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Abstract

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1 Introduction

Sophisticated parties often substitute by contract arbitration for civil trial.[1] Indeed, in international trade, arbitration is the default option. It is also prevalent in commercial law.

Typically, scholars identify three advantages of arbitration over civil trial. First, arbitration has no precedential effect. The parties make no law. Second, arbitrators typically have more expertise than either juries or judges on courts of general jurisdiction. Third, arbitration is said to be more expeditious and less expensive than civil trial.

In this paper, we provide a model of the choice between civil trial and arbitration that addresses the second and third differences between the two adjudicatory fora. In our model, arbitrators have more expertise than judges or juries in the sense that they understand evidence better. In addition, arbitrating parties must pay a fee to the arbitrator. (When the fee is zero, our model of arbitration reduces to a model of specialized courts.) The arbitration fee, however, is not the only relevant cost. The different expertise of the two fora entails that each uses a distinct rule of decision; each rule of decision provides different incentives for evidence collection and submission by the two parties. The differential cost of the two fora thus depends both on the size of the fee and the difference in evidence collection costs in the two fora.

We proceed as follows:. . .

[1] We consider only contracts between sophisticated parties with roughly equal bargaining power. Our model thus excludes the vast number of consumer form contracts that include arbitration clauses.

2 Model

We consider two parties—a plaintiff Π and a defendant Δ—who are in a dispute about a contested amount of money equal to $x \in (0, 1)$.[2] On one interpretation, plaintiff has a contract claim against defendant with x as the true amount of damages suffered by the plaintiff. An omniscient court would award x to plaintiff; but, though the parties know x, the court does not. It must rely on evidence submitted by the parties.

We use the following information structure. A piece of information, or signal, has two elements $\eta = (s, i)$—a "sign" s and an "informativeness index" i—where:

$$\begin{aligned} i &\sim \mathrm{U}[0,1] \\ s &= \begin{cases} 1 & \text{if} \quad i < x \\ -1 & \text{if} \quad i > x \end{cases} \end{aligned}$$

Therefore, a signal $\eta = (1, i)$ can be interpreted as meaning that the value of the contested amount is at least i. Similarly, a signal $\eta = (-1, i)$ indicates that the contested amount is at most i. If a court saw a pair of signals $\eta = \left(-1, \bar{i}\right)$ and $\eta' = (1, \underline{i})$, the court should conclude that $x \in \left(\underline{i}, \bar{i}\right)$, as depicted in Figure 1. Thus, the parties' signals give information to the court about the location of x. Plaintiff incurs a cost k_Π each time she acquires a signal while defendant incurs a cost k_Δ. We will use the following notation throughout. Let H_j be the set of signals drawn by party j and let H_j^* be the set of favorable signals drawn by party j. Note that favorable signals for plaintiff have $s = 1$, while favorable signals for defendant have $s = -1$, so that denoting as H_J^s the set of signals with component s drawn by party j, we have $H_\Pi^* = H_\Pi^1$ and $H_\Delta^* = H_\Delta^{-1}$. Define $\sigma_j \equiv \left|H_j^*\right|$ as the number of favorable signals drawn by party j.

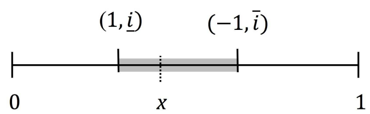


Figure 1: Signal space

2.1 Timing

The game unfolds as follows:

Time -1: The parties enter into a contract and decide whether to include an arbitration clause, which is binding ex post.[3]

[2] The fact that x lies in the unit interval is in fact a normalization to 1 of the amount at stake in the case. This is without loss of generality. What will be important in the model is the ratio of the costs of the adjudication system over the amount at stake, not the absolute value of the stakes per se. Therefore, we can think of the costs that will be introduced in our model as ratios of the nominal costs over the amount at stake and of x as a share of the amount at stake.

[3] Implicitly we assume that the arbitration option is not available ex post if not contracted for ex ante.

Time 0: A dispute arises, the parties jointly observe x and each of them privately observes a signal η_j^0, which cannot be credibly conveyed to the other party prior to trial.

Time 1: The parties attempt to settle the dispute. If they succeed, the game ends; if they fail, they pay a litigation fee and proceed to trial before a jury or an arbitrator as determined by the contract.

Time 2: The parties endogenously and simultaneously decide how many signals to collect (at a cost per signal).

Time 3: Each party decides which of the collected signals to submit to the adjudicator.

Time 4: The designated forum adjudicates the case according to the evidence submitted by the parties and the rule of decision available to the forum.

We will solve the game by backwards induction. In the next subsection we define the rules of decision for each type of adjudicator. Neither rule allows the adjudicator any discretion. The adjudicator, that is, is a non-strategic actor. Our analysis will thus begin with evidence production at time 3.

2.2 Fora and rules of decision

We consider two types of fora in which the parties may adjudicate their claim. A generalist court (jury trial), which does not have specific expertise on the matter that is the subject of the dispute, and a specialized court (commercial arbitration) endowed with a high level of specific knowledge about the disputed matter. We conceptualize this difference by assuming that only the arbitrator can fully process the signal $\eta = (s, i)$. In contrast, the jury can only process part of the information contained in the signal and, namely, the component s. The jury is simply unable to read i, the component that requires specialized knowledge.

We consider the rule of decision under arbitration first. Let H^s be the set of signals submitted to the arbitrator that have a first component s. We assume that the arbitrator rules $a = \frac{\underline{i}+\overline{i}}{2}$, where (with a slight abuse of notation) $\underline{i} \equiv \max_{\eta \in H^1} \{i_\eta\}$ and $\overline{i} \equiv \min_{\eta \in H^{-1}} \{i_\eta\}$ and i_η is the index of the signal $\eta = (s, i)$. That is, $\underline{i}$ is the highest index i of the signals η with sign $s = 1$. Since the signals $\eta = (1, i)$ establish a lower bound for a, it is clear that only the highest carries information; all signals $\eta = (1, i)$ with lower index i are less informative and, in particular, do not carry any additional information. Similarly, only the lowest of the signals $\eta = (-1, s)$ is informative, namely, $\overline{i}$. Therefore, it is efficient to only consider two signals among those submitted by the parties. This makes arbitration relatively expedient, as the arbitrator only verifies the two most informative signals.

In contrast, the jury only sees the component s and hence cannot exclude signals based on their informativeness i.[4] From the perspective of the jury, each signal carries the same amount of information. As a result, the court is bound to consider all of the evidence submitted by the parties without selection. The jury will rule $t = \frac{\sigma_1}{\sigma_1+\sigma_{-1}}$ (with $t = \frac{1}{2}$ if $\sigma_1 = \sigma_{-1} = 0$), where $\sigma_1 \equiv \sum (s \mid s = 1)$ and $\sigma_{-1} \equiv -\sum (s \mid s = -1)$. More plainly, σ_1 is the number of signals with component $s = 1$ submitted to the court and, similarly, σ_{-1} is the number of signals with component $s = -1$. The court simply considers the relative number of signals submitted by each party, the "weight of the evidence". Crucially, neither the jury nor the arbitrator is allowed to observe the number of signals drawn by each party or draw any additional inference from the number of submitted signals.

2.3 Equilibria

An equilibrium strategy for party j consists of a quadruple $\left(\kappa, b_j\left(\eta_j^0\right), h_j\left(\eta_j^0\right), h_j^*\left(\eta_j^0\right)\right)$ where the last three choices are conditional on the free signal η_j^0 that party j receives at time 0. The first element $\kappa \in \{A, T\}$ is the parties' choice whether to include an arbitration clause ($\kappa = A$) in the contract or not ($\kappa = T$), this choice is jointly made by the parties; $b_j\left(\eta_j^0\right)$ is the bid that party j submits in the settlement game played at time 1; $h_j\left(\eta_j^0\right)$ is party j's evidence collection decision at time 2; and $h_j^*\left(\eta_j^0\right)$ is the party's evidence submission strategy at time 3. We solve the game by backwards induction. Section 3 deals with the collection and submission of evidence. Section 3.1 identifies the equilibrium evidence submission strategy $h_j^*\left(\eta_j^0\right)$, that is, the choice of which signals to submit among all those collected. Section 3.2 provides the details of the parties' evidence collection efforts and Section 3.3 describes their collection strategy $h_j\left(\eta_j^0\right)$. Section 4 identifies the equilibrium bids $b_j\left(\eta_j^0\right)$.

3 Evidence

3.1 Evidence submission

At time 3, each party decides, given the evidence she has collected, which evidence to submit to the adjudicator. Let us start with arbitration. The arbitrator will only verify one signal for each party. This is because, since verification is costly and the most informative signal trumps all other signals, the parties have no incentive to submit more than one signal. Hence the plaintiff has incentives to submit the most favorable of her $(1, i)$ signals or to submit no signal at all,

[4] Here we could think of the informativeness of the signal $\eta = (s, i)$ as the product si. A signal $\eta = (1, i)$ is more informative when i is larger, which is equivalent to saying that it is more informative when the product $si = i$ is larger. Conversely, a signal $\eta = (-1, i)$ is more informative when i is smaller, that is, when the product $si = -i$ is larger. Thus a larger product si indicates that a signal is more informative.

from which the arbitrator will infer $(1,0)$, which is the worst possible $(1,i)$ signal. From the arbitrator's perspective a signal $(1,0)$ is entirely uninformative as it means that damages are bounded below by 0, which is what the arbitrator already knew at the outset. Thus, by attributing $(1,0)$ to a plaintiff who submits no evidence, the arbitrator is simply attributing her a non-informative signal without drawing negative inference from this behavior. Clearly, the plaintiff is better-off submitting no evidence—i.e. $(1,0)$—than submitting any signal $(-1,i)$ which can only carry negative (from the plaintiff's perspective) information.

To see why, assume that the defendant has submitted a signal $(-1,i')$. If $i > i'$ the signal $(-1,i)$ submitted by the plaintiff is not relevant for the final decision, which will be $a = \frac{0+i'}{2}$. If instead we have $i < i'$, then the plaintiff harms herself by submitting this signal, because the decision will be $a = \frac{0+i}{2}$ rather than $a = \frac{0+i'}{2} > \frac{0+i}{2}$, which would have been issued if the plaintiff had submitted no evidence and the arbitrator had had to decide only based on the defendant signals. Therefore, the plaintiff will submit a signal $(1,i)$ or no signal, which will be equated to $(1,0)$. Similarly, the defendant will submit a signal $(-1,i)$ or no signal, which in her case is equivalent to $(-1,1)$.

Let us now consider the jury trial. It is easy to see that the plaintiff will submit all of her $s = 1$ signals and the defendant will submit all of her $s = -1$ signals. We thus have the following 2 lemmata:

Lemma 1T. *Each party, when litigating in court, submits all the favorable signals she has received (*i.e., $h_j^{T*} = H_j^*$*); that is, party j submits all the σ_j signals that are in H_j^*.*

Lemma 1A. *Each party, when arbitrating, submits only the highest favorable signal she has received (i.e., $h_j^{A*} = \left\{\arg\max_{\eta \in H_j^*} \{i_\eta\}\right\}$; that is, plaintiff submits the signal η that has the largest index i among those with sign $s = 1$ while defendant submits the signal η with the smallest index i among those with sign $s = -1$.*

Notice that each party's evidence submission strategy is independent of her type (i.e., the free signal η_j^0 she received at time 0).

3.2 Evidence collection costs

Assume that the parties invest, respectively, in π and δ attorney-hours and that each attorney draws an average of 1 signal per hour at a cost k_Π and k_Δ, respectively. For simplicity assume that the expected time needed to collect each extra signal is constant. This allows us to describe evidence collection as a Poisson process; as each party only submits favorable signals, the relevant Poisson process has an arrival rate of favorable signals equal to x for the plaintiff and $(1-x)$ for the defendant.[5] This is a possibly restrictive assumption as it is

[5] Note that, in a Poisson process with base arrival rate λ, if only a fraction x of the draws are kept and the rest is discarded, the resulting arrival rate of favorable signals is $x\lambda$. In our

more likely that collecting an additional signal costs more time than the previous signals; yet, it greatly simplifies the analysis.

Evidence collection is a sequential process that stops when the marginal value of spending an additional hour of effort equals its marginal cost. We are interested in determining the favorable evidence that the parties expect to obtain given their optimal sequential investments and the expected costs of evidence collection.

3.2.1 Evidence collection for jury trial

Evidence in a jury trial is the total set of signals submitted by both parties. It is useful to look at the problem by setting a target number of signals that each party wants to collect (which is later to be determined in equilibrium) and to calculate the expected costs of collecting so many signals. Let us start with the plaintiff. Given that the arrival rate of favorable signals is x signals per hour, the average time needed to collect 1 signal is $\frac{1}{x}$ hours and hence the expected time needed to collect σ_Π favorable signals is $\frac{\sigma_\Pi}{x}$ hours at an expected cost of $\frac{\sigma_\Pi k_\Pi}{x}$. Similarly, the defendant expects to spend $\frac{\sigma_\Delta k_\Delta}{1-x}$ to collect σ_Δ favorable signals.

3.2.2 Evidence collection for arbitration

In arbitration, the parties are not simply interested in the number of favorable signals they collect but, more specifically, in the maximum or minimum index i, for the plaintiff or the defendant, respectively, of such signals. Therefore, the target measure for the plaintiff is an index i_Π such that the process stops when the attorney has found a signal η with index $i \in [i_\Pi, x]$ and continues as long as this threshold is not reached. Thus, conditional on not having reached the threshold yet, the signal that the plaintiff expects to draw at her last draw is $\frac{x+i_\Pi}{2}$, which is the expected value of a signal η such that $i \in [i_\Pi, x]$. To calculate the average waiting time note that effectively the plaintiff discards all signals below i_Π (because they do not contain enough information) and all signals above x (because they carry negative information), therefore the arrival rate of the resulting Poisson process is $x - i_\Pi$; the higher the target value i_Π, the lower the arrival rate. Given an arrival rate of $x - i_\Pi$, the expected time needed to collect a signal that satisfies the threshold is $\frac{1}{x-i_\Pi}$ so that the expected cost of collecting such a signal is $\frac{k_\Pi}{x-i_\Pi}$. Similarly, the defendant's target can be written as i_Δ, her arrival rate as $i_\Delta - x$, her expected waiting time as $\frac{1}{i_\Delta - x}$ and her expected cost as $\frac{k_\Delta}{i_\Delta - x}$.

3.3 Endogenous investments in litigation

The parties decide how much to invest in litigation or, more precisely, they set their targets for the evidence collection phase depending on the institution

model, we have $\lambda = 1$ and hence the plaintiff's arrival rate of favorable signals is x while the defendant arrival rate is $1 - x$.

they face. Recall that a Poisson process is memoryless and, hence, if it makes sense to invest additional time to find a new signal at time t, it also makes sense to keep investigating at time $t' > t$, indeed to keep investigating until that signal is found, because the additional expected waiting time is constant as we go forward. Crucially, the parties decide when to stop collecting signals independently of each other. Therefore, the question reduces to how many (favorable) signals the parties would collect in the Nash equilibrium of a game with simultaneous moves where the costs of collection are the expected costs from the sequential Poisson process calculated in the previous section.

3.3.1 Endogenous investments in jury trials

The investments in attorney-hours are chosen by the parties to maximize their expected trial outcome net of the costs. Recall that the judge decides in favor of the plaintiff with probability $t = \frac{\sigma_\Pi}{\sigma_\Pi + \sigma_\Delta}$ (with $t = \frac{1}{2}$ if $\sigma_\Pi = \sigma_\Delta = 0$) and that the cost of collecting signals is as specified in Section 3.2. Consider as a benchmark the case in which both parties have drawn an unfavorable signal at time 0 and hence enter the evidence collection game with no signal, the parties' decision problems are:[6]

$$\begin{array}{ll} \max_{\sigma_\Pi} \left[\frac{\sigma_\Pi}{\sigma_\Pi + \sigma_\Delta} - \frac{\sigma_\Pi k_\Pi}{x} \right] & \text{(plaintiff)} \\ \min_{\sigma_\Delta} \left[\frac{\sigma_\Pi}{\sigma_\Pi + \sigma_\Delta} + \frac{\sigma_\Delta k_\Delta}{1-x} \right] & \text{(defendant)} \end{array}$$

The first order conditions lead to the following result.

Lemma 2T. *In equilibrium, each party invests in evidence collection until she finds $\sigma_j^* = \left|H_j^*\right|$ favorable signals defined as follows:*

$$\begin{array}{lcll} \sigma_\Pi^* & = & \frac{x^2(1-x)^2}{(xk_\Delta + (1-x)k_\Pi)^2} \frac{k_\Delta}{1-x} & \textit{(plaintiff)} \\ \sigma_\Delta^* & = & \frac{x^2(1-x)^2}{(xk_\Delta + (1-x)k_\Pi)^2} \frac{k_\Pi}{x} & \textit{(defendant)} \end{array} \quad (1)$$

where $\frac{k_\Pi}{x}$ and $\frac{k_\Delta}{1-x}$ are the expected costs of acquiring one signal for the plaintiff and the defendant, respectively.

Note that, as we show more extensively in Section 4, the amount of evidence collection undertaken by the party depends on the content of the free signal she receives. If a party receives a favorable free signal, she need only collect $\sigma_j^* - 1$ signals but if she receives an unfavorable signal she must expend resources until she collects all σ_j^* signals.

[6] Obviously, each party can only acquire an integral number of signals. Nonetheless we analyze a continuous game that corresponds to this game. In a companion paper, "Discrete Rent Seeking Models" we demonstrate that the equilibrium of the discrete game must be near the equilibrium of the continuous game analyzed here. Specifically, the equilibrium will be one of the four possible equilibria that consist of the greatest integer less than equilibrium value for each party in the continuous game and the smallest integer greater than these equilibrium values. Comparative statics in the discrete game are similar to those in the continuous game.

Therefore we calculate the ex post costs of jury trial as follows:

$$(1-x)\frac{\sigma_{\Pi}^{*}k_{\Pi}}{x}+x\frac{\sigma_{\Delta}^{*}k_{\Delta}}{1-x}+x\left(\frac{\sigma_{\Pi}^{*}k_{\Pi}}{x}-\frac{k_{\Pi}}{x}\right)+(1-x)\left(\frac{\sigma_{\Delta}^{*}k_{\Delta}}{1-x}-\frac{k_{\Delta}}{1-x}\right)$$

where the first two addenda represent the evidence collection costs of parties without a favorable free signal and the last two addenda depict the evidence collection costs of parties with a favorable free signal. The expression above can be simplified as follows:

$$\frac{\sigma_{\Pi}^{*}k_{\Pi}}{x}+\frac{\sigma_{\Delta}^{*}k_{\Delta}}{1-x}-k_{\Pi}-k_{\Delta} \tag{2}$$

3.3.2 Endogenous investments in commercial arbitration

Recall that the arbitrator's decision is $a=\frac{i+\bar{i}}{2}$ and that the plaintiff's expected signal when she collects signals until she finds a signal $i\in[i_{\Pi},x]$ is $\frac{x+i_{\Pi}}{2}$; similarly, if the defendant collects signals until she finds a signal $i\in[x,i_{\Delta}]$, her expected signal is $\frac{x+i_{\Delta}}{2}$. Therefore, the arbitrator's expected decision is $\frac{1}{2}\left(\frac{x+i_{\Pi}}{2}+\frac{x+i_{\Delta}}{2}\right)=\frac{1}{2}\left(x+\frac{i_{\Pi}+i_{\Delta}}{2}\right)$. Using again the memoryless property of the Poisson process, the parties' problems are:

$$\begin{array}{ll}\max_{i_{\Pi}}\left[\frac{1}{2}\left(x+\frac{i_{\Pi}+i_{\Delta}}{2}\right)-\frac{k_{\Pi}}{x-i_{\Pi}}\right] & \text{(plaintiff)}\\ \min_{i_{\Delta}}\left[\frac{1}{2}\left(x+\frac{i_{\Pi}+i_{\Delta}}{2}\right)+\frac{k_{\Delta}}{i_{\Delta}-x}\right] & \text{(defendant)}\end{array}$$

Note that the problems are completely separable: unlike in the jury trial, the strategy of one party is independent of the strategy of the other party. we have:

Lemma 2A. *In equilibrium, plaintiff collects evidence until she receives a signal* $\hat{\eta}_{\Pi}=\left(1,\hat{i}_{\Pi}\right)$ *where* $\hat{i}_{\Pi}\in[i_{\Pi}^{*},x]$. *Defendant collects evidence until she receives a signal* $\hat{\eta}_{\Delta}=\left(-1,\hat{i}_{\Delta}\right)$ *where* $\hat{i}_{\Delta}\in[x,i_{\Delta}^{*}]$. *The thresholds* i_{j}^{*} *are defined by:*

$$\begin{array}{rcll} i_{\Pi}^{*} & = & \max\left\{0,x-2\sqrt{k_{\Pi}}\right\} & \text{(plaintiff)}\\ i_{\Delta}^{*} & = & \min\left\{x+2\sqrt{k_{\Delta}},1\right\} & \text{(defendant)}\end{array} \tag{3}$$

The parties' collection strategies are depicted in Figure 2.

(a) Plaintiff's target

(b) Defendant's target

Figure 2: Signal collection for arbitration

Comment 1: As in the case of jury trial, the extent to which party j engages in evidence collection depends on her initial, free signal. If say plaintiff's signal is $\eta = (1, i)$ she will only engage in evidence collection if $i \notin [i^*_\Pi, x]$. Her behavioral strategy thus depends on the free signal.

Comment 2: If $k_\Pi > \frac{x^2}{4}$, then $i^*_\Pi = 0$, which implies that the plaintiff does not collect any evidence irrespective of the free signal—including when the free signal is unfavorable—because the cost of doing so is too high. Similarly, if $k_\Delta > \frac{(1-x)^2}{4}$, then $i^*_\Delta = 1$ and the defendant does not collect any evidence irrespective of the free signal because the cost of doing so is too high.

In equilibrium, the parties' expected payoffs are:

$$\begin{array}{ll} x - \sqrt{k_\Pi} + \frac{\sqrt{k_\Delta}}{2} & \text{(plaintiff)} \\ x + \sqrt{k_\Delta} - \frac{\sqrt{k_\Pi}}{2} & \text{(defendant)} \end{array}$$

Where the first two addenda are due to the party's own strategy and the third addendum is just a fixed value reflecting the opponent's strategy. Note that this value does not affect the incentives of the party and it can be regarded as a constant. If the parties have signals i^*_Π and i^*_Δ already and do not investigate further, they earn

$$\begin{array}{lcll} \frac{i^*_\Pi + i^*_\Delta}{2} & = & x - \sqrt{k_\Pi} + \sqrt{k_\Delta} & \text{(plaintiff)} \\ \frac{i^*_\Pi + i^*_\Delta}{2} & = & x + \sqrt{k_\Delta} - \sqrt{k_\Pi} & \text{(defendant)} \end{array}$$

which is more than in the case of investigation. However, the difference is due to the fact that the opponent's signal is no longer distributed between x and the stopping point, but is simply the stopping point. Yet, as above, the first two addenda are the only incentive-relevant portions of the payoff. Therefore, taking the opponent's choice as given, a party with a signal equal to i^*_j is indifferent between investigating further and submitting that signal to the arbitrator.

It is useful to define the parties' probability of having a favorable free signal as follows:

$$\begin{array}{lcll} \chi_\Pi & \equiv & \min\left\{x, 2\sqrt{k_\Pi}\right\} & \text{(probability that the plaintiff has a favorable free signal)} \\ \chi_\Delta & \equiv & \min\left\{1 - x, 2\sqrt{k_\Delta}\right\} & \text{(probability that the defendant has a favorable free signal)} \end{array} \tag{4}$$

Then the parties ex post costs of evidence collection (conditional on going to trial) are

$$(1 - \chi_\Pi)\, i^*_\Pi + (1 - \chi_\Delta)\, i^*_\Delta \tag{5}$$

3.3.3 Comparison of the ex post costs of litigation

Here we compare the costs of litigation of all cases, including those that, as we will see below, settle out of court never reaching the litigation stage. Arbitration and jury trial give parties different incentives to collect evidence in case of litigation. Expressions (2) and (5) describe these costs. In the case of jury trial, parties with a favorable free signal save the cost of collecting one signal in litigation. In arbitration, parties with a favorable free signal collect no evidence in court. The two fora are also different with respect to the parties' incentives to collect evidence. In a jury trial the parties play a strategic game in evidence collection. If the case is close (x close to $\frac{1}{2}$) the parties have the strongest incentives to invest in evidence because both of them have good chances to win. If instead the case is clearly in favor of either party (x close to 0 or to 1), then both parties invest less: the loser because she can do little to improve her position at reasonable costs and the winner because the loser invests little. This justifies the inverted-U shape of the ex post costs of a jury trial in Figure 3.

In arbitration, the parties' decision problems with respect to evidence collection are separable. In the intermediate region, the parties' investments do not depend on x. Close to the extreme, at least one of the parties will have a favorable free signal with a very small probability and invest relatively large amounts in evidence collection, which drives up the total costs. Consider for instance the plaintiff. When x goes below $2\sqrt{k_\Pi}$, the plaintiff's probability of having a favorable free signal, χ_Π, becomes dependent on (and decreasing in) x. Therefore, the plaintiff will collect evidence more often as x decreases. For values of x close to 0 the plaintiff's increased evidence collection efforts drive up the total costs. For values of x close to 1 the defendant's costs increase leading to a similar outcome. The result is a U-shaped curve.

Figure 3 compares the ex post evidence collection costs in the two fora. (Note that adding a positive f only shifts the costs of arbitration upwards by the same amount.) Close cases (with intermediate levels of x) fare better under arbitration due to the fact that in a jury trial the parties would engage in a race to sway the court. Conversely, very clear cases (with low or high levels of x) yield lower costs under jury trial, because of the increased incentives of the weak party to engage in evidence collection under arbitration. In a jury trial, the same dynamic that raises the costs of close cases, dampens the incentives to collect information when the case is clearly in favor of one party.

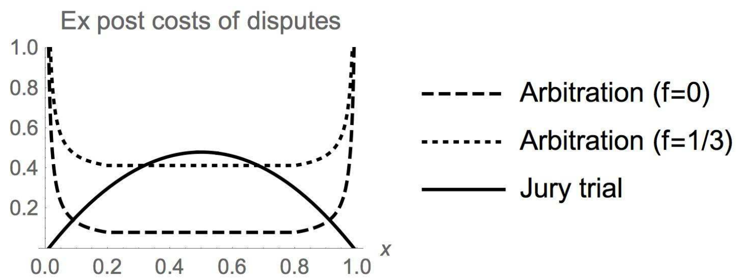


Figure 3: Ex post costs of evidence collection ($k_\Pi = k_\Delta = .01$; $f = 0$)

4 Settlement

Each party has one free signal η_j^0, privately drawn from $[0,1]$ at time 0. The parties attempt to settle and will go to trial if they fail. Settlement is modeled as in **(author?)** [1] as a simultaneous bid process where the parties simultaneously submit their bids to a mediator and, if the bids cross they settle, otherwise they go to trial. In essence, we assume that the first signal is free but additional signals can only be collected at a cost, as described above.

Note that, as noted above, after the draw a party might or might not have a favorable signal to submit to the adjudicator. If the plaintiff has drawn a signal below x, then the signal might be submitted at trial along with (in the jury trial) or instead of (in arbitration) other signals collected later. If instead the plaintiff has drawn a signal above x, then the signal will not be submitted at trial. Vice versa for the defendant. Recall that submitting no signal is equivalent to submitting the least informative signal, that is, $\eta = (1,0)$ for the plaintiff and $\eta = (-1,1)$ for the defendant. Crucially, signals are private information and cannot be credibly conveyed to the other party prior to trial. Therefore, the settlement decision occurs as the equilibrium of a game with two-sided asymmetric information about the free signal that each party has.

4.1 Expected outcomes from litigation

Before analyzing the parties' settlement decisions it it useful to describe the parties' behavior during and expectations from litigation, because settlement will occur is the shadow of such outcomes.

4.1.1 Expected outcomes from jury trial

Since the jury cannot verify the index i of the signal, i is immaterial and we can fully describe the settlement stage with reference to the sign of the initial signal η_j^0 only. Let s_j^0 be the sign of the free signal η_j^0 drawn by party j. The parties are asymmetrically informed about the component s of the signal that each has. Thus, the defendant knows that the plaintiff has drawn a favorable signal $s_\Pi^0 = 1$—which will be submitted at trial—with probability x and an unfavorable signal $s_\Pi^0 = -1$—which will not be submitted at trial—with the complementary probability of $1-x$. The plaintiff's expectations about the defendant's signal are analogous.

There are four possibilities resulting from the fact that each party can enter the evidence collection phase with or without a favorable signal. Here we assume that both parties know whether their opponent has a favorable signal or not. We later address the problem of asymmetric information. Given the stationarity of the Poisson process, we can derive the expected payoff for each party from the single case in which neither party receives a favorable free signal. This event occurs with probability $x(1-x)$. Lemma 2T identified the equilibrium strategies of the parties in this case. We reproduce them here:[7]

[7] Note that in the discrete game, each party will choose either the greatest integer less

$$\begin{aligned}\sigma^*_\Pi &= \tfrac{x^2(1-x)k_\Delta}{(xk_\Delta+(1-x)k_\Pi)^2} \quad \text{(plaintiff)}\\ \sigma^*_\Delta &= \tfrac{x(1-x)^2k_\Pi}{(xk_\Delta+(1-x)k_\Pi)^2} \quad \text{(defendant)}\end{aligned}$$

Plaintiff's expected payoff from litigation is given by $\frac{\sigma^*_\Pi}{\sigma^*_\Pi+\sigma^*_\Delta} - \frac{\sigma^*_\Pi k_\Pi}{x}$. Some simple algebraic manipulation yields

$$T_\Pi \equiv \left(\frac{xk_\Delta}{xk_\Delta + (1-x)c\Pi}\right)^2$$

Similarly the defendant's expected payoff from litigation is given by $\frac{\sigma^*_\Pi}{\sigma^*_\Pi+\sigma^*_\Delta} - \frac{\sigma_\Delta k_\Delta}{1-x}$. Simple manipulation yields the following expression

$$T_\Delta \equiv 1 - \left(\frac{(1-x)\,k_\Pi}{xk_\Delta + (1-x)\,k_\Pi}\right)^2$$

There are three additional cases: (1) both parties received a favorable signal prior to settlement negotiations; (2) only the plaintiff received a favorable signal; and (3) only the defendant received a favorable initial signal. It is straightforward to derive the parties's equilibrium strategies and expected payoffs in each case. In each of these equilibria, any party j without a signal chooses σ^*_j while any party with a signal chooses

$$\tau^*_j \equiv \max\left\{\sigma^*_j - 1, 0\right\}$$

Similarly the expected payoffs to any party without a signal is unchanged from before while the expected payoff for any party with a signal increases by the expected cost of the signal she did not have to purchase, which amounts to either $\frac{k_\Pi}{x}$ or $\frac{k_\Delta}{(1-x)}$. We may now state Proposition 1T:

Proposition 1T. *In the event of litigation before a jury:*

(a) *The parties submit evidence in the amount indicated in Table 1 and submit all the signals they collect.*

Plaintiff	Defendant: Signal ($s^0_\Delta = -1$)	Defendant: No signal ($s^0_\Delta = 1$)
Signal ($s^0_\Pi = 1$)	$(\tau^*_\Pi, \tau^*_\Delta)$	$(\tau^*_\Pi, \sigma^*_\Delta)$
No signal ($s^0_\Pi = -1$)	$(\sigma^*_\Pi, \tau^*_\Delta)$	$(\sigma^*_\Pi, \sigma^*_\Delta)$

Table 1: Parties' equilibrium strategies for evidence submission (Π, Δ)

than her equilibrium value in the continuous game or the smallest integer greater than that equilibrium value. See footnote 6.

(b) *They receive the expected payoff indicated in Table 2.*

		Defendant: Signal ($s^0_\Delta = -1$)	Defendant: No signal ($s^0_\Delta = 1$)
Plaintiff	Signal ($s^0_\Pi = 1$)	$\left(T_\Pi + \frac{k_\Pi}{x}, T_\Delta - \frac{k_\Delta}{1-x}\right)$	$\left(T_\Pi + \frac{k_\Pi}{x}, T_\Delta\right)$
	No signal ($s^0_\Pi = -1$)	$\left(T_\Pi, T_\Delta - \frac{k_\Delta}{1-x}\right)$	(T_Π, T_Δ)

Table 2: Parties' expected payoffs (Π, Δ)

4.1.2 Expected outcomes from arbitration

As in the case of jury trial, there are four possibilities that arise depending on which parties, if any, have received a free, favorable signal. In arbitration, however, the problem is simpler as each party's decision to search for evidence is independent of the other party's decision.

Let i^0_j be the index of the free signal η^0_j drawn by party j. We start with the plaintiff. If evidence collection costs are low, $k_\Pi \leq \frac{x^2}{4}$, the plaintiff chooses $i^*_\Pi \geq 0$. Her free signal will be relevant only if it has index $i^0_\Pi \in [i^*_\Pi, x]$; if so, that is, with probability $x - i^*_\Pi$, the plaintiff submits this signal in arbitration and collects no new signals. If not, that is, with probability $1 - x + i^*_\Pi$, the plaintiff will collect new signals until she hits her target. In both cases the plaintiff only submits the first signal she finds in $[i^*_\Pi, x]$ and discards all other signals. Hence in expectation she submits a signal with index $i = \frac{i^*_\Pi + x}{2}$ and spends $\frac{k_\Pi}{x - i^*_\Pi}(1 - x + i^*_\Pi)$ in evidence collection. If instead the evidence collection cost is high, $k_\Pi > \frac{x^2}{4}$, we have $i^*_\Pi = 0$. This implies that it is preferable for the plaintiff to submit whatever signal she has rather than collecting evidence. Also plaintiffs with $i > x$ collect no signal and submit no signal to the arbitrator, which is equivalent to submitting $\eta = (1, 0)$. In this case, the plaintiff submits a signal with index $i = \frac{x^2}{2}$ and spends nothing in evidence collection.

A similar reasoning applies to the defendant. If $k_\Delta \leq \frac{(1-x)^2}{4}$, with probability $i^*_\Delta - x$ the defendant has a favorable signal; with probability $1 - i^*_\Delta + x$, the defendant collects new signals until she finds a signal with index in $[i^*_\Delta - x]$. In expectation, the defendant submits a signal with index $i = \frac{x + i^*_\Delta}{2}$ and spends $\frac{k_\Delta}{i^*_\Delta - x}(1 - i^*_\Delta + x)$ in evidence collection. If instead $k_\Delta > \frac{(1-x)^2}{4}$, no defendant collects a signal and those defendants with $i < x$ submit no signal to the arbitrator, which is equivalent to submitting the least informative signal $\eta = (-1, 1)$. In this case, in expectation the defendant submits a signal with index $i = x + \frac{1-x^2}{2}$ and spends nothing in evidence collection.

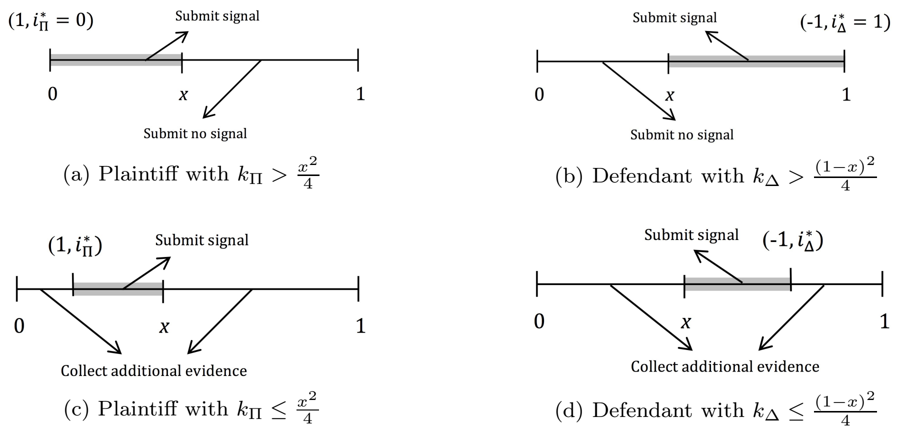
Recalling that parties pay a fee f when they go to arbitration, we thus have:

Proposition 1A. *In the event of litigation before an arbitrator:*

Plaintiff. *If the evidence collection costs is low,* $k_\Pi \le \frac{x^2}{4}$*, then* $i^*_\Pi \ge 0$*. If* $i^0_\Pi \in [i^*_\Pi, x]$ *the plaintiff submits her free signal, otherwise she collects new evidence until she finds a signal in* $[i^*_\Pi, x]$*; she discards all other signals. In expectation she submits a signal with index* $i = \frac{i^*_\Pi + x}{2}$ *and spends* $\frac{k_\Pi}{x - i^*_\Pi}(1 - x + i^*_\Pi)$ *in evidence collection. If instead the evidence collection cost is high,* $k_\Pi > \frac{x^2}{4}$*, then* $i^*_\Pi = 0$*. The plaintiff never collects new evidence: if* $i_\Pi \in [i^*_\Pi = 0, x]$ *the plaintiff submits her free signal, otherwise she submits no signal. In expectation she submits a signal with index* $i = \frac{x^2}{2}$ *and spends nothing in evidence collection.*

Defendant. *If the evidence collection costs is low,* $k_\Delta \le \frac{(1-x)^2}{4}$*, then* $i^*_\Delta \le 1$*. If* $i^0_\Delta \in [x, i^*_\Delta]$ *the defendant submits her free signal, otherwise she collects new evidence until she finds a signal in* $[x, i^*_\Delta]$*; she discards all other signals. In expectation she submits a signal with index* $i = \frac{x + i^*_\Delta}{2}$ *and spends* $\frac{k_\Delta}{i^*_\Delta - x}(1 - i^*_\Delta + x)$ *in evidence collection. If instead the evidence collection cost is high,* $k_\Delta > \frac{(1-x)^2}{4}$*, then* $i^*_\Delta = 1$*. The defendant never collects new evidence: if* $i_\Delta \in [x, i^*_\Delta = 1]$ *the defendant submits her free signal, otherwise she submits no signal. In expectation she submits a signal with index* $i = x + \frac{1-x^2}{2}$ *and spends nothing in evidence collection.*

Figure 4 illustrates Proposition 1A.



(a) Plaintiff with $k_\Pi > \frac{x^2}{4}$

(b) Defendant with $k_\Delta > \frac{(1-x)^2}{4}$

(c) Plaintiff with $k_\Pi \le \frac{x^2}{4}$

(d) Defendant with $k_\Delta \le \frac{(1-x)^2}{4}$

Figure 4: Collection strategies for arbitration

4.2 Settlement before a jury trial

In this section we state a main result concerning settlement. We identify the conditions for each of five classes of equilibria in which some settlement occurs, the settlement amount, and the probability of settlement. The argument is long and dense; we relegate most of it to the appendix. Here we set out the result and sketch the structure of the argument. The analysis of settlement is complex because it is a game of incomplete information generated by the fact that each party receives a free, private signal about the case. In this context, there are six possible classes of equilibria, one of which never arises. In some cases, however, equal division does not identify a unique point. Within each class there are multiple equilibria but the specified bargaining game picks out the equal division outcome. Which equilibrium class is realized depends on the costs of evidence collection that the parties face. This fact follows from Proposition 1T which indicates that the costs of evidence collection vary with the signal the party receives. Those parties receiving a free favorable signal incur lower costs of evidence collection thereby increasing their expected return from litigation. Consequently, those who receive a favorable free signal demand more in settlement.

In full settlement, one of these types of equilibria—complete pooling of types—occurs. In the other four types of equilibria, partial pooling exists. The theorem identifies the conditions on costs under which each type of equilibrium occurs, the equilibrium bids made in each type of equilibrium and the equilibrium amount of the settlement. It summarizes the results in three tables:

Theorem 1T. *Before a jury trial, for all parameters, at least some parties settle.*

(a) *Recall that* $\frac{k_\Pi}{x}$ *and* $\frac{k_\Delta}{1-x}$ *are the expected costs of collecting a favorable signal and let*

$$\Psi \equiv \frac{\sigma_\Pi^* k_\Pi}{x} + \frac{\sigma_\Delta^* k_\Delta}{1-x} = \frac{2x(1-x)\,k_\Pi k_\Delta}{(x k_\Delta + k_\Pi (1-x))^2}$$

be the sum of the parties' expected expenditures in evidence collection in equilibrium. Table 3 identifies the nature of the equilibrium, and the conditions on costs under which it is realized.

Case	Description	Probability of litigation	Conditions for the equilibrium
1T	Full settlement	0	$\frac{k_\Pi}{x} + \frac{k_\Delta}{1-x} \leq \Psi$
2T	Defendants with a signal litigate with plaintiffs with a signal, other types settle	$x(1-x)$	$\begin{cases} \frac{k_\Pi}{x} + \frac{k_\Delta}{1-x} > \Psi \\ \frac{k_\Pi}{x} \leq \Psi \\ \frac{k_\Delta}{1-x} \leq \Psi \end{cases}$
3T	Defendants without a signal settle Defendants with a signal litigate	$1-x$	$\begin{cases} \frac{k_\Pi}{x} \leq \Psi \\ \frac{k_\Delta}{1-x} > \Psi \end{cases}$
4T	Plaintiffs with a signal litigate Plaintiffs without a signal settle	x	$\begin{cases} \frac{k_\Pi}{x} > \Psi \\ \frac{k_\Delta}{1-x} \leq \Psi \end{cases}$
5T	Defendants without a signal settle with plaintiffs without a signal, other types litigate	$1-x(1-x)$	$\begin{cases} \frac{k_\Pi}{x} > \Psi \\ \frac{k_\Delta}{1-x} > \Psi \end{cases}$
6T	Full litigation	1	Never

Table 3: Settlement equilibria with jury trial

(b) *Let*

$$\begin{cases} \tilde{S} & \equiv \frac{T_\Pi + T_\Delta}{2} + \frac{(1-x)k_\Pi - xk_\Delta}{2x(1-x)} \\ \overline{S} & \equiv \frac{T_\Pi + T_\Delta}{2} + \frac{k_\Pi}{2x} \\ \underline{S} & \equiv \frac{T_\Pi + T_\Delta}{2} - \frac{k_\Delta}{2(1-x)} \\ \breve{S} & \equiv \frac{T_\Pi + T_\Delta}{2} \end{cases}$$

In equilibrium, parties submit the following bids $b_j^T\left(s_j^0\right)$ indicated in Table 4, which depend on the sign s_j^0 of the free signal.

Case	Description	Bids in equilibrium	$b_\Delta^T(-1)$	$b_\Delta^T(1)$
1T	Full settlement	$b_\Pi^T(1)$	$\left(\tilde{S}, \tilde{S}\right)$	$\left(\tilde{S}, \tilde{S}\right)$
		$b_\Pi^T(-1)$	$\left(\tilde{S}, \tilde{S}\right)$	$\left(\tilde{S}, \tilde{S}\right)$
2T	Defendants with a signal litigate with plaintiffs with a signal, other types settle	$b_\Pi^T(1)$	$\left(\overline{S}, \underline{S}\right)$	$\left(\overline{S}, \overline{S}\right)$
		$b_\Pi^T(-1)$	$\left(\underline{S}, \underline{S}\right)$	$\left(\underline{S}, \overline{S}\right)$
3T	Defendants without a signal settle Defendants with a signal litigate	$b_\Pi^T(1)$	$\left(\overline{S}, 0\right)$	$\left(\overline{S}, \overline{S}\right)$
		$b_\Pi^T(-1)$	$\left(\overline{S}, 0\right)$	$\left(\overline{S}, \overline{S}\right)$
4T	Plaintiffs with a signal litigate Plaintiffs without a signal settle	$b_\Pi^T(1)$	$\left(1, \underline{S}\right)$	$\left(1, \underline{S}\right)$
		$b_\Pi^T(-1)$	$\left(\underline{S}, \underline{S}\right)$	$\left(\underline{S}, \underline{S}\right)$
5T	Defendants without a signal settle with plaintiffs without a signal, other types litigate	$b_\Pi^T(1)$	$(1, 0)$	$\left(1, \breve{S}\right)$
		$b_\Pi^T(-1)$	$\left(\breve{S}, 0\right)$	$\left(\breve{S}, \breve{S}\right)$
6T	Full litigation	Never an equilibrium		

Table 4: Bids in the shadow of jury trial (Π, Δ)

(c) *Settling parties receive the amounts in settlement indicated in Table 5.*

Case	Description	Settlement amount in equilibrium		
			$b_{\Delta}^{T}(-1)$	$b_{\Delta}^{T}(1)$
1T	Full settlement	$b_{\Pi}^{T}(1)$	$\breve{S}$	$\breve{S}$
		$b_{\Pi}^{T}(-1)$	$\breve{S}$	$\breve{S}$
			$b_{\Delta}^{T}(-1)$	$b_{\Delta}^{T}(1)$
2T	Defendants with a signal litigate with plaintiffs with a signal, other types settle	$b_{\Pi}^{T}(1)$	Trial	$\overline{S}$
		$b_{\Pi}^{T}(-1)$	$\underline{S}$	$\frac{\underline{S}+\overline{S}}{2}$
			$b_{\Delta}^{T}(-1)$	$b_{\Delta}^{T}(1)$
3T	Defendants without a signal settle Defendants with a signal litigate	$b_{\Pi}^{T}(1)$	Trial	$\overline{S}$
		$b_{\Pi}^{T}(-1)$	Trial	$\overline{S}$
			$b_{\Delta}^{T}(-1)$	$b_{\Delta}^{T}(1)$
4T	Plaintiffs with a signal litigate Plaintiffs without a signal settle	$b_{\Pi}^{T}(1)$	Trial	Trial
		$b_{\Pi}^{T}(-1)$	$\underline{S}$	$\underline{S}$
			$b_{\Delta}^{T}(-1)$	$b_{\Delta}^{T}(1)$
5T	Defendants without a signal settle with plaintiffs without a signal, other types litigate	$b_{\Pi}^{T}(1)$	Trial	Trial
		$b_{\Pi}^{T}(-1)$	Trial	$\breve{S}$
6T	Full litigation	Never an equilibrium		

Table 5: Settlement amounts in the shadow of jury trial (Π, Δ)

In cases 1T to 5T a number of Pareto inferior equilibria exist. Here is the structure of the proof. We begin by noting that Proposition 1T sets out the disagreement point of each possible pair of parties. Settlement can only occur if there is a potential settlement that is mutually preferred to the litigated outcome. We then look for pure strategy equilibria. Since the parties have either a signal or not, their bids at the settlement stage can be either high or low. Let the parties' demand and offer, respectively, be denoted as:

$$b_{\Pi}^{T}\left(s_{\Pi}^{0}\right) = \begin{cases} \overline{b}_{\Pi} & \text{if} \quad s_{\Pi}^{0}=1 \\ \underline{b}_{\Pi} & \text{if} \quad s_{\Pi}^{0}=-1 \end{cases} \quad \text{and} \quad b_{\Delta}^{T}\left(s_{\Delta}^{0}\right) = \begin{cases} \overline{b}_{\Delta} & \text{if} \quad s_{\Delta}^{0}=1 \\ \underline{b}_{\Delta} & \text{if} \quad s_{\Delta}^{0}=-1 \end{cases}$$

where $\underline{b}_{j}^{T} \leq \overline{b}_{j}^{T}$ and settlement occurs if $b_{\Pi}^{T} \leq b_{\Delta}^{T}$. Consider the plaintiff first. If the plaintiff demands b_{Π}^{T}, the outcome is

$$\begin{cases} \text{settlement with probability 1} & \text{if} \quad b_{\Pi}^{T} \leq \underline{b}_{\Delta}^{T} & \Longrightarrow \quad b_{\Pi}^{T} = \underline{b}_{\Delta}^{T} \\ \text{settlement with probability } x & \text{if} \quad \underline{b}_{\Delta}^{T} < b_{\Pi}^{T} \leq \overline{b}_{\Delta}^{T} & \Longrightarrow \quad b_{\Pi}^{T} = \overline{b}_{\Delta}^{T} \\ \text{settlement with probability 0} & \text{if} \quad b_{\Pi}^{T} > \overline{b}_{\Delta}^{T} & \Longrightarrow \quad b_{\Pi}^{T} = 1 \end{cases}$$

It is easy to see that, given that she is settling, the plaintiff is better off increasing her demand up to the point where her demand perfectly matches the defendant's offer. Any lower demand cannot be part of a pure-strategy Nash equilibrium because the plaintiff would have incentives to deviate and increase her bid, thereby increasing the settlement amount without decreasing the probability of settlement. In case of full litigation (last line above), take for convenience the plaintiff's demand to be equal to 1 (it is in fact immaterial which value it takes as long as it is larger than the defendant's offer). Similarly, for the defendant we have:

$$\begin{cases} \text{settlement with probability 1} & \text{if} \quad b_{\Delta}^{T} \geq \overline{b}_{\Delta}^{T} & \implies & b_{\Delta}^{T} = \overline{b}_{\Delta}^{T} \\ \text{settlement with probability } 1-x & \text{if} \quad \underline{b}_{\Delta}^{T} \leq b_{\Delta}^{T} < \overline{b}_{\Pi} & \implies & b_{\Delta}^{T} = \overline{b}_{\Delta}^{T} \\ \text{settlement with probability 0} & \text{if} \quad b_{\Delta}^{T} < \overline{b}_{\Delta}^{T} & \implies & b_{\Delta}^{T} = 0 \end{cases}$$

Therefore, in the equilibrium, each party's bid can take either of three values depending of whether that party is settling with all opponents, is screening opponents with whom to settle or is litigating with all opponents. The settlement outcome is $S = \frac{b_{\Pi}^{T} + b_{\Delta}^{T}}{2}$ for both parties. If the parties litigate, there is no fixed litigation fee (it is normalized to zero) but the parties pay their attorneys to collect signals and the outcomes are as defined in Proposition 1T. Recall that a party's litigation payoff does not depend on the other party's type. However, the opponent's type is only relevant because it determines the opponent's reservation price and hence the amount for which the case can be settled. If the plaintiff's reservation price is higher than the defendant's reservation price, there is no settlement amount S that is sustainable in equilibrium and the parties litigate. If the plaintiff's reservation price is lower than the defendant's reservation price, the parties can settle. The results reported in tables 3, 4 and 5 follow from working out the conditions that lead to each type of equilibrium. We do this in the appendix. Note an unconventional result in Table 3. Equilibria where settlement is more likely occur when the parties' hourly costs of collecting evidence are lower. This is contrary to intuition and common wisdom. The reason is that parties with low hourly costs of evidence collection collect more evidence in equilibrium and hence bear larger expected costs. Traditional models usually consider fixed costs, while here we endogenize evidence collection and hence also the total costs borne by the parties. When considering the sum of the parties' equilibrium evidence collection expenditures, Ψ, rather than the parties' hourly costs, the logic of the results follows a more familiar pattern,

4.3 Settlement before arbitration

The analysis of settlement under arbitration differs from the analysis of settlement in court in several respects. First, in the shadow of trial, the incomplete information generated by the free signals of each party creates only two types of plaintiff and two types of defendant. As the arbitrator can observe the second element i of any signal η, the initial free signal creates a continuum of types of each party. Second, though evidence collection before trial is strategic, evidence collection before arbitration depends only on the party's own signal. So that a party's forecast of her investment in court is not uncertain (as it does not depend on the other party's type) but her expected outcome at trial is (since this will depend on the other party's investment in evidence collection). Nonetheless, each party's settlement strategy $b_j^A\left(\eta_j^0\right)$ will be a bid function. Without loss of generality, we can make the parties' bid function only depend on the index i, since the parties know x and hence for them the sign s is redundant (while it is informative for a judge): hence we will write $b_j^A\left(i_j^0\right)$. This simplifies notation. From Lemma 2A we know that party j's bid function will depend on the final $\hat{i_j}$ after the receipt of which she stops collecting evidence. Third, the size of the arbitration fee determines the nature of the equilibrium that is realized. When the fee f is sufficiently small, arbitration is both inexpensive and accurate; consequently the parties always arbitrate. But when f is sufficiently high, the parties always settle. For intermediate f some parties settle and some litigate depending on the indexes i_j^0 of the free signals η_j^0 drawn by the parties at time 0.

Theorem 1A summarizes our results:

Theorem 1A. *Under arbitration,*

(a) *The parties use the bid functions*

$$b_{\Pi}^A\left(i_{\Pi}^0\right) = \begin{cases} \frac{1}{3}(2-3f+x)+\frac{2}{3}i_{\Pi}^* & \text{if} \quad i_{\Pi}^0 > x \\ \frac{1}{3}(2-3f+x)+\frac{2}{3}i_{\Pi} & \text{if} \quad i_{\Pi}^* \leq i_{\Pi}^0 \leq x \\ \frac{1}{3}(2-3f+x)+\frac{2}{3}i_{\Pi}^* & \text{if} \quad i_{\Pi}^0 < i_{\Pi}^* \end{cases} \tag{6}$$

$$\text{truncated above at} \quad \overline{b}_{\Pi}^A \equiv b_{\Delta}^A\left(i_{\Delta}^*\right)$$
$$\text{and below at} \quad \underline{b}_{\Pi}^A \equiv b_{\Delta}^A\left(x\right)$$

and

$$b_{\Delta}^A\left(i_{\Delta}^0\right) = \begin{cases} \frac{1}{3}(3f-2+x)+\frac{2}{3}i_{\Delta}^* & \text{if} \quad i_{\Delta}^0 > i_{\Delta}^* \\ \frac{1}{3}(3f-2+x)+\frac{2}{3}i_{\Delta} & \text{if} \quad x \leq i_{\Delta}^0 \leq i_{\Delta}^* \\ \frac{1}{3}(3f-2+x)+\frac{2}{3}i_{\Delta}^* & \text{if} \quad i_{\Delta}^0 < x \end{cases} \tag{7}$$

$$\text{truncated above at} \quad \overline{b}_{\Delta}^A \equiv b_{\Pi}^A\left(x\right)$$
$$\text{and below at} \quad \underline{b}_{\Delta}^A \equiv b_{\Pi}^A\left(i_{\Pi}^*\right)$$

(b) *The following table 6 identifies the conditions on the size of the arbitration fee and the parties' costs of evidence collection that determine the nature of the equilibrium:*

Table 6: Settlement equilibria with arbitration

Case	Description	Conditions for the equilibrium	Probability of litigation
1A	Full settlement	$f \geq \frac{2}{3}$	0
2A	Defendants with a signal may litigate with plaintiffs with a signal, other types settle	$f < \frac{2}{3}$ $f \geq \max\left\{\frac{1}{3}\left(2-\chi_\Pi\right), \frac{1}{3}\left(2-\chi_\Delta\right)\right\}$	$\frac{(2-3f)^2}{2}$
3A	Defendants without a signal settle Defendants with a signal may litigate	$f < \frac{1}{3}\left(2-\chi_\Pi\right)$ $f \geq \frac{1}{3}\left(2-\chi_\Delta\right)$	$2-3f-\chi_\Pi+\frac{1}{2}\chi_\Pi^2$
4A	Plaintiffs with a signal may litigate Plaintiffs without a signal settle	$f < \frac{1}{3}\left(2-\chi_\Delta\right)$ $f \geq \frac{1}{3}\left(2-\chi_\Pi\right)$	$2-3f-\chi_\Delta+\frac{1}{2}\chi_\Delta^2$
5A	Defendants without a signal settle with plaintiffs without a signal, other types may litigate	$f < \min\left\{\frac{1}{3}\left(2-\chi_\Pi\right), \frac{1}{3}\left(2-\chi_\Delta\right)\right\}$ $f \geq \frac{1}{3}\left(2-\chi_\Pi-\chi_\Delta\right)$	$(2-3f)\left(1+\frac{3}{2}f\right)-\left(\chi_\Pi+\chi_\Delta\right)+\frac{1}{2}\left(\chi_\Pi^2+\chi_\Delta^2\right)$
6A	Full litigation	$f < \frac{1}{3}\left(2-\chi_\Pi-\chi_\Delta\right)$	1

and recall that

$$\begin{array}{lll}\chi_\Pi & \equiv & \min\left\{x, 2\sqrt{k_\Pi}\right\} \quad \textit{(probability that the plaintiff has a favorable free signal)} \\ \chi_\Delta & \equiv & \min\left\{1-x, 2\sqrt{k_\Delta}\right\} \quad \textit{(probability that the defendant has a favorable free signal)}\end{array} \tag{8}$$

Comment 1: The bid functions are parallel to each other and have intercepts that are symmetric around x.

Comment 2: Note that the condition on f for full litigation is always less than or equal to $\frac{1}{3}$.

Comment 3: We have the following comparative statics:

- If the arbitration fee f increases the bids move closer to each other, increasing the settlement rate.
- If x increases both bids increase and the three cutoff points (i^*_Π, x, i^*_Δ) move to the right while keeping their relative distances unaltered. The settlement rate does not change.
- If k_Π increases, i^*_Π decreases and the demand of a plaintiff without a signal decreases; if k_Δ increases, i^*_Δ increases and the offer of a defendant without a signal increases. In both cases the settlement rate increases.

Figure provides an example of how the parties' bids.

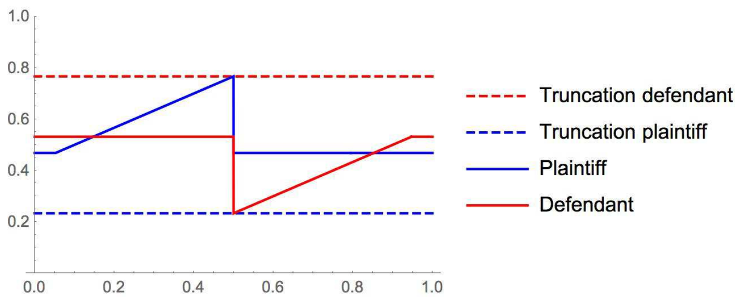


Figure 5: Parties' bids when $f \geq \max\left\{\frac{1}{3}(2-\chi_\Pi), \frac{1}{3}(2-\chi_\Delta)\right\}$.

5 Ex ante costs of dispute resolution

Here we calculate the expected payoffs that arise from the contract decision at time -1. The parties will include an arbitration clause in their contract if the payoff from the arbitration clause is positive and otherwise if it is negative. The payoff deriving from the arbitration clause is simply the difference between the ex ante payoff of resolving future disputes before an arbitrator (and paying f if settlement fails) and resolving future disputes before a jury.

Since at the contracting stage the parties are interested in their joint payoffs (as they can make side-payments through adjusting the price of the contract), we need not examine how the relevant payoffs are shared among the parties. The award at the litigation stage and the settlement amount are transfers; we are thus interested only in the total costs of each system: the expected costs of acquiring evidence (accounting for the probability of settlement failure) and the fee (which is positive in arbitration and is normalized to zero with a jury).

5.1 Ex ante cost of jury trial

In Section 3 we have shown that the expected evidence collection costs are:

		Defendant	
		Signal ($s_\Delta^0 = -1$)	No signal ($s_\Delta^0 = 1$)
Plaintiff	Signal ($s_\Pi^0 = 1$)	$\left((\sigma_\Pi^* - 1)\frac{k_\Pi}{x}, (\sigma_\Delta^* - 1)\frac{k_\Delta}{1-x}\right)$	$\left(\frac{\sigma_\Pi^* k_\Pi}{x}, (\sigma_\Delta^* - 1)\frac{k_\Delta}{1-x}\right)$
	No signal ($s_\Pi^0 = -1$)	$\left((\sigma_\Pi^* - 1)\frac{k_\Pi}{x}, \frac{\sigma_\Delta^* k_\Delta}{1-x}\right)$	$\left(\frac{\sigma_\Pi^* k_\Pi}{x}, \frac{\sigma_\Delta^* k_\Delta}{1-x}\right)$

Table 7: Evidence collection costs in a jury trial (Π, Δ)

Recalling that the plaintiff has a favorable signal with probability x, while the defendant has a favorable signal with probability $1-x$, we have the following cases (Table 8):

Table 8: Ex ante costs of jury trials

Description	Ex ante costs of jury trials
Defendants with a signal litigate with plaintiffs with a signal, other types settle	$x\left(1-x\right)\left(\frac{\sigma^*_\Pi k_\Pi}{x}-\frac{k_\Pi}{x}\right)+x\left(1-x\right)\left(\frac{\sigma^*_\Delta k_\Delta}{1-x}-\frac{k_\Delta}{1-x}\right)$
Defendants without a signal settle Defendants with a signal litigate	$\left(1-x\right)\left(\frac{\sigma^*_\Delta k_\Delta}{1-x}-\frac{k_\Delta}{1-x}\right)+\left(1-x\right)\left(x\left(\frac{\sigma^*_\Pi k_\Pi}{x}-\frac{k_\Pi}{x}\right)+\left(1-x\right)\frac{\sigma^*_\Pi k_\Pi}{x}\right)$
Plaintiffs with a signal litigate Plaintiffs without a signal settle	$x\left(\frac{\sigma^*_\Pi k_\Pi}{x}-\frac{k_\Pi}{x}\right)+x\left(x\frac{\sigma^*_\Delta k_\Delta}{1-x}+\left(1-x\right)\left(\frac{\sigma^*_\Delta k_\Delta}{1-x}-\frac{k_\Delta}{1-x}\right)\right)$
Defendants without a signal settle with plaintiffs without a signal, other types litigate	$x\left(\frac{\sigma^*_\Pi k_\Pi}{x}-\frac{k_\Pi}{x}\right)+\left(1-x\right)^2\frac{\sigma^*_\Pi k_\Pi}{x}+\left(1-x\right)\left(\frac{\sigma^*_\Delta k_\Delta}{1-x}-\frac{k_\Delta}{1-x}\right)+x^2\frac{\sigma^*_\Delta k_\Delta}{1-x}$

Simplifying the expressions, and recalling that $\frac{\sigma^*_\Pi k_\Pi}{x}+\frac{\sigma^*_\Delta k_\Delta}{1-x}=\Psi$ we can summarize the ex ante costs of a jury trial in Table 9.

Table 9: Ex ante costs of jury trials

Case	Description	Conditions for the equilibrium	Ex ante costs of jury trials
1T	Full settlement	$\frac{k_\Pi}{x} + \frac{k_\Delta}{1-x} \leq \Psi$	0
2T	Defendants with a signal litigate with plaintiffs with a signal, other types settle	$\begin{cases} \frac{k_\Pi}{x} + \frac{k_\Delta}{1-x} > \Psi \\ \frac{k_\Pi}{x} \leq \Psi \\ \frac{k_\Delta}{1-x} \leq \Psi \end{cases}$	$x\left(1-x\right)\Psi - xk_\Delta - \left(1-x\right)k_\Pi$
3T	Defendants without a signal settle Defendants with a signal litigate	$\begin{cases} \frac{k_\Pi}{x} \leq \Psi \\ \frac{k_\Delta}{1-x} > \Psi \end{cases}$	$\left(1-x\right)\Psi - k_\Delta - \left(1-x\right)k_\Pi$
4T	Plaintiffs with a signal litigate Plaintiffs without a signal settle	$\begin{cases} \frac{k_\Pi}{x} > \Psi \\ \frac{k_\Delta}{1-x} \leq \Psi \end{cases}$	$x\Psi - xk_\Delta - k_\Pi$
5T	Defendants without a signal settle with plaintiffs without a signal, other types litigate	$\begin{cases} \frac{k_\Pi}{x} > \Psi \\ \frac{k_\Delta}{1-x} > \Psi \end{cases}$	$\left(1-x+x^2\right)\Psi - k_\Delta - k_\Pi$
6T	Full litigation	Never	

5.2 Ex ante cost of arbitration

The ex ante costs of arbitration consist of two components: the arbitration fee f and the parties' expected costs of evidence collection, which we can rewrite in terms of the parties' probability of having a signal, in line with the case of jury trial:

$$\begin{cases} \frac{k_\Pi}{x-i^*_\Pi} & = & \frac{k_\Pi}{\chi_\Pi} & \text{(plaintiff)} \\ \frac{k_\Delta}{i^*_\Delta - x} & = & \frac{k_\Delta}{\chi_\Delta} & \text{(defendant)} \end{cases}$$

Recall that only parties without a favorable signal invest in evidence collection in arbitration. Table 10 depicts the case in which both parties have low collection costs. Parties with high collection costs never collect a new signal (which is a degenerate version of the general case and need not be considered separately).

		Defendant: Signal ($i^0_\Delta \in [x, i^*_\Delta]$)	Defendant: No signal ($i^0_\Delta \notin [x, i^*_\Delta]$)
Plaintiff	Signal ($i^0_\Pi \in [i^*_\Pi, x]$)	$(0, 0)$	$\left(0, \frac{k_\Delta}{\chi_\Delta}\right)$
Plaintiff	No signal ($i^0_\Pi \notin [i^*_\Pi, x]$)	$\left(\frac{k_\Pi}{\chi_\Pi}, 0\right)$	$\left(\frac{k_\Pi}{\chi_\Pi}, \frac{k_\Delta}{\chi_\Delta}\right)$

Table 10: Evidence collection costs in arbitration when collection costs are low, $k_\Pi \leq \frac{x^2}{4}$ and $k_\Delta \leq \frac{(1-x)^2}{4}$ (Π, Δ)

While the cost f is paid by the parties whenever there is litigation—and hence to obtain the expected costs we simply need to multiply the probability of litigation in each case by f—the evidence collection costs are paid only by the parties without a signal. In Table 11 we report the ex ante costs of arbitration. The table is easy to interpret. If there is full settlement the costs are zero (Case 1A). When litigation concerns only parties with a signal, the only cost is the arbitration fee f (Case 2A). In the other cases, the probability of litigation multiplies f to obtain the expected arbitration fee but there is also another component of the total cost: the parties' evidence collection cost. When defendants only litigate if they have a signal, evidence collection costs can be borne only by plaintiffs (Case 3A): the second addendum of the total costs is the evidence collection cost of the plaintiff, $\frac{k_\Pi}{\chi_\Pi}$, multiplied by the probability that litigation involves a plaintiff without a signal, $(2 - 3f - \chi_\Pi)(1 - \chi_\Pi)$. The opposite happens when plaintiffs only litigate if they have a signal (Case 4A). If settlement occurs only between two parties without a signal, a party without a signal might end up in litigation if the counterpart has a signal and hence the total cost of arbitration needs to consider the evidence collection costs of both parties multiplied by the probability that a party without a signal is involved in litigation (Case 5A). Finally (Case 6A), if there is full litigation, the arbitration fee f is paid with certainty and the parties bear their evidence collection costs whenever they do not have a signal (sixth line).

Table 11: Ex ante costs of arbitration

Case	Description	Conditions for the equilibrium	Ex ante cost of arbitration
1A	Full settlement	$f \geq \frac{2}{3}$	0
2A	Defendants with a signal may litigate with plaintiffs with a signal, other types settle	$f < \frac{2}{3}$ $f \geq \max\left\{\frac{1}{3}(2-\chi_\Pi), \frac{1}{3}(2-\chi_\Delta)\right\}$	$\frac{(2-3f)^2}{2} f$
3A	Defendants without a signal settle Defendants with a signal may litigate	$f < \frac{1}{3}(2-\chi_\Pi)$ $f \geq \frac{1}{3}(2-\chi_\Delta)$	$\left(2-3f-\chi_\Pi+\frac{1}{2}\chi_\Pi^2\right) f + (2-3f-\chi_\Pi)(1-\chi_\Pi)\frac{k_\Pi}{\chi_\Pi}$
4A	Plaintiffs with a signal may litigate Plaintiffs without a signal settle	$f < \frac{1}{3}(2-\chi_\Delta)$ $f \geq \frac{1}{3}(2-\chi_\Pi)$	$\left(2-3f-\chi_\Delta+\frac{1}{2}\chi_\Delta^2\right) f + (2-3f-\chi_\Delta)(1-\chi_\Delta)\frac{k_\Delta}{\chi_\Delta}$
5A	Defendants without a signal settle with plaintiffs without a signal, other types may litigate	$f < \min\left\{\frac{1}{3}(2-\chi_\Pi), \frac{1}{3}(2-\chi_\Delta)\right\}$ $f \geq \frac{1}{3}(2-\chi_\Pi-\chi_\Delta)$	$\left[(2-3f)\left(1+\frac{3}{2}f\right)-(\chi_\Pi+\chi_\Delta)+\frac{1}{2}\left(\chi_\Pi^2+\chi_\Delta^2\right)\right] f +$ $(2-3f-\chi_\Delta)(1-\chi_\Delta)\frac{k_\Delta}{\chi_\Delta}+(2-3f-\chi_\Pi)(1-\chi_\Pi)\frac{k_\Pi}{\chi_\Pi}$
6A	Full litigation	$f < \frac{1}{3}(2-\chi_\Pi-\chi_\Delta)$	$(1-\chi_\Pi)\frac{k_\Pi}{\chi_\Pi}+(1-\chi_\Delta)\frac{k_\Delta}{\chi_\Delta}+f$

5.3 Comparison of ex ante costs

Comparing the costs of jury trial and arbitration ex ante in Figures 6 and 7, we see that jury trial yields lower ex ante costs. Most commonly, case tried in front of a jury settle and hence yield no costs ex post. In case of arbitration, instead, settlement depends chiefly on the magnitude of the arbitration fee. If the fee is zero or low all cases litigate (Figures 6). If the fee is substantial, some cases settle and, namely, those in the middle of the distribution (Figure 7). To induce some settlement, however, the fee increases the expected cost of both settled and litigated case, yielding again higher costs than jury trial.

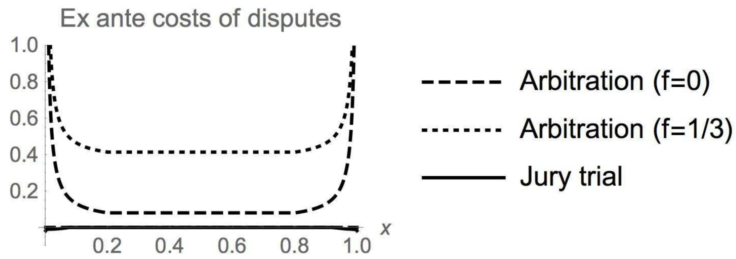


Figure 6: Ex post costs of evidence collection with $k_\Pi = k_\Delta = .01$

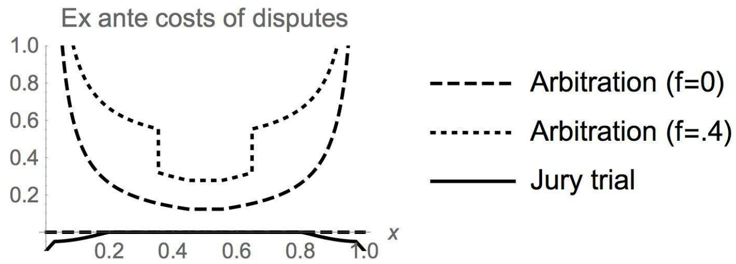


Figure 7: Ex post costs of evidence collection with $k_\Pi = k_\Delta = .05$

References

[1] D. Friedman and D. Wittman. Litigation with Symmetric Bargaining and Two-Sided Incomplete Information. *Journal of Law, Economics, and Organization*, 23(1):98–126, aug 2007.