilde{\Pi}_A^\tau(x_T)$ and $\widetilde{Y}_A^\tau(x, x_T)$ denote the plaintiff's and a type-$x$ defendant's equilibrium payoffs, respectively, following each possible trial outcome $\tau$, and assuming that the defendant would have settled pretrial if and only if $x \geq x_T$. Then,

$$\widetilde{\Pi}_A^\tau(x_T) = \Pi_A^\tau(x_A^\tau) \tag{12}$$

$$\widetilde{Y}_A^\tau(x, x_T) = -d^\tau(\min\{x, x_A^\tau\})D - c_A^d. \tag{13}$$

Note that, in order to obtain these payoffs, I need not distinguish between types of defendant who file appeal and those who accept the trial outcome as both litigants are indifferent between both choices to be made by defendant types $x \in [x_A^1, x_T]$, due to the construction of the equilibrium.

## 6 Pretrial Settlement Bargaining

### 6.1 The Plaintiff's Objective Function

The analysis so far has been based on the assumption that there is a type $x_T$ such that, in equilibrium, the defendant settles pretrial if and only if $x \geq x_T$. I will now analyse pretrial settlement bargaining when litigants anticipate the equilibrium play characterised in the preceding sections, and show that the assumption that I had made there, that there is a threshold such that the defendant will reject pretrial settlement if and only if his type is below that threshold, is indeed in line with the equilibrium of the pretrial settlement bargaining game.

Suppose the plaintiff makes a pretrial settlement demand $S_T$. A type-$x$ defendant anticipates his equilibrium payoff from the posttrial settlement bargaining game and compares it with $S_T$. Let us fix some threshold type $x_T$ such that the defendant settles pretrial if and only if $x \geq x_T$. Then, a type-$x$ defendant's payoff from rejecting $S_T$ is $\widetilde{Y}_A^\tau(x, x_T)$ given by (13), so that he will accept $S_T$ if and only if

$$-S_T \geq \sum_\tau p^\tau(x)\widetilde{Y}_A^\tau(x, x_T) - c_T^d \tag{14}$$

The following proposition establishes that, if the equilibrium threshold types $x_A^0$ and $x_A^1$ in the posttrial bargaining game satisfy $d^0(x_A^0) < d_1(x_A^1)$ (which Assumption 2 (a) is a sufficient condition for), then the right-hand side of (14) is strictly decreasing in $x$. As a consequence, there is indeed a threshold type $x_T$ such that the defendant settles pretrial if and only if $x \geq x_T$,[12] and the plaintiff's optimal choice of settlement demand $S_T$ can be analysed as a choice of this threshold type $x_T$, just like in the well-known single-stage model.

**Proposition 3** *If $d^0(x_A^0) < d_1(x_A^1)$ and the settlement demand $S_T$ is ever accepted, then there is a unique threshold type $x_T$ such that the defendant accepts $S_T$ if and only if $x \geq x_T$.*

As a result of Proposition 3, just like in the single-stage model, the plaintiff's problem is equivalent to finding the optimal threshold type of defendant $x_T$ to be indifferent between settling and not settling pretrial, so as to maximise

$$\begin{aligned}\Pi(x_T) = &\int_0^{x_T}\left(\sum_\tau p^\tau(x)\widetilde{\Pi}_A^\tau(x_T) - c_T^p\right) f(x)dx \\ &+ \left[-\sum_\tau p^\tau(x_T)\widetilde{Y}_A^\tau(x_T, x_T) + c_T^d\right]\int_{x_T}^1 f(x)dx.\end{aligned} \tag{15}$$

If the defendant's type is $x < x_T$, the defendant rejects the pretrial settlement demand. In this case, the plaintiff anticipates her expected payoff of the posttrial bargaining game, conditional on each trial outcome $\tau$ and the range of defendant's types rejecting pretrial settlement. If $x \geq x_T$, the case is settled pretrial. Then, the term in solid brackets is the equilibrium pretrial settlement demand $S_T$ obtained by substituting for $x = x_T$ on the right-hand side of (14) and requiring both sides to be equal.

When substituting for $\widetilde{\Pi}_A^\tau(x_T)$ and $\widetilde{Y}_A^\tau(x_T, x_T)$, the plaintiff's objective function (15) becomes

$$\begin{aligned}\Pi(x_T) = \sum_\tau\Bigg[&\int_0^{x_A^\tau}(d^\tau(x)D - c_A^p - c_T^p)p^\tau(x)f(x)dx + (d^\tau(x_A^\tau)D + c_A^d - c_T^p) \\ &\int_{x_A^\tau}^{x_T} p^\tau(x)f(x)dx\Bigg] + \left[\sum_\tau p^\tau(x_T)(d^\tau(x_A^\tau)D + c_A^d) + c_T^d\right]\int_{x_T}^1 f(x)dx.\end{aligned} \tag{16}$$

Proposition 3 establishes a sufficient condition for the assumption that the defendant's type at that stage is from some interval $[0, x_T)$ to hold in equilibrium: This

[12] If, contrary to the condition in Proposition 3, $d^1(x_A^1) < d^0(x_A^0)$, the defendant's payoff when rejecting the pretrial settlement demand would be no longer monotonically decreasing in his type $x$. In this case, it would be intermediate types who settle, whereas the lowest *and* the highest types reject a given settlement demand. In other words, the initial supposition of all types of defendant above $x_T$ to settle pretrial is no longer valid.

condition $d^0(x_A^0) < d_1(x_A^1)$ means that winning at trial is always better news for a given litigant's eventual payoff in the posttrial bargaining game than losing at trial. Assumption 2 (a) ensures that this condition is satisfied.

As a consequence, the equilibrium that I have characterised so far always exists. Furthermore, as there are no relevant information sets that are reached with zero probability in equilibrium, any restrictions on off-equilibrium beliefs are irrelevant for this equilibrium:

**Proposition 4** *Under Assumptions 1 and 2, the equilibrium characterised by Propositions 1, 2 and 3 exists and is independent of any restrictions on off-equilibrium beliefs.*

### 6.2 Marginal Costs and Benefits of Pretrial Settlement

The aim of this Subsection is to understand the effects that drive the impact of the plaintiff's choice of $x_T$, the threshold type above which the defendant will settle pretrial, on her payoff. A full comparative statics analysis of the plaintiff's optimal choice of $x_T$ will not be provided as stronger assumptions on the functional forms would be required in order to ensure uniqueness of the $x_T$ that satisfies the first-order condition. It will turn out that the first derivative of the plaintiff's payoff w.r.t. $x_T$ is discontinuous at two values for $x_T$, which are related to both kinds of boundary solution in the posttrial game discussed above: (i) where a plaintiff who has lost at trial wants to settle with certainty posttrial and, therefore, confines herself to extracting the defendant's legal costs saved in settlement, $S_A = c_A^d$, and (ii) where some types of defendant who have lost at trial do not want to appeal the trial judgment, in which case the plaintiff's equilibrium posttrial settlement demand is given by $S_A = D$.

Taking the first derivative of the plaintiff's payoff (16) w.r.t. $x_T$ whenever it exists helps us understand the plaintiff's marginal costs and benefits of increasing $x_T$, i.e., of being tougher in the pretrial settlement bargaining.

**Proposition 5** *Under Assumptions 1 and 2, the first derivative of the plaintiff's payoff* (16) *w.r.t. $x_T$, if it exists, is*

$$\frac{\partial \Pi(x_T)}{\partial x_T} = \left\{ \underbrace{p^{1'}(x_T)(d^1(x_A^1) - d^0(x_A^0))}_{\textit{Information Effect}} + \underbrace{\sum_\tau \left( d^{\tau\prime}(x_A^\tau) \frac{dx_A^\tau}{dx_T} p^\tau(x_T) \right)}_{\textit{Strategic Effect}} \right\} \\ (1 - F(x_T))D - f(x_T)(c_T^d + c_T^p). \tag{17}$$

Equation (17) is key to understanding the incentives to settle pretrial, as it displays the plaintiff's marginal costs and benefits of increasing the threshold type above which the defendant would settle pretrial. The last summand in equation (17) represents the costs of increasing the threshold type $x_T$: the higher $x_T$, the less likely is a settlement that saves the litigants' legal costs at trial. This effect is identical to the marginal costs of increasing the threshold type in the single-stage model.

The first summand represents the benefit of increasing $x_T$, which is the increase in the settlement sum with probability $1 - F(x_T)$, just like in the single-stage model. However, instead of just $D$ (the size of this effect in the single-stage model), this effect is now $D$ times the expression in curly brackets, which consists of two sub-effects: The *Information Effect* captures the plaintiff's higher anticipated post-trial payoff due to her higher probability of winning at trial over the threshold type of defendant $x_T$. As the trial outcome causes the litigants to update their expectations of the appeal outcome, winning at trial results in a higher expected posttrial payoff represented by $d^1(x_A^1) - d^0(x_A^0)$. On the other hand, the *Strategic Effect* captures that the plaintiff will negotiate more aggressively posttrial with a stronger average case conditional on reaching that stage, implied by higher $x_T$.

With regards to the strategic effect, note that $\frac{dx_A^\tau}{dx_T}$ is not continuous everywhere as $x_A^\tau$ may be a boundary solution at $x_A^\tau = 0$ for sufficiently small $x_T$ or, if $\tau = 1$, at $x_A^1 = \tilde{x}_A$ for sufficiently large $x_T$. Under Assumption 2, there are unique thresholds $\underline{x}_T^\tau$ and $\tilde{x}_T$ such that $x_A^\tau = 0$ if and only if $x_T \leq \underline{x}_T^0$ and $x_A^1 = \tilde{x}_A$ if and only if $x_T \geq \tilde{x}_T$, which are given by

$$\text{[Definition of } \underline{x}_T^\tau\text{]} \qquad d^{\tau\prime}(0)D = \frac{\mu^\tau(0)}{\int_0^{\underline{x}_T^\tau} \mu^\tau(x)dx}(c_A^p + c_A^d) \tag{18}$$

$$\text{[Definition of } \tilde{x}_T\text{]} \qquad d^{1\prime}(\tilde{x}_A)D = \frac{\mu^1(\tilde{x}_A)}{\int_{\tilde{x}_A}^{\tilde{x}_T} \mu^1(x)dx}(c_A^p + c_A^d). \tag{19}$$

Where changes in $x_T$ shift the posttrial settlement demand from an interior to a boundary solution or vice versa, $\frac{dx_A^\tau}{dx_T}$ and, therefore, $\frac{\partial \Pi(x_T)}{\partial x_T}$, will jump discontinuously. The following Lemma states some comparative statics of these thresholds:

**Lemma 2** *(a)* $\underline{x}_T^\tau$ *is increasing in the sum* $c_A^p + c_A^d$ *of litigants' legal costs of the appeals stage and decreasing in the potential damages* $D$.

*(b)* $\tilde{x}_T$ *is increasing in the plaintiff's legal costs* $c_A^p$ *of the appeals stage but has an ambiguous relation with* $c_A^d$ *and* $D$.

The proof is straightforward and, therefore, omitted. For $\tilde{x}_T$, there is a countervailing indirect effect of the defendant's legal costs $c_A^d$ and the potential damages $D$ via the anticipated post-trial boundary solution $x_A^1 = \tilde{x}_A$.

Figure 1[13] illustrates the impact of the plaintiff's choice of $x_T$ on her expected payoff. The first-order condition for an interior optimum is satisfied where the curve $\frac{\partial \Pi(x_T)}{\partial x_T}$ intersects with the horizontal line. The dashed line represents $x_T = \underline{x}_T^0$, and the dotted line $x_T = \tilde{x}_T$. In the region between these lines, posttrial equilibria following either trial outcome are interior solutions. If $x_T < \underline{x}_T^0$, a plaintiff who has lost at trial always wants to settle posttrial, so that $\frac{dx_A^0}{dx_T} = 0$ and, therefore, $\frac{\partial \Pi(x_T)}{\partial x_T}$ jumps upwards

[13] All diagrams are based on the Example introduced at the end of Section 2, assuming that the defendant's type is ex-ante uniformly distributed. Equilibrium and comparative statics in this example are fully analysed in Appendix D.

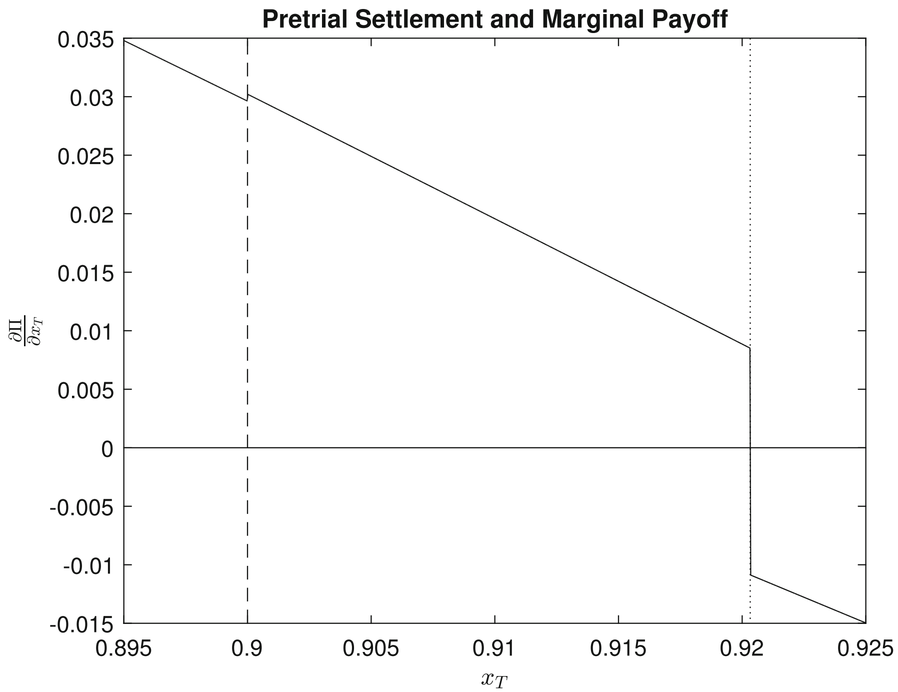


**Fig. 1** Dashed line: $x_T = \underline{x}_T^0$; dotted line: $x_T = \tilde{x}_T$

at $x_T = \underline{x}_T^0$. Similarly, if $x_T > \tilde{x}_T$, then some losing defendants won't file appeal, so that $\frac{dx_A^1}{dx_T} = 0$ and, therefore, $\frac{\partial \Pi(x_T)}{\partial x_T}$ jumps downwards at $x_T = \tilde{x}_T$.

For the optimal choice of $x_T$, denoted by $x_T^*$, these jumps have different implications: If $\frac{\partial \Pi(x_T)}{\partial x_T}$ crosses the horizontal axis both to the left and right of $\underline{x}_T^0$, there are two local maxima of the plaintiff's expected payoff. Conversely, in the vicinity of $\tilde{x}_T$, $\frac{\partial \Pi(x_T)}{\partial x_T}$ may be positive just to the left and negative just to the right of $\tilde{x}_T$, as in the case depicted in Figure 1. In this case, the optimal choice is $x_T^* = \tilde{x}_T$ for a whole range of parameters.

Note that the monotonically decreasing shape of $\frac{\partial \Pi(x_T)}{\partial x_T}$ within each of the three intervals does not always hold, which restricts the scope for generally valid comparative statics results. Instead, I will use the insights from this Subsection to intuitively discuss the impact of various parameters on the incentives to settle pretrial, using the Example introduced at the end of Section 2 as illustration.

## 7 Comparative Statics and Legal Implications

### 7.1 Legal Costs at Trial

Court fees are an important policy variable in civil justice reform: First, they determine which part of the costs of the civil justice system is borne by litigants and which by the taxpayer. This is economically relevant because, *ceteris paribus*, access to justice is improved if taxpayers subsidise a larger portion of these costs. At the same time, the existing literature on settlement bargaining such as Bebchuk (1984) implies that lower legal costs at trial borne by litigants also reduce settlement incentives. However, a lower settlement rate offsets part of the beneficial effect of the subsidy on court costs, which constitutes a countervailing effect on access to justice. Furthermore, more cases proceeding to trial risk overwhelming courts and come at additional costs for taxpayers.

In this subsection, I will explore to what extent this trade-off between access to justice and settlement incentives in determining court fees is present in my model. Analysing the impact of the legal costs at trial, $C_T := c_T^d + c_T^p$, is straightforward, as an increase in $C_T$ shifts the plaintiff's marginal payoff in (17) and Figure 1 downward by the same amount everywhere. At the same time, the discontinuity thresholds $\underline{x}_T^\tau$ and $\tilde{x}_T$ are left unchanged. Therefore, the optimal choice of $x_T^*$ is weakly decreasing in $C_T$, similar to the single-stage model.

However, while the optimal interior solution $x^* > 0$ in the single-stage model is even strictly decreasing in the total legal costs, there may be a range of $C_T$ in which the plaintiff's optimal choice $x_T^*$ is constant in $C_T$ in my model: As explained above, $x_T = \tilde{x}_T$ whenever the plaintiff's marginal payoff is positive everywhere to the left and negative to the right of $\tilde{x}_T$, i.e., for a range of parameters such that the plaintiff optimal posttrial settlement demand is anticipated to be equal to $D$ even if all types of losing defendant appeal. Figure 2 illustrates the plaintiff's optimal pretrial negotiation strategy $x_T^*$ as a function of $C_T$.[14]

The top region above the dotted line is where $x_A^1 = \tilde{x}_A$, so that there is a positive mass of types of losing defendants who are indifferent between accepting that trial outcome and filing appeal. Figure 2 shows that there is a whole range of levels of trial costs for which the optimal choice $x_T^*$ implies that, following a win at trial by the plaintiff, the interior posttrial solution given by (7) coincides with this boundary solution $x_A^1 = \tilde{x}_A$.

This result challenges the established wisdom based on the single-stage model has been that, whenever settlement bargaining is non-trivial in the sense that some types of defendant reject the offer, reducing court fees also reduces the incentives to settle, so that at least some of the cost savings for litigants will be offset by a higher usage of the legal system. By contrast, this model shows that, if there is the possibility of an appeal, there is a parameter range within which the incentives to settle pretrial are insensitive to such changes in legal costs. In particular, this is true whenever, in equilibrium, all losing defendants at trial file appeal, but those who anticipate to settle posttrial are

[14] Note that this result cannot be established generally as there is nothing that guarantees the plaintiff's interior optimal choice of $x_T$ to be unique.

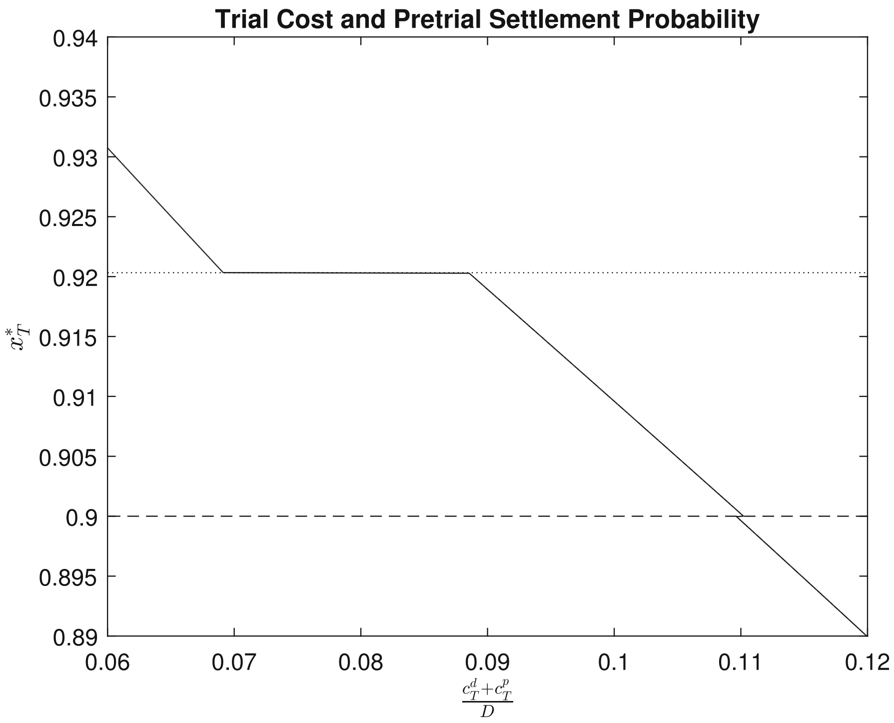


**Fig. 2** Dashed line: $x_T = \underline{x}_T^0$; dotted line: $x_T = \tilde{x}_T$

indifferent between filing appeal and accepting the trial judgment. However, it needs to be stressed that this theoretical analysis cannot claim how significant this insight is from a policy perspective, as the probability that a case is in the relevant parameter range is an empirical question.

### 7.2 Legal Costs on Appeals Stage

The legal costs on the appeals stage $c_A^d$ and $c_A^p$ do not feature directly in (17) but rather affect the pretrial settlement incentives via their impact on the anticipated posttrial equilibrium outcomes $x_A^0$ and $x_A^1$. In this subsection, it will turn out that in the parameter range where, after the defendant has lost at trial, the upper bound $S_A \leq D$ for the plaintiff's posttrial settlement demand is binding, shifting a larger portion of a given level of legal appeals costs to the defendant increases the plaintiff's incentives to settle pretrial. The intuitive reason for this is that, for a given posttrial settlement demand, more types of defendant will settle as the defendant's legal appeals costs increase, thus reducing the plaintiff's expected gain from winning at trial. This reduces the information effect and, therefore, increases the plaintiff's incentives to achieve a pretrial settlement.

To derive this effect more formally, recall that whenever the posttrial equilibrium settlement demands are interior solutions, it is again only the sum of these legal costs

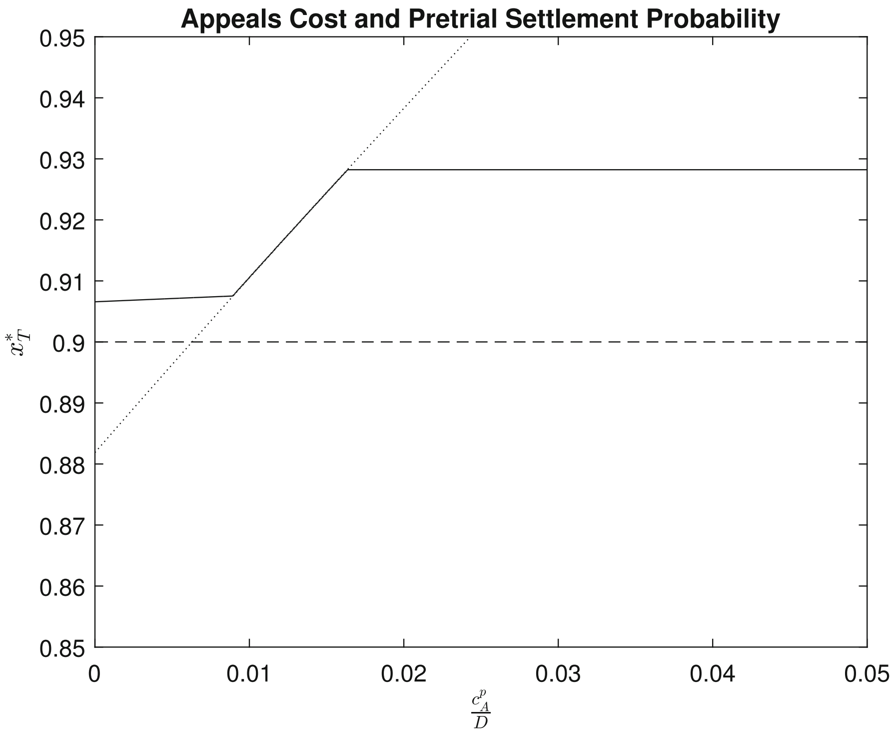


**Fig. 3** Dashed line: $x_T = \underline{x}_T^0$; dotted line: $x_T = \tilde{x}_T$

$c_A^d + c_A^p$ that matter, irrespective of how these costs are allocated between litigants. However, the boundary solution $x_A^1 = \tilde{x}_A$, given by $D(1 - d^1(\tilde{x}_A)) = c_A^d$, depends on $c_A^d$ but not on $c_A^p$. As a consequence, both the threshold $\tilde{x}_T$ above which said boundary solution will occur, and the marginal payoff $\frac{\partial \Pi(x_T)}{\partial x_T}$ will be impacted differently by changes in both litigants' legal costs on the appeals stage. Hence, whenever litigants anticipate such a boundary solution to eventually occur posttrial, pretrial settlement incentives depend on how a given amount of legal costs on the appeals stage is allocated between both litigants.

In particular, fix the total legal costs on the appeals stage $c_A^d + c_A^p$ at some level $C_A$. Whenever $x_T < \tilde{x}_T$, the marginal payoff $\frac{\partial \Pi(x_T)}{\partial x_T}$ is independent of how this $C_A$ is allocated between litigants. If $x_T > \tilde{x}_T$, then $x_A^1 = \tilde{x}_A$ is decreasing in $c_A^d$ and, thus, increasing in $c_A^p = C_A - c_A^d$. As the following Proposition shows, this implies that the equilibrium pretrial settlement threshold type $x_T^*$ is weakly increasing in $c_A^p$, and that it is strictly increasing in $c_A^p$ below a certain threshold $\tilde{c}_A^p$.

**Proposition 6** *Fix the total legal costs on the appeals stage $c_A^d + c_A^p$ at some level $C_A$. Then, $x_T^*$ is weakly increasing in $c_A^p$, and whenever there is a level of $c_A^p$ for which $x_T^* = \tilde{x}$, there is an interval of $c_A^p$ in which $x_T^*$ is strictly increasing in $c_A^p$.*

Figure 3 illustrates this result for the Example. The horizontal line to the right of the dotted curve represents the case where posttrial equilibria are interior solutions. To the left of the dotted curve, the equilibrium posttrial settlement demand is at its upper boundary $S_A^1 = D$. If less of the legal cost is imposed on the plaintiff and more on the defendant, more types of defendant will settle, which increases the plaintiff's posttrial payoffs equally after either trial judgment for the additional types of defendant who will now settle posttrial. However, the plaintiff's marginal case that is not settled posttrial after the plaintiff has won at trial is now weaker. Hence, the difference between the plaintiff's expected posttrial payoffs following either trial judgment (the information effect) and, therefore, the plaintiff's marginal benefit $\frac{\partial \Pi(x_T)}{\partial x_T}$ of being tough in pretrial bargaining, goes down. In other words, this increases the plaintiff's incentive to settle pretrial (i.e., reduces $x_T^*$).

As discussed above, the established wisdom based on the single-stage model is that, whenever each litigant bears their own costs ('American Rule'), the allocation of a fixed total amount of costs between litigants does not matter for pretrial settlement incentives. Proposition 6 challenges this wisdom by showing that apportioning a larger part of the posttrial legal costs to the plaintiff may reduce pretrial settlement incentives.[15] In other words, if the aim is to encourage pretrial settlement in order to save social costs related to the judicial system, this tends to be easier to achieve when imposing a higher portion of the posttrial legal costs on the defendant.

### 7.3 Correlation of Judgments at Both Levels of Jurisdiction

Another dimension along which the design and reform of legal procedure is discussed concerns the correlation between judgments at both levels of jurisdiction. For instance, common law countries have traditionally barred appeal courts from redetermining facts, whereas civil law countries typically allow for new facts to be brought forward in appellate courts under certain circumstances (e.g. Schmidt, 2007). In this model, appeal court outcomes in the former case are more likely to coincide with trial outcomes than in the latter case. Similarly, if judges are more independent of political influences or precedent, outcomes on both levels of jurisdictions may be seen as being drawn more independently.

In a different vein, many countries discuss legal reforms that aim to lower the costs of the judicial system by introducing arbitration as a low-cost but less accurate first stage of jurisdiction. Arbitration is similar to a lower-level court in my model which sends a public but not very accurate signal on the higher-level court's likely judgment to both litigants.

[15] There is an extensive literature discussing the impact of making the loser pay for the winner's legal costs ('English Rule') on litigation effort (e.g. Chen and Rodrigues-Neto, 2023) and settlement incentives (e.g. Bebchuk, 1984). The latter strand of this literature typically finds that fee shifting reduces incentives to settle pretrial, but for different reasons than in this paper: Intuitively, shifting legal costs to the losing litigant amplifies the effect of asymmetric information over the winning probability and, thus, makes agreement less likely (Spier, 2007). By contrast, in the present model, shifting appeals costs to the plaintiff no matter who won increases the plaintiff's marginal benefit of demanding more in pretrial settlement, as she anticipates to be able to extract more in potential posttrial settlement bargaining.

All these discussions have in common that they concern the extent to which the lower-level outcome, whether it comes in the form of arbitration or a trial judgment, predicts the final, binding judgment. In this subsection, I will use the Example to illustrate how the strength of the correlation between judgments at trial and appeal may affect the strategic and the information effect in opposite directions if the equilibrium of posttrial bargaining is anticipated to be interior. Furthermore, if some constraint on the equilibrium posttrial settlement demand is binding, so that the plaintiff's anticipated posttrial settlement demand is at the lower bound $S_A = c_A^d$ for $\tau = 0$ or the upper bound $S_A = D$ for $\tau = 1$, the strategic effect related to the respective trial outcome disappears, which makes the impact of the correlation between judgments via the information effect more likely to dominate.

The Example includes a parameter $\rho$ that captures the correlation between judgments at trial and appeal and allows analysing its impact on equilibrium pretrial settlement. In particular, recall from (4) that the probability that a type-$x$ defendant will be found liable in the appeals court conditional on having lost at trial is $d^1(x) = \rho + (1-\rho)x$, and this probability conditional on having won at trial is $d^0(x) = (1-\rho)x$.

The strategic effect in (17) consists of $d^{\tau\prime}(x) = 1-\rho$, which is decreasing in $\rho$; the ex-ante probabilities of the threshold type $x_T$ winning or losing at trial, which are independent of $\rho$; and the derivatives of the posttrial threshold types with respect to the pretrial threshold type, $\frac{dx_A^\tau}{dx_T}$. The analysis in the appendix shows that these latter parts are also weakly decreasing in $\rho$. In summary, the strategic effect is decreasing in $\rho$. Intuitively, the more strongly correlated the judgments at both levels of jurisdictions are, the less important the defendant's average strength gets in shaping the plaintiff's posttrial bargaining strategy.

On the other hand, the information effect reflects the difference that winning at trial makes for the plaintiff's expected equilibrium posttrial payoff and, therefore, the plaintiff's benefit of litigating a stronger case at trial rather than settling. Intuitively, a stronger correlation of court judgments makes the winner at trial stronger in the posttrial bargaining, so that we would expect a positive effect of $\rho$ on the information effect. While the analysis in Appendix D shows that this is not necessarily true if $x_T < \underline{x}_T^0$, the conclusion is still that the impact of $\rho$ on both effects may go in opposite directions, so that the total effect is ambiguous.

Figure 4 illustrates $x_T^*$ as a function of $\rho$ in a specific numerical example. Again, the region between the dashed and the dotted curves represents the outcomes of pretrial settlement bargaining for which posttrial equilibria will be interior solutions. If $x_T^*$ is in this region, this means that the marginal payoff in Figure 1 intersects the horizontal axis between $\underline{x}_T^0$ (the dashed line) and $\tilde{x}_T$ (the dotted line). In this region, I have just argued that the strategic and the information effect typically work in opposite directions. Under the specific parameter values used in this numerical example, the negative impact of $\rho$ on the strategic effect slightly dominates.

To the left of the dashed curve both in Figure 1 and Figure 4, $x_A^0$ switches to the boundary solution $x_A^0 = 0$ with $S_A^0 = c_A^d$, whereas to the right of the dotted curve $x_A^1$ switches to the boundary solution $x_A^1 = \tilde{x}_A$ with $S_A^1 = D$. In both cases, the strategic effect in equation (17) becomes zero for the respective trial outcome, which makes the

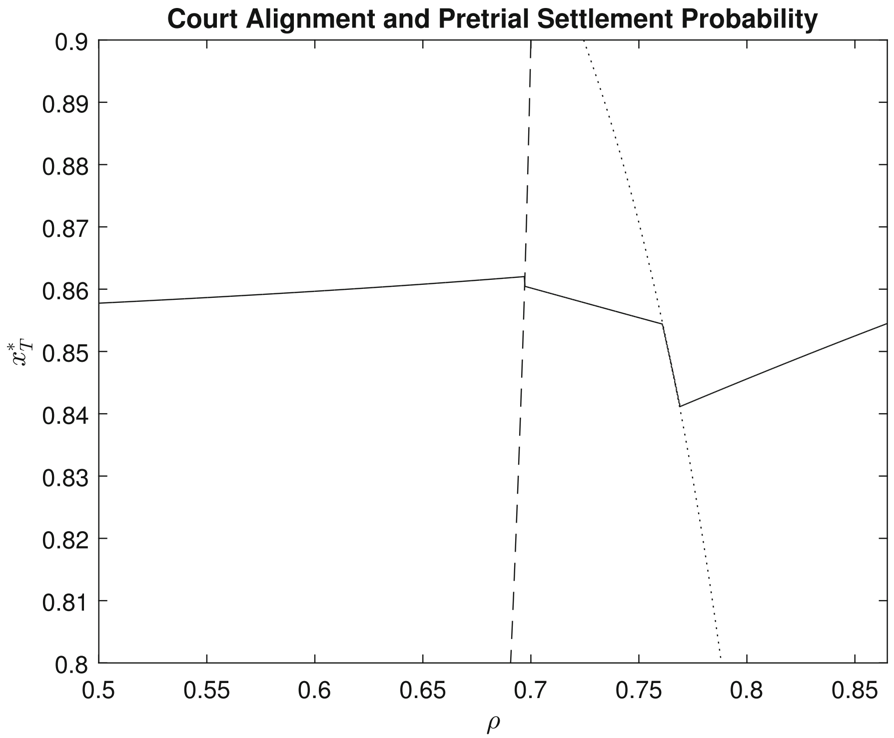


**Fig. 4** Dashed line: $x_T = \underline{x}_T^0$; dotted line: $x_T = \tilde{x}_T$

impact via the information effect more likely to dominate. I have argued above that this impact via the information effect tends to be positive. Indeed, Figure 4 exhibits an increasing relationship between $\rho$ and $x_T^*$ in both regions where a boundary solution in posttrial bargaining is anticipated for some trial outcome. In such a case, incentives to settle pretrial increase as the trial judgment gets less accurate in predicting the appeal judgment.

For some values of $\rho$, the optimal choice $x_T^*$ follows the dotted line $\tilde{x}_T$. In this case, the marginal utility in Figure 4 is positive to the left and negative to the right of the dotted line. Therefore, $x_T^* = \tilde{x}_T$ in this range, but $\tilde{x}_T$ itself depends on $\rho$. Looking at the definition of $\tilde{x}_T$, (19), we see that $\rho$ has an indirect effect on $\tilde{x}_T$ via $\tilde{x}_A$ and $d^{1'}(\cdot)$. However, both sides of (19) are decreasing in $\rho$, so that the impact of $\rho$ on $\tilde{x}_T$ cannot be generally determined. Therefore, all that we can read into Figure 4 is that for the parameter values we used in this numerical example, $\tilde{x}_T$ is decreasing in $\rho$ in that interval.

## 8 Conclusion

In this paper, I have studied settlement bargaining with incomplete information when the litigant who has lost at trial may appeal against this outcome. My results on the impact of legal costs on litigants' incentives to settle pretrial are strikingly different than those for the well-known single-stage model: If an appeal is possible, legal costs at trial may be reduced without reducing incentives to settle. Furthermore, the allocation of a given amount of legal costs on the appeal stage between both litgants matters for pretrial settlement incentives. In particular, incentives to settle pretrial are maximum if this allocation is very asymmetric, which means, under the specific assumptions made in this model, to allocate all the legal costs on the appeal stage to the defendant. Both of these deviations from the standard single-stage model's results are related to the nature of equilibrium when some types of defendant do not file appeal after losing at trial.

Additionally, my model allows for an analysis of the impact of how closely judgments at both levels of jurisdiction are correlated. It turns out that this effect on pretrial settlement incentives is far from straightforward. In particular, both intuitive elements of these incentives that I identify in the analysis are typically affected in opposite directions by changes in the correlation between judgments at both levels of jurisdiction.

These results have some important implications for civil justice reform. Improving access to justice and encouraging resolution of disputes outside the court system typically take centre stage in such reform attempts,[16] but these goals seem to be conflicting as lower litigation costs typically reduce settlement incentives. This paper's results contribute to this debate by demonstrating that this tension between both goals of civil justice reform depends in a subtle way on the losing litigant's incentives to file appeal. Furthermore, the analysis of the impact of the correlation of results at both levels of jurisdiction (Figure 4) showed that a first instance that only provides a noisy signal on the final outcome, such as arbitration, is not only less costly for society but may also improve pretrial settlement incentives.

While the appeal decision, which takes centre stage in this paper and drives the comparative statics of pretrial settlement incentives, is unique to this particular aspect of litigation, the insights from this paper that relate to the public signal observed between rounds of settlement negotiation could be applied to other aspects of litigation in which litigants may negotiate before and after the revelation of public information. First, trials might be bifurcated, which means that questions of liability and damages are addressed sequentially rather than simultaneously (Chen et al. (1997)). Settlement bargaining may occur before the first or between both stages. The insights from my model could be applied to this scenario when assuming that the first stage can never produce a verdict, but that the plaintiff needs to proceed to the second stage to win damages. Second, pretrial negotiations may take place before or after discovery, which is a costly process that produces public information relevant for the case (Lee and Bernhardt (2016)). This scenario requires an assumption that the accuracy of the public signal is a choice variable of the uninformed litigant, where higher accuracy comes at greater costs. Compared to the papers referenced in this paragraph, my formulation of

[16] For instance, the 2009 Review of Civil Litigation Costs in the UK was tasked with making "*recommendations in order to promote access to justice at proportionate costs*". More recently, the 2024 update of the UK's Civil Procedure Rules amended their Overriding Objective so as to promote the use of alternative dispute resolution.

the public signal technology is more general and allows for identifying the strategic and information effects highlighted in the present paper.

Some of the assumptions that I made in the analysis deserve further discussion as they drive some of this paper's key results. First, I allocate all of the bargaining power to the plaintiff by assuming that the plaintiff makes a take-it-or-leave-it offer in settlement bargaining. This assumption is standard in the literature and usually made for technical convenience, as take-it-or-leave-it offers are straightforward to analyse, and if such an assumption is made, letting the uninformed player make such an offer avoids technical complications associated with signalling games. However, as I have explained in section 5, this assumption immediately implies that a losing plaintiff would always file appeal. This introduces an asymmetry in the incentives to file appeal, as the defendant's lack of bargaining power may reduce his payoff from the posttrial game below that when accepting the trial judgment. As a consequence, some of the comparative statics results presented in Section 7, which are based on the boundary solution to make the types of defendant who eventually settle posttrial indifferent between filing and not filing appeal, are also partially driven by this assumption. Intuitively, giving the defendant some bargaining power may introduce the possibility that the plaintiff no longer wants to appeal an adverse trial outcome. For instance, in a model where the plaintiff has private information and the defendant makes a take-it-or-leave-it settlement offer, it would be shifting legal costs of the appeals court to the plaintiff that would make pretrial settlement more likely.

However, the key economic insights from this paper are invariant to such alternative assumptions: The possibility that one of the litigants might not want to appeal restricts the range which equilibrium posttrial settlement demands may be from, and this restriction drives various comparative-static results, such as the impact of the size and allocation of legal costs, or the impact of the correlation between judgments on both court levels. Furthermore, some model features that are implied by the assumption of the plaintiff having full bargaining power are in line with empirical evidence: For instance, Eisenberg and Farber (2013) show that plaintiffs tend to be less likely to win at trial and, as a result, more likely to have a win overturned on appeal. This resembles my model's features that the strongest cases for plaintiffs settle and that, as a result, cases at the appeals court tend to be weak for plaintiffs. Furthermore, while the size of the flat portion of the curve in Figure 2, which shows the impact of trial cost on pretrial settlement rates, is unknown in the real world, there is tentative empirical evidence that indicates that court costs may only play a minor role in the decision to go to court (e.g. Mitsopoulos and Pelagidis (2010)). Last, according to Figure 4, higher appeals rates are associated with lower accuracy of the trial judgment. In line with this feature of my model, evidence from antitrust litigation in Baye and Wright (2011) shows that appeals rates are lower for judges who have received economics training and are, thus, better equipped to accurately judge on economically complex antitrust cases.

A second assumption worth discussing is that I followed much of the standard literature on settlement bargaining by making the simplifying assumption that cases automatically proceed to court if settlement bargaining has failed. In reality, however, the plaintiff's threat to go to court may not be entirely credible. In the standard single-stage settlement bargaining model, Nalebuff (1987) introduced the option for a plaintiff to withdraw from the lawsuit if her settlement demand has been rejected. He showed that the lack of commitment introduces a lower boundary to the settlement demand, the 'credibility constraint'. Using a similar assumption in the posttrial settlement bargaining stage of the present model would introduce a similar lower boundary to the equilibrium posttrial settlement demand that can be seen as a mirror image of the upper boundary caused by the constraint related to the defendant's incentives to file appeal, and that would introduce similar discontinuities of the plaintiff's marginal pretrial utility as the ones discussed in this paper.

Last, the analysis is confined to decisions after the plaintiff has suffered harm and suit has been brought. In particular, I focus on litigants' incentives to settle pretrial. However, it needs to be stressed that more settlement does not necessarily mean welfare improvement: As Polinsky and Rubinfeld (1988) and Friedman and Wickelgren (2010) have discussed, settlement results in a lower accuracy of the final outcome with regards to the true fault, which may reduce e.g. potential injurers' incentives to avoid accidents. Therefore, a full welfare analysis would require the inclusion of an accident model in the analysis and is left for future research.

## Appendix

## A The Signal Technology

In this Appendix, I will show how my assumptions on the posterior probabilities $p^{\tau}(\cdot)$ and $d^{\tau}(\cdot)$ can be derived from basic assumptions about probabilities of states of nature, and I will relate these assumptions to the notation commonly used in the literature on public signals.

**Underlying assumptions on state and event spaces** Let $Z$ be the set of all states of nature $z$. Given the state of nature, the courts' verdicts $\tau \in \{0, 1\}$ and $\alpha \in \{0, 1\}$ are deterministic. Let us denote $\tau(z)$ and $\alpha(z)$ the realisation of each verdict in state $z \in Z$.

Furthermore, let us define an event space $\Omega = \{\omega \subseteq Z\}$, where each event $\omega = (\omega_{00}, \omega_{01}, \omega_{10}, \omega_{11})$ is characterised by the probabilities of the courts' verdicts conditional on this event, $\omega_{ij} = \text{prob}(\tau(z) = i, \alpha(z) = j \mid z \in \omega)$.[17] In this setting, I am assuming that, at the start of the game, a defendant privately observes that the state of nature is in a specific event $\omega \in \Omega_x$, where $x \in [0, 1]$ is referred to as the defendant's type. For every $x$, all events $\omega \in \Omega_x$ have in common that $\text{prob}(\alpha(z) = 1 \mid z \in \omega) = \omega_{01} + \omega_{11} = x$. Furthermore, I assume that all events within each particular $\Omega_x$ are identical with regards to how this probability $x$ can be split up into $\omega_{01}$ and $\omega_{11}$ and, accordingly, how $1 - x$ can be split up into $\omega_{00}$ and $\omega_{10}$. The following formal definition of $\Omega_x$ summarises these assumptions:

$$\Omega_x = \left\{ \omega \in \Omega : \omega_{01} + \omega_{11} = x, \frac{\omega_{11}}{\omega_{01} + \omega_{11}} = \sigma_1(x), \frac{\omega_{00}}{\omega_{00} + \omega_{10}} = \sigma_0(x) \right\}. \quad (20)$$

[17] I am grateful to Urs Schweizer for suggesting this definition of an event space in this model.

**Accuracy of public signal** The assumption that I have made when defining $\Omega_x$ in equation (20) aligns the model with the literature on public signals, as $\sigma_\alpha(x)$ can be interpreted as the accuracy of the public signal $\tau$ in predicting the outcome $\alpha$ of the appeals court, conditional on the defendant's type $x$.[18] In this sense, the assumption that I am making above is that a defendant's type $x$ uniquely determines the accuracies with which the public signal $\tau$ predicts each possible outcome $\alpha \in \{0, 1\}$.

By contrast, the plaintiff initially does not observe any information that the true state of nature is in any smaller set than $Z$. However, the plaintiff knows that, ex ante, the defendant's type $x$ is randomly drawn from $[0, 1]$ with density $f(x)$ and cdf $F(x)$.

The informational structure that I have just introduced implies the functions $p^\tau(x)$ and $d^\tau(x)$ defined in Section 2: Using Bayes' rule, we get the probability of a public signal (trial court verdict) $\tau$ given the defendant's private information $x$, but unconditional on $\alpha$:

$$p^1(x) = \omega_{10} + \omega_{11} = \sigma_1(x)x + (1 - \sigma_0(x))(1 - x) \tag{21}$$

$$p^0(x) = \omega_{00} + \omega_{01} = \sigma_0(x)(1 - x) + (1 - \sigma_1(x))x = 1 - p^1(x). \tag{22}$$

Similarly, the probability of the true state of nature being in event $\alpha = 1$ conditional on the realizations of the private signal $x$ and the public signal $\tau$, which is denoted $d^\tau(x)$, can be expressed in terms of the public signal's accuracy $\sigma_\alpha(\cdot)$ using Bayes' rule whenever the respective denominators are positive:

$$d^1(x) = \frac{Prob(\alpha = 1 \wedge \tau = 1 \mid x)}{Prob(\tau = 1 \mid x)} = \frac{\omega_{11}}{\omega_{10} + \omega_{11}} = \frac{\sigma_1(x)x}{\sigma_1(x)x + (1 - \sigma_0(x))(1 - x)} \tag{23}$$

$$d^0(x) = \frac{Prob(\alpha = 1 \wedge \tau = 0 \mid x)}{Prob(\tau = 0 \mid x)} = \frac{\omega_{01}}{\omega_{00} + \omega_{01}} = \frac{(1 - \sigma_1(x))x}{\sigma_0(x)(1 - x) + (1 - \sigma_1(x))x}. \tag{24}$$

Having shown that the way in which $p^\tau(\cdot)$ and $d^\tau(\cdot)$ are defined in Section 2 is implied by the definition of the accuracy of the public signal $\tau$ conditional on the private signal $x$, it is easy to see that Assumption 1 is also based on this accuracy. In particular, Assumptions 1 (a) and (b) impose restrictions on the relationship between the first derivatives of $\sigma_1(\cdot)$ and $\sigma_0(\cdot)$. Furthermore, Assumption 1 (c) simply requires that $\sigma_1(x) + \sigma_0(x) \geq 1$ for every $x$.

***Example*** It is straightforward to use above formulae to work out the functions $p^\tau(x)$ and $d^\tau(x)$ in the example developed in the introduction. With probability $\rho$, the trial court is perfectly accurate at predicting the appeals outcome. With probability $1 - \rho$, the trial outcome is $\tau = 1$ with probability $x$, drawn independently of the eventual appeals outcome. Hence, the probability that the trial outcome predicts a given appeals outcome is $x$ if $\alpha = 1$ and $1-x$ if $\alpha = 0$. Taking the expectations over both cases yields the accuracies $\sigma_1(x) = \rho + (1 - \rho)x$ and $\sigma_0(x) = \rho + (1 - \rho)(1 - x)$. Substituting for $\sigma_1(x)$ and $\sigma_0(x)$ in (21), (23) and (24) yields

[18] See, for instance, the literature on information aggregation in committees, e.g. Ottaviani and Sørensen (2001) or Gerardi and Yariv (2008).

$$p^1(x) = [\rho + (1-\rho)x]x + (1-\rho)x(1-x) = x,$$

as well as the functions $d^\tau(x)$ in (4).

## B Increasing Hazard Rates in the Example

**Lemma 3** *For any distribution on $x \in [0, 1]$ with density of the form $f(x) = (a+1)x^a$, $a \in \mathbb{N}_0$, the distributions of beliefs with densities $\frac{xf(x)}{\int_0^1 x' f(x')dx'}$ and $\frac{(1-x)f(x)}{\int_0^1 (1-x')f(x')dx'}$ satisfy the increasing hazard rate property.*

***Proof*** Clearly, if the density is $\frac{xf(x)}{\int_0^1 x' f(x')dx')} = (a+2)x^{a+1}$, it is increasing throughout, which is sufficient for an increasing hazard rate.

For the case of $\frac{(1-x)f(x)}{\int_0^1 (1-x')f(x')dx')} = (a+1)(a+2)(1-x)x^a$, it is convenient to write the survival function as

$$1 - F(x) = 1 + (a+1)x^{a+2} - (a+2)x^{a+1} = (1-x)^2 \sum_{i=0}^{a} (i+1)x^i.$$

The first derivative of the hazard rate

$$h'(x) = \frac{f'(x)(1-F(x)) + f(x)^2}{(1-F(x))^2}$$

is positive if and only if its numerator is positive, which we can write as

$$\begin{aligned} f'(x)(1-F(x)) + f(x)^2 =& (a+1)(a+2)(1-x)^2 \\ & \left[ x^{a-1}(a-(a+1)x) \sum_{i=0}^{a} (i+1)x^i + (a+1)(a+2)x^{2a} \right] \\ =& (a+1)(a+2)(1-x)^2 x^{a-1} \left[ a + (a+1)x^{a+1} + \sum_{i=1}^{a-1} i x^{a-i} \right] \\ >& 0 \end{aligned}$$

for all $x \in (0, 1)$. □

## C Proofs

### C.1 Proof of Lemma 1

As $d^\tau(\cdot)$ are strictly increasing in $x$ due to Assumption 1, there is, for every $S_A$ and $\tau$, at most one $\tilde{x}_A^\tau(S_A) \in [0, 1]$ such that $S_A = d^\tau(\tilde{x}_A^\tau(S_A))D + c_A^d$. Let us, therefore, show that an $S_A$ such that $\tilde{x}_A^\tau(S_A)$ does not exist cannot be optimal. There are two cases:

First, if $S_A \geq d^\tau(\hat{x}_T)D + c_A^d$, then $S_A$ will be rejected with probability 1. Then there exists a sufficiently small $\varepsilon > 0$ such that $S'_A = d^\tau(x_T - \varepsilon)D + c_A^d$ yields the plaintiff a strictly higher expected payoff than $S_A$. The plaintiff's expected payoff with this $S'_A$ is

$$\int_0^{\hat{x}_T} (d^\tau(x)D - c_A^p)m^\tau(x;\hat{x}_T)dx \\ + \int_{\hat{x}_T-\varepsilon}^{\hat{x}_T} \left[c_A^d + c_A^p - (d^\tau(x) - d^\tau(\hat{x}_T - \varepsilon))D\right] m^\tau(x;\hat{x}_T)dx,$$

where the first integral is equal to her payoff with a never-accepted settlement demand, and the integrand of the second integral goes to $[c_A^d + c_A^p]m^\tau(x;\hat{x}_T) > 0$ as $\varepsilon$ goes to zero.

Second, if $S_A < d^\tau(0)D + c_A^d$, this $S_A$ will always be accepted, but yield the plaintiff less payoff than $S'_A = d^\tau(0)D + c_A^d$, which will also be accepted with probability 1. □

### C.2 Proof of Proposition 1

Assumption 2 (b) implies that there is at most one interior solution (7), and the rest of the proposition is obtained by taking the derivative of (6). In particular, by construction, there is a $x_A^\tau(\hat{x}_T)$ for every $\hat{x}_T$. □

### C.3 Proof of Proposition 2

Part (a) is implied by the argument in the text. As for part (b), Proposition 1 implies that $x_A^1(\overline{x}_T)$ is indeed the plaintiff's optimal choice in posttrial settlement bargaining under the consistent beliefs $m^\tau(x;\overline{x}_T)$. On the other hand, none of the types of defendant can do any better than the choices detailed in the Proposition. Last, the continuity of all functions in (7) implies that $\overline{x}_T$ always exists. □

### C.4 Proof of Proposition 3

Suppose first that the posttrial settlement bargaining game is anticipated to be in pure strategies with unique threshold types $x_A^\tau$ following each possible trial outcome $\tau$. Using (22), (23) and (24), we can write the right-hand side of (14) as $-s(x)D - c_A^d - c_T^d$, where

$$s(x) = \begin{cases} x, & \text{if } x \leq \min\{x_A^0, x_A^1\}; \\ (1-p^1(x))d^0(x_A^0) + p^1(x)d^1(x), & \text{if } x_A^0 < x < x_A^1; \\ (1-p^1(x))d^0(x) + p^1(x)d^1(x_A^1), & \text{if } x_A^1 < x < x_A^0; \\ d^0(x_A^0) + p^1(x)(d^1(x_A^1) - d^0(x_A^0)), & \text{if } x \geq \max\{x_A^0, x_A^1\}. \end{cases} \tag{25}$$

If $d^0(x_A^0) < d^1(x_A^1)$, then $s(\cdot)$ is strictly increasing in $x$: This is obvious for the first and the last case in (25); if $x_A^0 < x < x_A^1$ then, as $s(\cdot)$ is continuous and differentiable in $x$, $S'(x) = p^1(x)d^{1'}(x) + p^{1'}(x)(d^1(x) - d^0(x_A^0)) > p^1(x)d^{1'}(x) + p^{1'}(x)(d^1(x) - d^0(x)) \geq 0$; and if $x_A^1 < x < x_A^0$ then $S'(x) = (1 - p^1(x))d^{0'}(x) + p^{1'}(x)(d^1(x_A^1) - d^0(x)) > (1 - p^1(x))d^{0'}(x) + p^{1'}(x)(d^1(x_A^1) - d^0(x_A^0)) > 0$. Hence, the right-hand side of (14) is strictly decreasing in $x$, which implies that if any type of defendant rejects $S_T$, it will be those who observed low $x$. □

### C.5 Proof of Proposition 4

Consider a subgame where some pretrial settlement demand $S_T$ has been made by the plaintiff, and suppose that it has been rejected by the defendant. For any beliefs of the plaintiff, the defendant's payoff cannot be higher than $\sum_\tau p^\tau(0)\widetilde{Y}_A^\tau(0,0) - c_T^d$: when losing at trial (probability $p^1(x)$) after rejecting $S_T$, the defendant can either accept the judgment implying payoff $-c_T^d - D < -c_T^d - d^1(0)D - c_A^d = \widetilde{Y}_A^1(0,0) - c_T^d$ or file appeal. When winning at trial (probability $p^0(x)$), I have shown in Section 5 that the plaintiff will definitely file appeal. In either case, following an appeal, it is never optimal for the plaintiff to settle posttrial for less than the defendant's court costs plus expected damages, the minimum of which is $c_A^d + d^\tau(0)D$, as the plaintiff has full bargaining power. Hence, the case will either settle posttrial, implying a payoff for the defendant of at most $-c_T^d - c_A^d - d^\tau(0)D = \widetilde{Y}_A^\tau(0,0) - c_T^d$, or end in an appeal judgment, also implying an expected payoff for the defendant of at most $-c_T^d - c_A^d - d^\tau(0)D = \widetilde{Y}_A^\tau(0,0) - c_T^d$. Combining both cases and taking expectations, the defendant's payoff when rejecting $S_T$ is no higher than $\sum_\tau p^\tau(0)\widetilde{Y}_A^\tau(0,0) - c_T^d$.

Consider a subgame following some $S_T \leq \sum_\tau p^\tau(0)\widetilde{Y}_A^\tau(0,0) - c_T^d$. As shown in the previous step, rejecting $S_T$ can never earn the defendant a higher payoff than $\sum_\tau p^\tau(0)\widetilde{Y}_A^\tau(0,0) - c_T^d \leq S_T$. Hence, it is optimal for the defendant to accept $S_T$.

Consider now a subgame following some $S_T > \sum_\tau p^\tau(0)\widetilde{Y}_A^\tau(0,0) - c_T^d$. Then, Proposition 3 implies that there exists a unique threshold type $x_T > 0$ such that the defendant accepts $S_T$ if and only if $x \geq x_T$. The probability of $x < x_T$ and the defendant winning at trial is positive as $p^0(0) > 0$ due to Assumption 1 (a). Hence, the information set where the plaintiff has to decide whether to file appeal is reached with positive probability in equilibrium. Furthermore, Proposition 2 defines, for every $x_T$, the equilibrium appeals decision and implies that the losing defendant appeals with positive probability. Hence, any information set where the plaintiff's optimal choices or final payoffs depend on the defendant's type is reached with positive probability in equilibrium, so that restrictions on off-equilibrium beliefs are irrelevant.

To sum up, I have shown that, for the proper subgame following any pretrial settlement demand $S_T$, the weak PBE characterised by Propositions 1, 2 and 3 is independent of off-equilibrium beliefs. At the same time, these propositions also constructively prove existence of the weak PBE in these proper subgames. As this implies the same for the overall game, it completes the proof. □

### C.6 Proof of Proposition 5

Suppose that $x_T \notin \{\underline{x}_T^0, \underline{x}_T^1, \tilde{x}_T\}$ (all of which are defined in (18) and (19)), so that, due to Assumption 2, the appeals-stage equilibrium threshold types $x_A^\tau$ are continuous and differentiable in $x_T$. Then, the derivative of (16) w.r.t. $x_T$ exists and is equal to

$$\begin{aligned}\frac{\partial \Pi(x_T)}{\partial x_T} = &\left\{ p^{1'}(x_T)(d^1(x_A^1) - d^0(x_A^0)) + \sum_\tau \left( d^{\tau\prime}(x_A^\tau) \frac{dx_A^\tau}{dx_T} p^\tau(x_T) \right) \right\} \\ &(1 - F(x_T))D - f(x_T)(c_T^d + c_T^p) \\ &+ \sum_\tau \frac{dx_A^\tau}{dx_T} \left[ d^{\tau\prime}(x_A^\tau) D \int_{x_A^\tau}^{x_T} p^\tau(x) f(x) dx - p^\tau(x_A^\tau) f(x_A^\tau)(c_A^p + c_A^d) \right]\end{aligned}$$

The first two lines are identical to (17), and the last line is always zero: If $x_A^\tau$ is an interior solution, it satisfies the first-order condition (7) for $\hat{x}_T = x_T$, so that the expression in solid brackets is equal to zero. Conversely, if $x_A^\tau$ is a boundary solution, then $\frac{dx_A^\tau}{dx_T} = 0$. □

### C.7 Proof of Proposition 6

For the entire proof, suppose that $c_A^p + c_A^d$ is fixed at some level $C_A$, and consider variations in $c_A^p$, so that $c_A^d$ is given by $c_A^d = C_A - c_A^p$.

Firstly, $\Pi(x_T)$ is invariant in $c_A^p$ whenever $x_T < \tilde{x}_T$ as $x_A^0$ and $x_A^1$ are invariant in $c_A^p$ in this case.

Secondly, $\tilde{x}^A$ is constant in $x_T$ and increasing in $c_A^p$. Therefore, $\lim_{x \searrow \tilde{x}_T} \frac{\partial \Pi}{\partial x_T} < \lim_{x \nearrow \tilde{x}_T} \frac{\partial \Pi}{\partial x_T}$.

The first part, that $x_T^*$ is weakly increasing, follows immediately. To see the second part, suppose that $x_T^* = \tilde{x}_T$. Then, $\lim_{x \nearrow \tilde{x}_T} \frac{\partial \Pi}{\partial x_T} \leq 0$ and $\lim_{x \searrow \tilde{x}_T} \frac{\partial \Pi}{\partial x_T} \geq 0$. If the latter inequality is strict, then reducing $c_A^p$ by a sufficiently small margin reduces $\tilde{x}_T$ and keeps both of these inequalities intact at this new value of $\tilde{x}_T$. Hence, we still have $x_T^* = \tilde{x}_T$ at the new, reduced level.

On the other hand, if $\lim_{x \searrow \tilde{x}_T} \frac{\partial \Pi}{\partial x_T} = 0$, then reducing $c_A^p$ by a sufficiently small margin reduces $\tilde{x}_T$, keeps the inequality $\lim_{x \nearrow \tilde{x}_T} \frac{\partial \Pi}{\partial x_T} \leq 0$ intact but increases $\frac{\partial \Pi}{\partial x_T}$ for all $x_T > \tilde{x}_T$. Hence, $x_T^* < \tilde{x}_T$. □

## D The Example with Uniformly Distributed Types

In this Appendix, we derive equilibrium bargaining strategies for the example signal technology introduced at the end of Section 2 where $p^1(x) = x = 1 - p^0(x)$, $d^1(x) = \rho + (1 - \rho)x$ and $d^0(x) = (1 - \rho)x$ and assume that the defendant's types $x$ are ex-ante uniformly distributed on [0, 1]. These assumptions imply that

$$\mu^\tau(x) = \frac{p^\tau(x)}{\int_0^1 p^\tau(x')dx'} \tag{26}$$

An interior solution $\hat{x}_A^\tau$ is given by the first-order condition (7), which is, in this example, equivalent to

$$(1-\rho)D = \frac{p^\tau(\hat{x}_A^\tau)}{\int_{\hat{x}_A^\tau}^{x_T} p^\tau(x)dx}(c_A^p + c_A^d) \tag{27}$$

Defining the fraction of total legal costs at the appeals stage and potential damages as $Z_A := \frac{c_A^p + c_A^d}{D}$, we get

$$\hat{x}_A^1 = -\frac{Z_A}{1-\rho} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2} \tag{28}$$

$$\hat{x}_A^0 = 1 - \frac{Z_A}{1-\rho} - \sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2}. \tag{29}$$

Clearly, $\hat{x}_A^1 > 0$, so that the boundary solution $x_A^\tau = 0$ can only occur for $\tau = 0$. Furthermore, Proposition 2 implies the optimal choice of $x_A^1$ where $\hat{x}_A^1 > \tilde{x}_A = 1 - \frac{c_A^d}{(1-\rho)D}$. Hence,

$$x_A^1 = \min\left\{\hat{x}_A^1, \tilde{x}_A\right\} = \min\left\{-\frac{Z_A}{1-\rho} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2}, 1 - \frac{c_A^d}{(1-\rho)D}\right\} \tag{30}$$

$$x_A^0 = \max\left\{\hat{x}_A^0, 0\right\} = \max\left\{1 - \frac{Z_A}{1-\rho} - \sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2}, 0\right\}. \tag{31}$$

In each of the cases $\tau$, there is a unique threshold type $\underline{x}_T^0$ and $\tilde{x}_T$ for which the boundary solution satisfies the respective first-order condition (see (18) and (19)). These threshold types are given by

$$\tilde{x}_T = \sqrt{\left(1 - \frac{c_A^d}{(1-\rho)D}\right)\left(1 + \frac{2c_A^p + c_A^d}{(1-\rho)D}\right)} \tag{32}$$

$$\underline{x}_T^0 = 1 - \sqrt{1 - \frac{2Z_A}{1-\rho}}. \tag{33}$$

Recall that the plaintiff's optimal choice is an interior solution $x_A^1 = \hat{x}_A^1$ if and only if $x_T < \tilde{x}_T$, and $x_A^0 = \hat{x}_A^0$ if and only if $x_T > \underline{x}_T^0$.

Turning to the pretrial bargaining game, we can identify both effects within the marginal benefit of increasing $x_T$ for the plaintiff. First, the information effect is equal to

$$p^{1'}(x_T)(d^1(x_A^1) - d^0(x_A^0)) = \rho + (1-\rho)(x_A^1 - x_A^0),$$

where

$$x_A^1 - x_A^0 = \begin{cases} -\frac{Z_A}{1-\rho} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2}, & \text{if } x_T \le \min\{\underline{x}_T^0, \tilde{x}_T\}; \\ -1 + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2}, & \text{if } \underline{x}_T^0 < x_T < \tilde{x}_T; \\ 1 - \frac{c_A^d}{(1-\rho)D}, & \text{if } \tilde{x}_T < x_T < \underline{x}_T^0; \\ \frac{c_A^p}{(1-\rho)D} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2}, & \text{if } x_T \ge \max\{\underline{x}_T^0, \tilde{x}_T\}. \end{cases}$$

Recalling that $Z_A = \frac{c_A^p + c_A^d}{D}$, all lines except the third are increasing in $c_A^p$ and $c_A^d$ and decreasing in $D$. The third line is decreasing in $c_A^d$ and $D$ and constant in $c_A^p$. Hence, as long as $\underline{x}_T^0 \le \tilde{x}_T$, the information effect is increasing in $c_A^p$ and $c_A^d$ and decreasing in $D$. As for the effect of $\rho$, the first and the last lines are increasing in $\rho$, the third line is decreasing in $\rho$, and the effect of $\rho$ in the second line is indeterminate. Therefore, we cannot say anything definite about the effect of $\rho$ on the information effect.

Second, the strategic effect is equal to

$$\sum_\tau \left( d^{\tau\prime}(x_A^\tau) \frac{dx_A^\tau}{dx_T} p^\tau(x_T) \right) = (1-\rho) \left( x_T \frac{dx_A^1}{dx_T} + (1-x_T) \frac{dx_A^0}{dx_T} \right),$$

where

$$\frac{dx_A^1}{dx_T} = \begin{cases} \frac{x_T}{\sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2}}, & \text{if } x_T < \tilde{x}_T; \\ 0, & \text{if } x_T \ge \tilde{x}_T, \end{cases}$$

and

$$\frac{dx_A^0}{dx_T} = \begin{cases} 0, & \text{if } x_T < \underline{x}_T^0; \\ \frac{1-x_T}{\sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2}}, & \text{if } x_T \ge \underline{x}_T^0, \end{cases}$$

both of which are weakly decreasing in $Z_A$ and $\rho$. To sum up, the strategic effect is weakly decreasing in $c_A^p$, $c_A^d$ and $\rho$, and increasing in $D$.

To sum up these effects, if $\underline{x}_T^0 \le \tilde{x}_T$, (17) becomes

$$\frac{\partial \Pi(x_T)}{\partial x_T} = \begin{cases} \left\{\rho + (1-\rho)\left(-\frac{Z_A}{1-\rho} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2} + \frac{x_T^2}{\sqrt{\frac{Z_A^2}{(1-\rho)^2}+x_T^2}}\right)\right\} & \\ \qquad (1-x_T)D - (c_T^d + c_T^p), & x_T \le \min\{\underline{x}_T^0, \tilde{x}_T\}; \\ \left\{\rho + (1-\rho)\left(-1 + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + x_T^2} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2}\right.\right. & \\ \qquad \left.\left. + \frac{x_T^2}{\sqrt{\frac{Z_A^2}{(1-\rho)^2}+x_T^2}} + \frac{(1-x_T)^2}{\sqrt{\frac{Z_A^2}{(1-\rho)^2}+(1-x_T)^2}}\right)\right\} (1-x_T)D - (c_T^d + c_T^p), & \underline{x}_T^0 < x_T < \tilde{x}_T; \\ \left(1 - \frac{c_A^d}{D}\right)(1-x_T)D - (c_T^d + c_T^p), & \tilde{x}_T < x_T < \underline{x}_T^0; \\ \left\{\rho + (1-\rho)\left(\frac{c_A^p}{(1-\rho)D} + \sqrt{\frac{Z_A^2}{(1-\rho)^2} + (1-x_T)^2} + \frac{(1-x_T)^2}{\sqrt{\frac{Z_A^2}{(1-\rho)^2}+(1-x_T)^2}}\right)\right\} & \\ \qquad (1-x_T)D - (c_T^d + c_T^p), & x_T \ge \max\{\underline{x}_T^0, \tilde{x}_T\}. \end{cases} \tag{34}$$

## Declarations

**Conflicts of Interest** No conflicts of interest to declare.

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