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Amy Farmer and Paul Pecorino

ABSTRACT

We consider models of pretrial negotiations where both costly voluntary disclosure and costly mandatory discovery are possible. When the uninformed party makes the final offer (the screening game), mandatory discovery will be utilized if it is not very costly, but voluntary disclosure will not occur in the absence of a discovery procedure. When the informed party makes the final offer (the signaling game), mandatory discovery is never utilized, but voluntary disclosure will be utilized if it is not too costly to do so. Thus, mandatory discovery is effective in the information structure under which voluntary disclosure is not and vice versa. The results suggest that, taken together, the two institutions will lead to a great deal of information revelation and will significantly increase the probability of settlement.

1. INTRODUCTION

Asymmetric information is a leading explanation for bilateral bargaining failure that results in a costly dispute such as a trial or strike. Institutions that facilitate the transfer of information between the parties to the dispute have the potential to reduce dispute rates and the associated costs. In the case of civil litigation, one such institution is mandatory discovery. However, mandatory discovery can be costly, and there has been some question in the literature as to whether it is really necessary, given the ability of parties to a dispute to engage in voluntary disclosures.

In this paper, we develop both a screening game (Bebchuk 1984) and

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a signaling game (Reinganum and Wilde 1986) in which costly mandatory discovery and costly voluntary disclosure are both available to the parties to the dispute. We find that mandatory discovery and voluntary disclosure are complementary in the following sense: mandatory discovery tends to be effective under the information structure in which voluntary disclosure is ineffective and vice versa. In particular, mandatory discovery is utilized in the screening game, provided it is not too costly to do so. By contrast, in the absence of discovery, costly voluntary disclosures are never made in the screening game. In the signaling game, however, there is the potential for a significant amount of voluntary disclosure to take place, provided it is not very costly to do so. However, a costly mandatory discovery procedure is never invoked in the signaling game.

Mandatory discovery has been controversial because its use may be subject to abuse. The cost of responding to a discovery request is not borne by the party making the request (see the discussion in Cooter and Rubinfeld 1994, pp. 435–37). Our model does not address the issue of discovery abuse, but it does suggest an important role for discovery in reducing the incidence of disputes. In particular, if the screening game describes a significant proportion of disputes, then the existence of a mandatory discovery mechanism may lead to a very large reduction in the number of disputes that proceed to trial. A complete welfare analysis of the institution is beyond the scope of this paper as it would require modeling the effects of discovery on incentives for care in preventing (for example) accidents. We do analyze the welfare effects on the two parties to the dispute. While the effects of discovery ultimately depend on parameter values, if the costs of discovery to both parties are low relative to the cost of a trial and if a large number of trials would occur in the absence of discovery, then the institution will reduce total dispute costs (that is, be welfare enhancing) for the plaintiff and defendant.

In addition to shedding some light on the value of mandatory discovery, our analysis may prove useful in the design of alternative dispute resolution mechanisms. Arbitration is an increasingly important substitute for the courts. An important question in designing alternative dispute resolution mechanisms is whether to include a costly discovery procedure. Our analysis suggests that voluntary disclosure will not occur under all information structures and that the inclusion of mandatory discovery may be important if increasing the number of negotiated settlements is an important goal.

2. RELATIONSHIP TO THE PREVIOUS LITERATURE

Our work is in line with that of Shavell (1989) and Sobel (1989).[1] Shavell develops a screening model with an informed plaintiff and costless voluntary disclosure of private information. In his model, plaintiffs can take on a continuum of types. When information can be credibly transmitted, he finds an equilibrium under which there are no trials; plaintiffs with strong cases reveal their type, while plaintiffs with weak cases remain silent and receive a pooling offer that all accept. Shavell also considers costless discovery in the model with credible information transmission. Discovery does not reduce the probability of trial (since this is zero anyway), but it does reduce the expected payment by the defendant to the plaintiff, as the defendant is able to tailor his offers to the plaintiff's exact type.

Sobel (1989) considers a model with two-sided asymmetric information; plaintiffs and defendants may each take on one of two types. Sobel shows that costly voluntary disclosure will not take place if the opposing party makes the final offer. For example, if the plaintiff reveals her type but the defendant makes the final offer, the defendant will gain all of the benefits from settlement through this final offer. Thus, there is no benefit to the plaintiff from revealing her type, and with positive costs of disclosure, she strictly prefers to remain silent. As a consequence, if disclosure were costly in the Shavell model, it would not take place. Sobel also considers a mandatory discovery procedure in which the defendant's type is revealed to the plaintiff and a cost is imposed on the defendant in the process. Since the procedure imposes no costs on the plaintiff, it is automatically invoked.

Our work is related to the previous work of Shavell and Sobel, but it differs in some important ways. First, we separately consider a screening model and a signaling model. In both cases, we assume the plaintiff is the informed party, but this is not a critical assumption. That is, the results for the screening game would be very similar if the model were set up with an informed defendant (and the plaintiff made the offer), and the same is true of the signaling game. In addition, both voluntary disclosure and mandatory discovery are included in each of the models.

1. There is a very large literature on the revelation of private information outside the context of litigation. A partial list includes the following: Shavell (1994), Okuno-Fujiwara, Postlewaite, and Suzumura (1990), Farrell (1986), Milgrom and Roberts (1986), and Milgrom (1981). Within the law and economics literature see, among others, Lewis and Poitevin (1997) and Bebchuk and Shavell (1991).

Finally, we incorporate costs into both procedures.[2] Voluntary disclosure imposes a cost on the party making the disclosure, and, as a result, in the screening game voluntary disclosure will never take place in the absence of a discovery procedure. Mandatory discovery imposes a cost both on the party making the discovery request and on the party receiving the request. Thus, in contrast to Sobel's model, discovery will not always be invoked and there is an information structure in which a costly voluntary disclosure will be made.

In the wake of the papers by Shavell and Sobel, several authors have modeled the discovery process. Cooter and Rubinfeld (1994) develop a model of discovery in which plaintiffs and defendants have subjective beliefs about the outcome at trial. Settlement occurs if a contract zone exists, while a trial occurs when the contract zone fails to exist. The effect of discovery depends on how it changes the distribution of beliefs of the two parties to the dispute. In this context, discovery can either raise or lower the probability of trial depending on whether it makes the litigants more or less optimistic about the outcome. Cooter and Rubinfeld also analyze the possible abuse of discovery, which can occur because the party requesting discovery is not forced to internalize all associated costs.

The effects of discovery are fairly wide ranging, and several authors have explored alternative aspects of the procedure. Hay (1994) develops a model of discovery that incorporates care on the part of the defendant. Thus, he is able to link the value of discovery back to the incentives for defendant care. Mnookin and Wilson (1998) use mechanism design to model discovery with two-sided informational asymmetry. In their model, discovery is treated as a sampling process through which the party that is conducting discovery can form an updated expectation of the other party's private information. Among their findings are that discovery increases settlement and that the parties to the dispute can agree on an ex ante efficient plan of discovery.

Schrag (1999) focuses on the role of the judge in limiting discovery. Each party's payoff at trial is a function of the level of resources devoted to discovery. He finds that discovery may discourage early settlement

2. Daughety and Reinganum (1993) develops a model with two plaintiff types (high and low damages) under a variety of assumptions about the information structure. While they do not model it as mandatory discovery per se, they do consider the role of costly information acquisition in this model (in particular, see pp. 333–34). Watts (1994) develops a model with three players (defendant, plaintiff, and plaintiff's attorney), where the plaintiff's attorney engages in costly information acquisition.

but that the judge can, by limiting discovery, both increase the probability of an early settlement and reduce litigation costs.

We follow Shavell and Sobel by modeling discovery in a fairly simple way: once discovery is invoked, the plaintiff's private information becomes known to the defendant. It would be very straightforward to extend our analysis such that discovery is only successful with some probability. By keeping the modeling of discovery simple, we are able to fully analyze the underlying incentives to use both costly discovery and costly voluntary disclosure in the two basic models of pretrial settlement. This allows us to show how these two institutions complement one another in facilitating the flow of information between the plaintiff and defendant. Future extensions of this work could include incorporating some of the more detailed features of the work discussed above.

3. THE SCREENING MODEL

The screening model is closely based on Bebchuk (1984). Assume that the plaintiff knows the true level of damages and therefore knows the judgment, J, that will be awarded to her if she wins at trial. The value of J is known only by the plaintiff and defines her type. The defendant knows the distribution $f(J)$ from which the plaintiff's type is drawn, where $J \in [\underline{J}, \bar{J}]$, and $F(J)$ is the cumulative density function associated with $f(J)$. Prior to any offers being made, the plaintiff will have an opportunity to voluntarily reveal her information to the defendant at a cost C_P^V. If she reveals her type, J, it becomes known with certainty to the defendant. If she does not reveal her type, the defendant may then invoke a mandatory discovery procedure at a cost C_D^M to himself and a cost C_P^M to the plaintiff. If mandatory discovery is invoked, the plaintiff's type again becomes known with certainty. Whether or not information transmission occurs, the defendant will have an opportunity to make a single take-it-or-leave-it offer to the plaintiff. If this offer is rejected, trial ensues. The probability of a finding for the plaintiff is p, which is common knowledge. If a trial occurs, the plaintiff and the defendant incur, respectively, the costs C_P^T and C_D^T. As in Bebchuk (1984), we will assume that the plaintiff is willing to proceed to trial, even if she has the weakest possible case. Specifically, $p\underline{J} - C_P^T > 0$.[3]

3. Thus, we avoid the credibility issues raised in Nalebuff (1987).

3.1. The Structure of the Game

The game can be summarized in the following steps:

0. Nature determines the plaintiff's type J. The plaintiff knows J, but only the defendant knows the distribution $f(J)$ from which it is drawn. The probability p that the plaintiff will prevail at trial is common knowledge.
1. The plaintiff decides whether or not to make a credible voluntarily disclosure of her type at a cost C_P^V.
2. The defendant decides whether or not to invoke mandatory discovery at a cost C_D^M to himself and a cost C_P^M to the plaintiff.
3. The defendant makes an offer O_D to the plaintiff.
4. The plaintiff accepts or rejects the offer. If the offer is accepted, the game ends with the plaintiff receiving a payoff of O_D and the defendant receiving a payoff of $-O_D$.
5. If the offer is rejected, trial occurs. With probability p, there is a finding for the plaintiff at trial, in which case her payoff is $J - C_P^T$ and the defendant's payoff is $-(J + C_D^T)$. With probability $1 - p$, there is a finding for the defendant, in which case the plaintiff's payoff is $-C_P^T$ and the defendant's payoff is $-C_D^T$.

The plaintiff and defendant are both assumed to be risk neutral. Note that the payoffs in steps 4 and 5 are modified by the costs specified in steps 1 and 2 if voluntary disclosure or mandatory discovery is invoked.

3.2. Analysis of Each Stage of the Game

3.2.1. Stage 4: Plaintiff Accepts or Rejects the Offer. Solving the game requires a determination of which plaintiff types will accept a given offer. Since a plaintiff of type J expects to receive $pJ - C_P^T$ at trial, she will accept an offer if and only if $J \leq (O_D + C_P)/p$. Let this expression hold with equality to obtain

$$J^* = \frac{O_D + C_P^T}{p}, \tag{1}$$

where J^* is the borderline plaintiff. All plaintiff types $J \leq J^*$ will accept the offer O_D, and all types $J > J^*$ will reject the offer.

3.2.2. Stage 3: The Defendant's Optimal Offer. The defendant's optimal offer depends on whether or not he has learned the plaintiff's type in a previous stage of the game. If the defendant knows the plaintiff's type J, he will make the lowest offer acceptable to that type as follows:

$$O_D = pJ - C_P^T. \tag{2}$$

If the plaintiff's type is not known, the defendant will make an offer that is optimal, given the entire distribution of plaintiff types. An offer O_D will be accepted with probability $F(J^*)$, where J^* is determined as in equation (1). We can write the defendant's objective function as

$$E\pi_D^N = -F(J^*)O_D - [1 - F(J^*)]\left[C_D^T + \frac{p\int_{J^*}^{\bar{J}} Jf(J)dJ}{1 - F(J^*)}\right], \tag{3}$$

where the superscript N is used to indicate that a nondisclosure of information has taken place.

The defendant chooses O_D to maximize equation (3), while noting the dependence of J^* on O_D from equation (1). The first term in equation (3) represents the probability that the offer is accepted multiplied by the cost of the settlement, O_D. The second term is the probability that an offer is rejected multiplied by the expected value of a trial conditional on the offer being rejected. If a trial occurs, the defendant must pay his own costs C_D^T and will receive an expected judgment, which is conditioned on the fact that only plaintiffs of type $J > J^*$ will have rejected the original offer.

Making use of equations (1) and (2), the first- and second-order conditions from the maximization of equation (3) may be rearranged to obtain

$$F(J^*) = (C_P^T + C_D^T)\frac{f(J^*)}{p} \tag{4a}$$

and

$$f(J^*)p - f'(J^*)(C_P^T + C_D^T) > 0. \tag{4b}$$

We assume throughout that equations (4a) and (4b) are satisfied at an interior maximum. The optimal offer can be found from equation (1) after solving equation (4a) for J^*. Under this offer, the defendant expects to pay

$$E\pi_D^N = -F(J^*)(pJ^* - C_P^T) - \int_{J^*}^{\bar{J}} (pJ + C_D^T)f(J)dJ. \tag{5}$$

The borderline plaintiff receives an offer that (by definition) leaves her indifferent between settlement and trial, but all plaintiffs $J < J^*$ receive an offer that is more than the minimum they require for settlement. On the other hand, the defendant saves his court costs for all $J < J^*$ and is also able to extract the plaintiff's court costs. For plaintiffs who proceed to trial, the defendant pays the plaintiff exactly what her case is worth (in expected value) but loses (relative to the cases that settle) the sum of the court costs $C_D^T + C_P^T$. The incentive to use mandatory discovery is determined by the "overpayments" to the low-damages plaintiff types and the lost court costs for the high-damages plaintiff types who do not settle.

3.2.3. Stage 2: Mandatory Discovery. Since mandatory discovery is costly, it should be clear that the defendant will never utilize this procedure if the plaintiff has voluntarily revealed her type at stage 1. If the plaintiff does not reveal her type at stage 1, then the defendant's payoff in the absence of mandatory discovery is given by equation (5). With mandatory discovery, the defendant incurs the cost C_D^M and makes each plaintiff type the offer in equation (2). As a result, the defendant's expected payoff from utilizing discovery is

$$E\pi_D^M = -C_D^M - \int_{\underline{J}}^{\bar{J}} (pJ - C_P^T) f(J) dJ. \tag{6}$$

If the plaintiff does not voluntarily reveal her type, the defendant will choose mandatory discovery if the expected payoff in equation (6) is greater than the expected payoff in equation (5). This condition may be expressed as follows:

$$p\left[\int_{\underline{J}}^{J^*} (J^* - J) f(J) dJ\right] + (C_P^T + C_D^T)[1 - F(J^*)] \geq C_D^M. \tag{7}$$

The right-hand side of equation (7) is simply the cost to the defendant of utilizing mandatory discovery. The left-hand side is the value of the information gained via mandatory discovery. The use of mandatory discovery leads to a savings for the defendant for all plaintiff types (except $J = J^*$). This includes the reduction in the offer by the amount $J^* - J$ to plaintiffs who previously settled. This gain occurs because the defendant can tailor the offer to the plaintiff's type exactly, whereas before he made a single offer that left some surplus to plaintiffs $J < J^*$. The second term is the sum of the court costs, $C_P^T + C_D^T$, times the probability of trial in the absence of discovery. This gain is obtained by the defendant, as all cases settle when discovery is used.

The value of information to the defendant is potentially large. For example, suppose that half of all cases will end in trial in the absence of mandatory discovery. In this case, $.5(C_P^T + C_D^T)$ is a lower bound on the value of the information gained. Unless C_D^M is very large, the inequality in equation (7) is very likely to hold.

3.2.4. Stage 1: Voluntary Disclosure. If the plaintiff chooses to disclose her type, she incurs the cost and will receive the offer in equation (2). As a result, her payoff will be

$$E\pi_P^V = pJ - C_P^T - C_P^V. \tag{8}$$

If the plaintiff does not reveal her type, but the defendant invokes mandatory disclosure, then her payoff is

$$E\pi_P^M = pJ - C_P^T - C_P^M. \tag{9}$$

In the absence of either voluntary disclosure or mandatory discovery, the plaintiff's payoff is

$$E\pi_P^N = pJ^* - C_P^T, \quad \forall J \le J^* \tag{10a}$$

or

$$E\pi_P^N = pJ - C_P^T, \quad \forall J > J^*, \tag{10b}$$

Note that for all plaintiff types, the payoff in equations (10a) and (10b) is higher than the corresponding payoff in equation (8). Thus, if the defendant would not choose mandatory discovery at stage 2, then the plaintiff will not choose voluntary disclosure at stage 1. More generally, in the absence of a mandatory discovery procedure, the plaintiff will never voluntarily reveal her type in the screening model if it is costly to do so. Revealing her type gives no advantage to the plaintiff because the defendant extracts all of the joint surplus of settlement through his offer.

The result that, in the absence of mandatory discovery, the plaintiff never makes voluntary disclosures is clearly sensitive to the assumptions embedded in the bargaining model. If pretrial bargaining left the plaintiff a sufficient fraction of the joint surplus from settlement, then she would be willing to make a costly disclosure to the defendant.

3.3. Equilibrium

When the plaintiff's type is unknown, the defendant's behavior at stage 3 of the game is well understood. At the earlier stages of the game, the players must compare their payoffs both with and without a costly transmission of information. Equilibrium in the screening game will depend on the parameters of the model in the following way:

Proposition 1.

1.1. If the inequality in equation (7) does not hold, no information transmission occurs, and the defendant makes the offer implied by equation (4a). Trial occurs with probability $1 - F(J^*)$, where J^* is a function of the defendant's equilibrium offer.

1.2. If the inequality in equation (7) holds and the plaintiff's payoff in equation (8) is greater than in equation (9), the plaintiff voluntarily reveals her information, the defendant makes the offer $pJ - C_P^T$, and all cases settle.

1.3. If the inequality in equation (7) holds and the plaintiff's payoff in equation (8) is less than in equation (9), the plaintiff does not reveal her information, the defendant forces mandatory discovery and makes the offer $pJ - C_P^T$ to the plaintiff, and all cases settle.

Proof.

1.1. When equation (7) fails to hold, the defendant has a higher payoff without mandatory discovery. Since the payoff in equations (10a) and (10b) is always greater than in equation (8), the plaintiff will not use voluntary disclosure. The outcome of the game matches the outcome of the game without information transmission.

1.2. When equation (7) holds, the defendant will use mandatory discovery, unless the plaintiff discloses first. Since the payoff in equation (8) is greater than in equation (9), the plaintiff prefers costly disclosure to silence.

1.3. Since equation (7) holds, the defendant will force discovery in the absence of voluntary disclosure. Since the payoff in equation (9) is greater than in equation (8), the plaintiff prefers being forced into discovery to making a voluntary disclosure.

Part 1.2 of the proposition requires that we specify the defendant's out-of-equilibrium belief when the plaintiff is expected to reveal her type but does not. We assume the defendant simply maintains the prior distribution $f(J)$ as his belief.[4] As a result, it will be optimal for him to go forward with discovery if the plaintiff does not reveal her type when expected.

There may be some reason to think that in practice C_P^V is less than or equal to C_P^M. As a result, we may observe the use of voluntary disclosure as a method of avoiding the costs of mandatory discovery. It should be noted, however, that in the screening game, voluntary disclosure will not occur in the absence of a discovery mechanism.

Allowing a costless offer by the defendant prior to any opportunity for information exchange may have some minor effects on the results of the model but should not change their overall flavor. Suppose the defendant is allowed to make an offer prior to any opportunity for information exchange. If the inequality in equation (7) does not hold (that is, there is no credible threat to utilize discovery), standard arguments of sequential rationality will dictate that no settlement occurs at the early stage (see Spier 1992).[5] If the inequality in equation (7) holds, the defendant might be able to reach agreement with some of the low-damages plaintiff types who might be willing to settle early in order to avoid the costs associated with discovery.[6]

3.4. Welfare Effect on the Players

For the purpose of this subsection, we use reduced court costs as our measure of the joint welfare gain for the plaintiff and defendant that results from information transmission. A complete welfare analysis would include the effects on the incentives for care, but this is beyond

4. Recall that a perfect Bayesian equilibrium imposes very few restrictions on out-of-equilibrium beliefs. All plaintiffs stand to lose $C_P^M - C_P^V$ if they fail to voluntarily disclose when it is optimal for them to do so. Since all plaintiffs face the same disincentive for deviating from the equilibrium, it is reasonable for the defendant to maintain his prior beliefs on the plaintiff's type.

5. If offers were costly (as in Spier 1992), there would be some early settlement. When offers are costless, any early settlement will cause the defendant's offer to rise in the last period because he faces a truncated distribution of plaintiffs. This, in turn, would force up the initial offer. The defendant is better off with no settlement in the early period so that he can commit to a low offer in the final period.

6. Presumably, such an early offer by the defendant would be acceptable to only a small number of plaintiffs. If the defendant waits, he can learn the plaintiff's identity and make an offer tailored to her type. In addition, if too many plaintiffs settle early, it will no longer be sequentially rational to incur the costs of discovery (in which case, plaintiffs settling early will not take less). Set off against this is the willingness of plaintiffs to settle for less early, as they can avoid the costs of complying with discovery.

the scope of this paper. It is possible that reduced court costs can lower social welfare by reducing incentives for care.[7]

In the absence of a credible threat to use discovery by the defendant, the plaintiff never voluntarily discloses because she bears all the costs of disclosure and receives none of the benefits that accrue from increased settlement. When the defendant has a credible threat to use discovery, the plaintiff may use disclosure to preempt its use, and this may reduce the social costs associated with discovery. The plaintiff's gain from this preemptive use of disclosure is $C_P^M - C_P^V$, while the gain to the defendant and plaintiff as a pair is $C_P^M + C_D^M - C_P^V$. Clearly, the plaintiff has an incentive to underutilize voluntary disclosure.

The defendant's incentive to utilize discovery deviates from the group incentive for two reasons. The left-hand side of equation (7) includes two terms, the second of which reflects reduced court costs resulting from the use of discovery. However, the first term $p[\int_{\underline{J}}^{J^*}(J^* - J)f(J)dJ]$ reflects a transfer from the plaintiff to the defendant resulting from the use of discovery. The defendant achieves this transfer by being better able to tailor offers to the plaintiff's type after mandatory discovery has occurred. This gain is included in the defendant's private benefit from using mandatory discovery, but not the benefit to the defendant and plaintiff as pair. The second reason for a divergence between private and group incentives is related to cost. The right-hand side of equation (7) provides the defendant's cost of discovery C_D^M, but the group cost is $C_D^M + C_P^M$ if voluntary disclosure is not utilized by the plaintiff. If voluntary disclosure is utilized, the group cost is only C_P^V.

The relationship between the joint welfare of the players (as measured by court costs) and the equilibrium of the model is summarized in proposition 2:

Proposition 2.

2.1. If the inequality in equation (7) does not hold and $(C_P^T + C_D^T)[1 - F(J^*)]$ is less than C_P^V, then no information transmission takes place and this is the efficient outcome.

2.2. If the inequality in equation (7) does not hold and $(C_P^T + C_D^T)[1 - F(J^*)]$ is greater than C_P^V, then no information transmission takes place and this is an inefficient outcome. The efficient outcome requires voluntary disclosure by the plaintiff.

7. This point is made by Polinsky and Rubinfeld (1988). In addition, discovery may affect the accuracy of the decision at trial. Addressing this issue is beyond the scope of our paper; see Hay (1994).

2.3. If the inequality in equation (7) holds and $(C_P^T + C_D^T)[1 - F(J^*)]$ is greater than $C_D^M + C_P^M$, then information transmission takes place and this is the efficient outcome.

2.4. If the inequality in equation (7) holds, C_P^V is greater than C_P^M, and $(C_P^T + C_D^T)[1 - F(J^*)]$ is less than $C_D^M + C_P^M$, then information transmission takes place and this is an inefficient outcome.

2.5. If the inequality in equation (7) holds, C_P^V is less than C_P^M, and $(C_P^T + C_D^T)[1 - F(J^*)]$ is less than C_P^V, then information transmission takes place and this is an inefficient outcome.

Proof. The gain from information transmission to the plaintiff and defendant as a pair is $(C_P^T + C_D^T)[1 - F(J^*)]$, while the cost is C_P^V if voluntary disclosure is used and $C_D^M + C_P^M$ if mandatory discovery is invoked. Combining this analysis with the results from proposition 1, it is quite tedious but very simple to show that the statements above are correct.

Note that the level of information transmission may be optimal, too high, or too low relative to the group optimum. Clearly, the institutions of voluntary disclosure and mandatory discovery will lower net costs when trials are frequent and costly in the absence of information transmission and when the costs of information transmission are low. Also note that while voluntary disclosure is never effective in the absence of a discovery procedure, when used in conjunction with such a procedure, it may help reduce the total costs of information transmission and the total costs associated with dispute resolution.

4. THE SIGNALING MODEL

The underlying signaling game follows directly from Reinganum and Wilde (1986). To this model, we add costly voluntary disclosure by the plaintiff and a costly mandatory discovery procedure that may be invoked by the defendant. The stages of this game are identical to those outlined above, with the following exceptions:

1′. With a probability $1 - \delta$, the plaintiff has the opportunity to decide whether to make a credible voluntarily disclosure of her type at the cost C_P^V. With a probability δ, the plaintiff is unable to make a credible disclosure.

3′. The plaintiff makes an offer O_P to the defendant.

4′. The defendant accepts or rejects the offer. If the offer is accepted, the game ends with the plaintiff receiving a payoff of O_P and the defendant receiving a payoff of $-O_P$.

We are allowing for a small probability δ that credible disclosure by the plaintiff is not possible. This assumption is serving a technical purpose, but we should note that Shavell (1989, p. 193) argues that this is in fact a reasonable assumption to make. Because some plaintiffs cannot reveal their information, all offers made in the standard signaling model (without mandatory discovery or voluntary disclosure) will be made with some probability in the equilibrium of the game with information transmission.[8] This allows us to determine (using Bayes's rule) the defendant's belief when disclosure does not occur but the corresponding offer is associated with a plaintiff type that was expected to make a voluntary disclosure.[9] This greatly simplifies that analysis of the model, but the assumption that δ is greater than zero does not drive our results. In Section 4.4, we will briefly discuss the nature of the model solution when δ equals zero, that is, when all plaintiffs can credibly establish their private information. Compared with the results when δ equals zero, the results when δ is greater than zero place a lower bound on the extent of voluntary disclosure that will occur in the signaling model.

As in the original Reinganum and Wilde (1986) model, we assume that pJ_L is greater than C_P^T, so that all plaintiffs have a credible threat to proceed to trial.[10] In the absence of information transmission via disclosure, multiple equilibria are possible in the signaling game. Reinganum and Wilde use the refinement arguments of Banks and Sobel (1987) to eliminate all but a separating equilibrium in which there is a one-to-one correspondence between the plaintiff's type and her offer. In what follows, we will focus on this separating equilibrium in the game where information transmission via disclosure does not occur.

8. Assume that expenditures on disclosure are not observable. Thus, plaintiffs who cannot credibly disclose their private information also cannot send a signal by incurring the associated cost. As a result, plaintiffs who cannot credibly disclose their private information will not incur the costs associated with disclosure.

9. Without this assumption, these offers would occur off the equilibrium path of the game. As a result, we would need to appeal to a refinement concept to justify a set of out-of-equilibrium beliefs. For this model, it would be standard to appeal to the refinement concept D1 (Cho and Kreps 1987). See the further discussion of this issue in Section 4.4.

10. Farmer and Pecorino (2004) consider a version of the Reinganum and Wilde (1986) model in which this assumption is relaxed.

4.1. Analysis of Each Stage of the Game

4.1.1. Stage 4: The Defendant Accepts or Rejects O_P. If the plaintiff's type J is known, then the defendant expects to pay $pJ + C_D^T$ at trial and will accept any offer $O_P < pJ + C_D^T$ with probability 1. An offer $O_P = pJ + C_D^T$ is consistent with a mixed strategy by the defendant under which he accepts the offer with the probability $\varphi(O_P)$. If the plaintiff's type is not known, then the defendant bases his decision to accept or reject on his updated beliefs, $B(O_P)$, which are a function of the offer he receives.

4.1.2. Stage 3: The Plaintiff's Offer. If the plaintiff's type is known at stage 3, she will make the offer

$$O_P = pJ + C_D^T, \tag{11}$$

which is accepted with probability 1.

If the plaintiff's type is not known at stage 3, the analysis follows from Reinganum and Wilde (1986). Given the rejection function, $\varphi(O_P)$, the plaintiff will make an offer in order to maximize her expected wealth π_P^N, which can be written

$$\pi_P^N = \varphi(O_P)(pJ - C_P^T) + [1 - \varphi(O_P)]O_P. \tag{12}$$

Maximization of equation (12) by the plaintiff yields the following first-order condition:

$$\varphi'(O_P)[pJ - C_P^T - O_P] + [1 - \varphi(O_P)] = 0. \tag{13}$$

The function $B(O_P)$ describes the defendant's beliefs about the plaintiff's type as a function of her offer to the defendant. In a perfect Bayesian equilibrium, these beliefs must reflect the equilibrium actions of the plaintiff. Thus, beliefs are correct in equilibrium: $B[O_P(J)] = J$. As established below, some plaintiff types will want to credibly reveal their type to the defendant, but a small percentage of these players will be unable to do so. Players who are unable to credibly reveal their type will make the same offer (given below in equation [14]) that is associated with their type in the standard signaling game. This will preserve the mapping between offers and beliefs developed in the game without discovery or disclosure.

Since the defendant pursues a mixed strategy in equilibrium, the plaintiff's offer must make him indifferent between acceptance and rejection.

The equilibrium offer by a type J plaintiff equals the defendant's expected payoff at trial against this plaintiff:

$$\mathrm{O_P} = pJ + \mathrm{C_D^T}. \tag{14}$$

A solution to the differential equation in (13) is

$$\varphi(\mathrm{O_P}) = 1 - e^{-\psi}, \tag{15}$$

where $\psi(\mathrm{O_P}) = (\mathrm{O_P} - \underline{\mathrm{O_P}})/(\mathrm{C_P^T} + \mathrm{C_D^T})$ and $\underline{\mathrm{O_P}} \equiv p\underline{J} + \mathrm{C_D^T}$.[11] The equilibrium probability of settlement is $1 - \varphi(\mathrm{O_P})$, or $e^{-\psi}$. Use equation (14) to express the equilibrium probability of settlement as

$$S = e^{-p(J-\underline{J})/(\mathrm{C_P^T}+\mathrm{C_D^T})}. \tag{16}$$

In equilibrium, higher-damages plaintiff types must have their offers rejected more frequently in order to discourage lower-damages plaintiff types from bluffing by submitting an offer higher than the one associated with their type. The mapping between higher offers and an increased probability of rejection is exactly sufficient to induce fully revealing offers by the plaintiff.

4.1.3. Stage 2: The Defendant Chooses Whether to Utilize Mandatory Discovery. The defendant will never utilize mandatory discovery in the signaling game. Whether or not the plaintiff chooses to voluntarily reveal her type, the defendant will receive the offer $\mathrm{O_P} = pJ + \mathrm{C_D^T}$, which yields a payoff of $-(pJ + \mathrm{C_D^T})$. If the defendant uses mandatory discovery, he again receives the offer $\mathrm{O_P} = pJ + \mathrm{C_D^T}$ but now receives a payoff of $-(pJ + \mathrm{C_D^T} + \mathrm{C_D^M})$. The defendant is made strictly worse off by using discovery because the plaintiff captures all of the joint surplus of settlement through her offer. This is summarized as proposition 3:

Proposition 3. In the signaling game, the defendant will never choose to utilize a costly discovery procedure.

As with the analogous result in the screening game, this prediction is sensitive to the bargaining assumptions embedded in the model. If the defendant were able to retain a sufficient fraction of the joint surplus

11. This solution makes use of the boundary $\varphi(\underline{\mathrm{O_P}}) = 0$ (that is, $\underline{\mathrm{O_P}}$ is accepted with probability 1). This condition relates to out-of-equilibrium beliefs and actions. In particular, it is a dominant strategy to accept any offer $\mathrm{O_P} < \underline{\mathrm{O_P}}$, so these (out-of-equilibrium) offers are accepted with probability 1. Equilibrium requires that the acceptance probability not jump up as the offer falls below $\underline{\mathrm{O_P}}$. As a result, this offer must also be accepted with probability 1. This makes the expression in equation (15), which is the unique solution to equation (13). See Reinganum and Wilde (1986, p. 565).

from settlement, then he would be willing to invoke a costly mandatory discovery procedure.

4.1.4. Stage 1: The Plaintiff Chooses to Voluntarily Disclose or Not. First, if the plaintiff is unable to credibly establish her type, she will make the offer in equation (14), which is accepted with the probability in equation (16). If the plaintiff is able to credibly disclose her type, then she must decide whether it is worth doing so. If she chooses to disclose her type, she will offer the expected payout in trial and the defendant will accept such an offer with probability 1. She will receive

$$E\pi_{\mathrm{P}}^{\mathrm{V}} = pJ + C_{\mathrm{D}}^{\mathrm{T}} - C_{\mathrm{P}}^{\mathrm{V}}. \tag{17}$$

Since we have established that the defendant will never utilize mandatory discovery, if the plaintiff does not reveal her type, she makes the offer in equation (14), which is accepted with the probability in equation (16). Her expected payoff under nondisclosure is

$$E\pi_{\mathrm{P}}^{\mathrm{N}} = [1 - e^{-p(J-\underline{J})/(C_{\mathrm{P}}+C_{\mathrm{D}})}](pJ - C_{\mathrm{P}}) + e^{-p(J-\underline{J})/(C_{\mathrm{P}}+C_{\mathrm{D}})}(pJ + C_{\mathrm{D}}). \tag{18}$$

By comparing the payoffs in equations (17) and (18), we can see that the plaintiff will engage in voluntary disclosure if and only if

$$[1 - e^{-p(J-\underline{J})/(C_{\mathrm{P}}+C_{\mathrm{D}})}](C_{\mathrm{P}}^{\mathrm{T}} + C_{\mathrm{D}}^{\mathrm{T}}) > C_{\mathrm{P}}^{\mathrm{V}}. \tag{19}$$

When the plaintiff's type is not known, her offer is rejected with the probability $[1 - e^{-p(J-\underline{J})/(C_{\mathrm{P}}+C_{\mathrm{D}})}]$, and each time a trial occurs, she loses the joint surplus from settlement $(C_{\mathrm{P}}^{\mathrm{T}} + C_{\mathrm{D}}^{\mathrm{T}})$. When her type is known, her offer is accepted with probability 1. Thus, the left-hand side of equation (19) is the expected benefit of voluntary disclosure. If this exceeds the cost $C_{\mathrm{P}}^{\mathrm{V}}$, then disclosure will occur.

4.2. Discussion of the Main Results

The analysis of the game thus far leads to the key results summarized in proposition 4:

Proposition 4.

4.1. When the inequality in equation (19) fails to hold, no information transmission takes place. The plaintiff makes the offer in equation (14), which is accepted with the probability in equation (16).

4.2. When the inequality in equation (19) holds, there is voluntary disclosure by all plaintiffs who are able to credibly do so. These plaintiffs make the offer in equation (11), which is accepted with probability 1.

Parts 4.1 and 4.2 of proposition 4 rely on proposition 3, which states that the defendant will never utilize a costly discovery procedure in the signaling game. Thus, the question of whether or not the plaintiff makes a voluntary disclosure depends solely on the plaintiff's cost-benefit comparison in equation (19). Note that if disclosure is costless, all plaintiffs will choose to reveal their private information, when it is possible for them to do so.

From equation (19), it is possible to derive a cutoff plaintiff type J' such that all plaintiffs $J > J'$ reveal their information (when possible), while all plaintiff types $J < J'$ remain silent. Thus, it is high-damages plaintiffs who reveal their private information because these plaintiffs get rejected with a higher probability than low-damages plaintiffs in the equilibrium without voluntary disclosure. As a result, these plaintiffs have a greater potential gain from information revelation. Assuming that δ is small (that is, that almost all plaintiffs can credibly establish their private information prior to trial), the opportunity for information disclosure results in an almost total truncation of the right tail of distribution of plaintiff types faced by the defendant at trial.

The analysis above indicates that there is a nonmonotonic relationship between plaintiff type and probability of trial. Among those types who do not reveal their private information, there is the traditional relationship where higher-damages plaintiff types (and thus cases with higher stakes) proceed to trial with a higher probability. When the plaintiff type (hence the stakes) reaches a critical level, the probability of trial falls to near zero; this occurs because these plaintiffs voluntarily reveal their type with the exception of a small probability δ that credible revelation is not possible. Thus, we have identified a set of circumstances that partially contradict the standard result that the probability of trial is strictly increasing in the stakes at trial.

High-damages plaintiff types will choose (when possible) to reveal their private information under voluntary disclosure. These plaintiff types are those most likely to proceed to trial in the absence of the opportunity for disclosure. Thus, the availability of voluntary disclosure has the potential to significantly reduce the probability of trial.

As trial costs rise relative to C_P^V, the incidence of voluntary disclosure increases and the incidence of trial decreases. This is consistent with the standard result in the literature that higher costs at trial increase the probability of settlement.

Adding a plaintiff offer prior to the opportunity to exchange information will not have any effect on the results of the model. Any early offer by the plaintiff will be ignored by the defendant because it is a costless signal and will not contain any information.

4.3. Welfare Effect on the Players

In the screening model, we found that private decisions did not always lead to the optimal level of information transmission; under some parameter values, information transmission fails to occur when it is optimal for it to occur, and under others, information transmission occurs even though it is inefficient. If we assume, as appears reasonable, that C_V^P is less than $C_P^M + C_D^M$, then from equation (19), information transmission occurs in the signaling game if and only if it is efficient.[12] The left-hand side of equation (19) represents the saved court costs, which equals the joint benefit to the players of information transmission, while the right-hand side, C_P^V, is the joint cost.

4.4. Results When δ Equals Zero

We have assumed that there is some probability $\delta > 0$ that the plaintiff is unable to credibly reveal her information. If δ equals zero, then plaintiffs with damages greater than the cutoff value J' will always disclose their information in equilibrium (that is, there is no lack of disclosure due to an inability to disclose). As a result, an offer $O_P > pJ' + C_D$ will be observed only off the equilibrium path of the game. The refinement concept D1 (Cho and Kreps 1987) will require the defendant to believe that an offer $O_P > pJ' + C_D$ is made by the cutoff plaintiff type $J = J'$.[13] Under this belief, the defendant will reject any out-of-equilibrium offers $O_P > pJ' + C_D$ with probability 1. These out-of-equilibrium beliefs and actions will support an equilibrium along the lines we have described in Section 4.2. However, these beliefs can also support other equilibria, all of which are characterized by a lower value of J' than the one derived

12. If C_V^P is greater than $C_P^M + C_D^M$, transmission of private information will fail to occur in some cases where it is optimal for it to occur.

13. Under D1, the defendant will associate the offer with the type of plaintiff who is willing to deviate for the largest set of beliefs about the probability that the offer will be accepted. Each plaintiff type is willing to deviate for a set of probabilities of acceptance of the form $[q^*, 1]$, where q^* is a critical probability that leaves the plaintiff indifferent between making a given out-of-equilibrium offer and following the equilibrium strategy. The plaintiff type for whom this set is the largest is the type the defendant will associate with this offer. It is fairly straightforward to show that J' has a greater incentive to make an offer $O_P > pJ' + C_D$ than any other player type.

from equation (19).[14] The rejection function in equation (15) ensures that the cutoff value of J cannot exceed the value derived from equation (19). Thus, the value of J' derived from equation (19) is an upper bound on the cutoff value of J. If it is believed that δ equals zero, then the equilibrium described in Section 4.2 reflects a lower bound on the amount of voluntary disclosure that will occur in the signaling game.

5. CONCLUSION

We have developed both a signaling model and a screening model in which there is costly voluntary disclosure and costly mandatory discovery. We find two senses in which these procedures are complementary. First, each tends to be effective under a different information structure. Voluntary disclosure will (if it is not too expensive) be utilized in the signaling game but not (in the absence of a discovery procedure) in the screening game. The discovery procedure is utilized in the screening game but not the signaling game. The second sense in which the institutions are complementary concerns their use in the screening game. Absent a discovery procedure, voluntary disclosure will not be utilized in this game. However, voluntary disclosure may occur in order to preempt a costly discovery request. When this happens, the voluntary disclosure reduces the total costs of information transmission.

In the signaling model, the private incentives for voluntary disclosure lead to the optimal outcome if saved court costs are used as a measure of welfare. In the screening game, the joint benefits and costs of discovery do not coincide and the level of information transmission may be either higher or lower than the optimum. Thus, we cannot be assured that the institution of discovery raises joint welfare of the players within the context of our model. If trials are expensive relative to discovery and would occur frequently in its absence, then discovery will raise welfare. To the extent that the screening game correctly describes a significant number of legal disputes, voluntary disclosure alone cannot be relied on as a means of transmitting information between parties to the dispute.

If information transmission is relatively inexpensive compared with the cost of a trial, then our results suggest that a great deal of information

14. The reason is that when δ equals zero, there can be a self-fulfilling element in the equilibrium. Since all out-of-equilibrium offers are rejected with probability 1, certain plaintiff types may reveal their type because they are expected to reveal their type. This self-fulfilling aspect of the model can lower the cutoff value of J, but it cannot raise it.

transmission will take place and that most cases will settle prior to trial. If the condition we identify in the screening game were to hold, then mandatory discovery (or a preemptive use of voluntary disclosure) would ensure 100 percent settlement in the screening game. The analysis of the signaling game indicates that voluntary disclosure will lead to settlement in most, but not all, cases if disclosure is inexpensive relative to trial. This conclusion presumes that most plaintiffs can credibly transmit their information prior to trial (that is, δ is small).

A high degree of settlement seems consistent with the facts, which suggests that parties to the dispute are generally able to transmit information credibly prior to trial. Most cases, on the order of 95 percent, settle.[15] It is possible to generate such a high settlement rate in the Bebchuk (1984) and Reinganum and Wilde (1986) models without information transmission, but it requires that player types be described by a very tight distribution. If we add information transmission to these models, as in this paper, then we do not need to restrict ourselves to very tight distributions of player types in order to explain high settlement rates.[16] This suggests the importance of adding both costly disclosure and costly mandatory discovery to the standard models of pretrial settlement.

In addition, our results may give us some insight about the types of informational asymmetries that lead to trial. For information transmission to occur, it must be possible to credibly establish this information prior to trial. When information is verifiable, our results suggest that a great deal of information transmission will occur. However, information on preferences may be inherently difficult to verify prior to trial. This points to asymmetric information on the degree of litigiousness (Eisenberg and Farber 1997) or risk preferences (Farmer and Pecorino 1994) as candidates for informational asymmetries that will persist in the face of mandatory discovery and opportunities for voluntary disclosure.

15. See, for example, table 1 in Eisenberg and Farber (1997).

16. One could also appeal to high trial costs to explain the low settlement rate. Spier (1992) cites estimates of the sum of the court costs of 50 percent of the average judgment. If high court costs cause the credibility constraint $pJ - C_P > 0$ to fail to hold for some plaintiffs, this may cause a large jump in the dispute rate. This issue is addressed by Nalebuff (1987) for the screening game and by Farmer and Pecorino (2004) for the signaling game. Thus, while high dispute costs (combined with a fairly tight distribution of player types) can explain low dispute rates, parameter values would have to be chosen pretty carefully in order to generate the low dispute rates found in the field data.

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