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An Empirical Analysis of the Signaling and Screening Models of Litigation*

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Abstract

We present an experimental analysis of the signaling and screening models of litigation. In both models, bargaining failure is driven by asymmetric information. The difference between the models lies in the bargaining structure: In the signaling game, the informed party makes the final offer, while in the screening game the uninformed party makes the final offer. We conduct experiments for both models under a common set of parameter values, allowing only the identity of the party making the final offer to change. The predictions implied by the equilibrium refinement concept D1 are rejected by the data. Contrary to the theoretical predictions, dispute rates are higher in the signaling game. We also find anomalous offers to be more common in the signaling game.

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1. Introduction

Civil trials, strikes and wars are all examples of costly forms of dispute resolution which can result from failed negotiations. One of the leading explanations for costly bargaining failure is asymmetric information. We consider a stylized legal bargaining framework in which an informed "plaintiff" knows whether she has either a strong or weak case against an uninformed "defendant." Within this class of models, when the informed party makes the final offer, it is called the signaling model (as the informed plaintiff tries to signal her type with her offer), and when the uninformed party makes the final offer it is called the screening model (as the uninformed defendant tries to screen weak and strong cases with his offer). We examine both of these models experimentally.

There has been previous experimental analysis of both the signaling and screening models, and the screening model has previously been analyzed in the context of civil litigation. To our knowledge, however, there has not been a previous experimental analysis of the signaling model in the litigation context. As such, this part of our experiments is a major focus of our paper. We use the same parameter values in both the signaling and screening experiments; the only difference between the two is whether the informed plaintiff or the uninformed defendant makes the offer. This allows us to make a side-by-side empirical comparison of how well each model performs.

Our data suggest that both models have significant predictive power. In line with previous results, we find that most subjects in the screening game can find a screening offer as predicted by the theory. A screening offer by the defendant is a low offer that plaintiffs with a weak case will accept, but plaintiffs with a strong case will reject. Empirically, the screening offer made by our players in the role of the defendant is higher than predicted by theory. In

addition, disputes occur in the states of the world in which they are not supposed to occur. On the other hand, when disputes are predicted to occur, they do so with a very high probability. This mixed performance is very much in line with past experiments.

The signaling game too brings mixed results. Under the refinement D1, a pure strategy separating equilibrium is predicted for this game.[1] In this equilibrium, plaintiffs with a weak case make a low offer which reveals their type, and plaintiffs with a strong case make a high offer which is also revealing of their type. The high offers are rejected with a sufficiently high probability so as to discourage bluffing on the part of plaintiffs with a weak case. In practice, we find that some plaintiffs with a weak case reveal their type via a low offer, while others bluff by making a higher offer. In addition, while plaintiffs with a strong case make significantly higher offers than plaintiffs with a weak case, they generally do not make the unique offer predicted by the pure strategy separating equilibrium. Our results are very roughly consistent with a Bayes – Nash semi-pooling equilibrium, but they are not consistent with the pure strategy separating equilibrium implied by the refinement D1. The reason why D1 fails empirically is that the offer implied by this refinement is rejected at a 100% rate. This leads plaintiffs with a strong case to experiment with lower offers, and these lower offers are sometimes accepted. In contrast to our theoretical prediction we find a higher dispute rate in the signaling game. This is the direct result of the bluffing behavior by weak plaintiffs, which is not predicted by the theory.

We observe anomalous behavior in both models, but this behavior occurs with greater frequency in the signaling model. More poor offers are made in this model, and some of these offers are accepted when theory implies that they should be rejected.

[1] See Cho and Kreps (1987). We will discuss D1 in more detail below.

2. Background

There is a large literature in law and economics in which trials are an equilibrium outcome of games in which there is asymmetric information. In the Bebchuk (1984) model, the uninformed party makes an offer to the informed party. This is known as the screening game, and our version of this game is a simplified version of Bebchuk's model. In Reinganum and Wilde (1986), the informed party makes an offer to the uninformed party. This is known as the signaling game, and our version of this model is a simplified version of the Reinganum and Wilde Model. Much of the subsequent literature on pretrial bargaining was built upon the Bebchuk and Reinganum and Wilde models. Among other things, this literature analyzes how institutions such as fee shifting and contingency fees affect settlement rates. For a recent review of this literature, see Spier (2007).

There has been previous analysis of the screening and signaling models outside the law and economics context. For example, Forsythe, Kennan and Sopher (1991) analyze strikes in a model with asymmetric information. Bradts and Holt (1992, 1993) conduct signaling experiments to test certain refinement concepts which have been developed by game theorists to help select among the multiple equilibria that are prevalent in signaling games. Cooper et al. (1997) analyze a signaling model in the context of limit pricing.

There is an extensive experimental law and economics literature.[2] With a few exceptions, this work does not analyze the standard models of pretrial bargaining in which disputes result from asymmetric information. The extensive literature on arbitration has focused on how dispute rates affected by the choice of arbitration procedure, but this is generally done in a setting of

[2] Camerer and Talley (2007) provide a survey of the literature.

symmetric information.[3] A variety of issues have been examined experimentally in the civil litigation literature. These include conditional cost shifting under which the shifting of certain trial costs is a function of either the outcome of trial or of the relationship between the trial outcome and offers made in the pretrial negotiation period. (See, for example, Coursey and Stanley 1988 and Main and Park 2002). Again, in these experiments, the players are symmetrically informed. A partial exception is Inglis et al. (2005) who analyze conditional cost shifting and who have asymmetric information in one of their treatments. In their experiment, asymmetric information is two-sided (each party has information about the expected outcome at trial that the other does not) and so does not constitute a direct evaluation of the Bebchuk (1984) or Reinganum and Wilde (1986) models. Similarly, Stanley and Coursey (1990) provide a test of Priest and Klein's (1984) selection hypothesis. In this setting, each party obtains an independent draw from the distribution which will determine the outcome at trial. Thus, each party has a piece of information that the other does not, but this analysis does not correspond to either the screening or signaling models that we analyze here.

Pecorino and Van Boening (2004, 2011) have previously analyzed the screening model of litigation in the context of analyzing other issues. Pecorino and Van Boening (2004) analyze the role of voluntary disclosure in pretrial bargaining. They find that costless voluntary disclosures are frequently made by the party with a strong case, and this is effective in reducing dispute costs. Pecorino and Van Boening (2011) analyze the effects of shifting the distribution of dispute costs on both settlement offers and dispute rates. Among other findings, their data

[3] See, for example, Ashenfelter et al. (1992), Deck and Farmer (2007), Deck, Farmer and Zeng (2007 a,b), and Dickinson (2004) and (2005). Pecorino and Van Boening (2001) analyze arbitration with asymmetric information in order to test a prediction of Farmer and Pecorino (1998). The prediction, which is confirmed in the experimental data, is that dispute rates in final offer arbitration will be lower than in conventional arbitration if bargaining takes place after potentially binding offers have been submitted to the arbitrator. Kuhn (2009) provides a survey of the experimental literature on arbitration.

indicate that an asymmetric distribution of the dispute costs may raise the probability of a dispute.

In both of these previous papers, the screening model served as a baseline. Most experimental subjects in these experiments were able to identify a sorting strategy, though offers were generally somewhat in excess of those predicted by a model of narrow rationality. In addition, there were excess disputes relative to the predictions of theory. Both of these deviations from the predictions of a model of narrow rationality suggest some role for fairness in these experiments.[4] In what follows, we will also present the screening game as a baseline. The treatment is to switch from having the uninformed party make the offer to having the informed party make the offer, where the treatment corresponds to the signaling game. To our knowledge, there have been no previous experimental analyses of the signaling game in the litigation context.

3. The Theory

The screening model we describe is a simplified version of Bebchuk (1984), while the signaling model is a simplified version of Reinganum and Wilde (1986). Both the plaintiff and defendant are risk neutral. The level of damages to be awarded at trial is known by the plaintiff but not the defendant. The defendant only knows that with probability q he faces a high damage plaintiff J^H and with probability 1-q he faces a low damages plaintiff J^L. Using this simple environment, we first present the screening model and then the signaling model.

[4] However, the extent of fairness behaviors in these experiments is much smaller than is typically associated with ultimatum games. For example, Pecorino and Van Boening (2011) find, based on the actual offers made in the experiment, that the optimal offer contains between 10 and 17 percent of the surplus from settlement. Also see Pecorino and Van Boening (2010).

In all of our analyses, the probability p that the plaintiff prevails at trial is common knowledge, and we furthermore assume that $p = 1$. The plaintiff is one of two types, type H with a strong case or type L with a weak case. If the case proceeds to trial, the plaintiff receives judgment J^i, $i = H,L$ with $J^H > J^L$. The amounts of the state-contingent judgments are common knowledge. The court costs for the plaintiff and defendant are, respectively, C_P and C_D. (These costs are incurred only if the case proceeds to trial.) We assume that $J^L - C_P > 0$ so that the plaintiff always has a credible threat to proceed to trial.[5]

3.1 The Screening Game

The stages of the game are as follows:

0. Nature determines the plaintiff's type to be either H with judgment J^H or L with judgment J^L. The plaintiff is type H with probability q and type L with probability 1-q. The plaintiff knows her type, but the defendant knows only the probability q that the plaintiff is type H (and hence probability 1-q that the plaintiff is type L).

1. The defendant makes an offer O_D to the plaintiff.

2. 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 $-O_D$ (i.e., the defendant incurs a cost equal to O_D).

3. If the offer is rejected, trial occurs. The plaintiff receives the payoff $J^i - C_P$, and the defendant receives the payoff $-J^i - C_D$ (or incurs cost $J^i + C_D$), where $i = H, L$.

The plaintiff will accept any offer that leaves her at least as well off as the expected outcome at trial. In other words, a type i plaintiff will accept any offer such that $O_D \geq J^i - C_P$.

[5] Nalebuff (1987) analyzes a model in which this is not always true.

The defendant is free to make any offer he chooses, but the optimal offer will be one of the following:

$$O_D^L = J^L - C_P \tag{1a}$$

$$O_D^H = J^H - C_P \tag{1b}$$

In making his offer O_D, the defendant will choose either a high pooling offer O_D^H that both plaintiff types will accept or the low screening offer O_D^L that only a type *L* plaintiff will accept. The defendant offers O_D^L iff

$$(1-q)(J^L - C_P) + q(J^H + C_D) < J^H - C_P. \tag{2}$$

The left hand side represents the expected payout from the offer O_D^L which is accepted with probability 1-*q*. If this offer is rejected by a type *H* plaintiff, the defendant proceeds to trial and pays $J^H + C_D$. The right hand side is the defendant's payout from the higher offer, which is accepted by both plaintiff types. Rearranging equation (2), the defendant will make the low offer iff

$$q < \frac{(J^H - J^L)}{(J^H - J^L) + C_P + C_D}. \tag{3}$$

The defendant makes a low screening offer if the probability *q* of encountering a high damage plaintiff is sufficiently small. When the screening offer is made, trials will occur with probability *q*. If the condition in (3) fails to hold, the defendant will make the pooling offer under which all cases settle. In our experiment, we choose parameter values such that (3) holds. Therefore, our theoretical predictions are that the player in the role of the defendant will offer O_D^L, and that players in the role of a type *L* plaintiff will accept this offer with 100% probability and players in the role of a type *H* plaintiff will reject it with 100% probability.

To summarize, the predictions relevant for our experiments will be as follows:

1. The defendant offers $O_D^L = J^L - C_P$, which is accepted by type *L* plaintiffs and rejected by type *H* plaintiffs.

2. Type L plaintiffs have a 100% settlement rate and earn a payoff of O_D^L. Defendants incur a cost of O_D^L against type *L* plaintiffs.

3. Type *H* plaintiffs have a 0% settlement rate and earn a payoff of $J^H - C_P$. Defendants incur a cost of $J^H + C_D$ against type *H* plaintiffs.

3.2 The Signaling Game

The stages of the game are similar to those above with 1' and 2' replacing stages 1 and 2.

1'. The plaintiff makes an offer O_P to the defendant.

2'. The defendant accepts or rejects the offer. If the offer is accepted, the game ends with the plaintiff receiving payoff O_P and the defendant receiving payoff $-O_P$ (or incurring cost O_P).

Multiple equilibria are a problem in signaling games. In this particular game, the refinement concept D1 has been used to eliminate all but a pure strategy separating equilibrium. We will consider that equilibrium first, but then briefly consider others that are not consistent with D1. The refinement D1 places restrictions on out-of-equilibrium beliefs. It requires that the defendant believe than an out-of-equilibrium offer be made by the plaintiff type most likely to benefit from that offer.[6] In the separating equilibrium, each plaintiff makes a unique offer associated with her type. These offers are as follows:

[6] In our model, this works as follows: Suppose an *L* plaintiff would be willing to deviate to a particular out of equilibrium offer if it were accepted with a probability of ½ or higher, but that an *H* plaintiff would only switch if the same offer were accepted with a probability of ¾ or higher. In this case, the *L* plaintiff is considered to have the

$$O_P^L = J^L + C_D \tag{4a}$$

$$O_P^H = J^H + C_D \tag{4b}$$

In the separating equilibrium, *H* plaintiffs make the offer O_P^H and *L* plaintiffs offer O_P^L. Since the plaintiff follows a pure strategy, these offers are revealing of the plaintiff's type. In other words, a defendant receiving an offer O_P^H believes with probability 1 that this offer has been made by a type *H* plaintiff.

The low offer O_P^L will be accepted by the defendant with probability 1.[7] Type *L* plaintiffs will reveal their type via the offer O_P^L only if O_P^H is rejected with a sufficiently high probability. Note that the revealing offer O_P^H leaves the defendant indifferent between acceptance and rejection. Thus, the defendant is free to respond to this offer with a mixed strategy. The offer O_P^H will be rejected by the defendant with probability ϕ such that

$$(1-\phi)(J^H + C_D) + \phi(J^L - C_P) \leq J^L + C_D. \tag{5}$$

Rearranging yields the condition

$$\phi \geq \frac{(J^H - J^L)}{(J^H - J^L) + C_P + C_D}. \tag{6}$$

The probability of a trial is $q\phi$, the probability that the plaintiff is type *H* times the probability that the high offer is rejected. More specifically, the dispute rate for A_L plaintiffs is 0% and the dispute rate for A_H plaintiffs is ϕ%. Under the refinement D1, the expression in (6) will hold as an equality. (See Daughety 1999: 133-4.)

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greater incentive to make the offer and the defendant must put a weight of 1 on the probability that such an offer comes from an *L* player. See Cho and Kreps (1987).

[7] It is a dominant strategy to accept offers below O_P^L, so these out of equilibrium offers must be accepted with probability 1. To support the equilibrium, we must avoid a jump up in the acceptance rate as offers fall below O_P^L. Thus, O_P^L must also be accepted with probability 1. See Reinganum and Wilde (1986, p. 565).

Out-of-equilibrium beliefs and actions are as follows: An offer $O_P < O_P^L$ is believed to be from a type *L* plaintiff and is accepted with probability 1 while an offer $O_P > O_P^H$ is believed to be from a type *H* plaintiff and is rejected with probability 1. An offer $O_P^L < O_P < O_P^H$ is believed to be from a type *L* plaintiff and is rejected with probability 1. It is straightforward to show that these beliefs are consistent with D1 (Cho and Kreps 1987). Furthermore it is possible, using D1, to rule out all potential pooling and semi-pooling equilibria (Reinganum and Wilde 1986, p. 566).

Whether or not the D1 refinement places valid restrictions on out-of-equilibrium beliefs is an empirical question. As such, it is worth discussing some equilibria of the signaling game that do not satisfy D1. First, we can eliminate a pure strategy pooling equilibrium if we impose the following parameter restriction: $C_P + C_D < (1 - q)(J^H - J^L)$.[8] Our experimental parameters satisfy this restriction.

Under our experimental parameters, a semi-pooling equilibrium is possible. In this equilibrium, the *L* plaintiff plays a mixed strategy in which she makes the revealing offer O_P^L with some probability and bluff by offering O_P with some probability where $J^H - C_P \leq O_P < J^H + C_D$. If *L* is to mix between these strategies, she must be indifferent between the offers. The low offer is accepted with probability 1. If the higher offer is accepted with probability

$$r = \frac{C_P + C_D}{O_P - J^L + C_P}, \tag{7}$$

[8] A type *H* plaintiff will accept no less than $J^H - C_P$ in a pooling equilibrium. If the condition in the text holds, the defendant will prefer to take all types to trial rather than settling at $J^H - C_P$ in a pure pooling equilibrium. Obviously, the defendant would reject all higher offers as well, if they were part of a pure pooling equilibrium.

then L will be indifferent between the two offers.

In this semi-pooling equilibrium, the defendant must be indifferent between accepting or rejecting O_P. If s is the conditional probability that the offer O_P is made by L, then the defendant is indifferent between acceptance and rejection when

$$s = \frac{J^H + C_D - O_P}{J^H - J^L}. \tag{8}$$

An infinite number of semi-pooling equilibria are possible, since O_P can take on a range of values. However, in any particular semi-pooling equilibrium, all the H plaintiffs and all of the bluffing L plaintiffs will pool on one and only one value of O_P.[9]

If we impose the requirements of the D1 refinement on the model, we obtain the following predictions relevant for our experiment:

1a. Type L plaintiffs make the offer $O_P^L = J^L + C_D$, which is always accepted by the defendant.

1.b. Type H plaintiffs make the offer $O_P^H = J^H + C_D$ which is accepted by the defendant with probability $1-\phi = (C_P + C_D)/[(J^H - J^L) + C_P + C_D]$.

2. Type L plaintiffs have a 100% settlement rate and earn the payoff O_P^L. Defendants incur the cost O_P^L against type L plaintiffs.

3. Type H plaintiffs have a $(1-\phi)$% settlement rate and earn the expected payoff $J^H + C_D - \phi(C_P + C_D)$. Defendants incur the cost $J^H + C_D$ against type H plaintiffs.

3.3. Comparative Static Predictions

[9] It is not possible to have the H plaintiffs and bluffing L plaintiffs pool on more than one value of O_P, because it is not possible to find rejection probabilities that make both plaintiff types indifferent between both pooling offers while also making the L plaintiffs indifferent between bluffing and not bluffing.

The point predictions from sections 3.1 and 3.2 can be used to generate a set of comparative static predictions about how certain outcomes will change when the offer is made by the plaintiff instead of the defendant Even if the model cannot hit the point predictions, it may in some cases be able to replicate the comparative static predictions of the model. In computing the comparative statics, we will use the predictions generated by the refinement D_1. These predictions follow directly from our previous analysis, and will number each prediction for convenience.

When moving from the screening game to the signaling game:

1. The demand of type L plaintiffs in the signaling game is $C_P + C_D$ greater than the offer by the defendant in the screening game. As a result, the payoff of type L plaintiffs increases by $C_P + C_D$.
2. The expected cost of the defendant against type L plaintiffs increases by $C_P + C_D$.
3. The probability of a dispute for type L plaintiffs remains unchanged.
4. The expected payoff of type H plaintiffs increases by $(1-\phi)(C_P + C_D)$.
5. The expected cost of the defendant against type H plaintiffs stays the same.
6. The probability of a dispute for type H plaintiffs falls by $(1-\phi)$.

4. Experimental Design

Table 1 summarizes the 10 sessions in our experimental design. In the Scr sessions, subjects played the screening game and in the Sig sessions, they played a signaling game. The designed is balanced so that five sessions of each game were run. Subjects were recruited from summer business classes at the University of Alabama. The number of bargaining pairs per session ranges from 5 to 8, while each session lasted 12 – 14 rounds. The player in the role of

the plaintiff is referred to as the *A* player, with type *L* plaintiff denoted A_L and type *H* plaintiffs denoted A_H. The player in the role of the defendant is referred to as the *B* player. In each round of the experiment, the *A* and *B* players were randomly and anonymously paired. Subjects were not informed ahead of time how many rounds there would be. A typical session, inclusive of an instructional period at the beginning and private payment at the end, lasted between one-and-a-half and two hours. The mean and median earnings for our subjects were about $31 with a minimum of $17.05 and a maximum of $46.75. (Subjects were not paid a show-up fee; all earnings were from decision-making.)

Table 1. Experimental Design

			Number of obs. by player type			Subject earnings
Session	Pairs	Rounds	A_L	A_H	B	Average (Min, Max)
I. Screening Game						
Scr1	7	12	49	35	84	$32.63 ($24.54, $46.10)
Scr2	5	13	47	18	65	$31.81 ($21.06, $42.50)
Scr3	8	13	75	29	104	$32.38 ($24.80, $40.41)
Scr4	5	13	41	24	65	$31.85 ($24.55, $36.06)
Scr5	6	14	61	23	84	$30.42 ($24.40, $38.53)
Total	31	65	273	129	402	$31.89 ($21.06, $46.10)
II. Signaling Game						
Sig1	6	12	50	22	72	$29.82 ($17.05, $42.28)
Sig2	8	12	61	35	96	$29.35 ($19.10, $38.64)
Sig3	8	12	68	28	96	$27.35 ($19.30, $46.75)
Sig4	5	12	42	18	60	$29.95 ($18.89, $40.05)
Sig5	7	12	55	29	84	$33.12 ($24.40, $43.45)
Total	34	60	276	132	408	$31.28 ($17.05, $46.75)

Note: All sessions conducted at the University of Alabama.

As they arrived to a session, subjects were randomly assigned to one of two rooms, with subjects in one room being player *A* and subjects in the other room player *B*. An experimenter was assigned to each room. Subjects were not informed of their role until the end of the experimental instructions; all subjects received common instructions that explained how both player *A* and player *B* made decisions and earned money. Subjects maintained the same role throughout the session, and other than the written messages transmitted by experimenters between the two rooms, there was no interaction between the *A* and *B* players. Each subject had a private Record Sheet, and each experimenter had forms on which to record information. Players wrote their decisions on their respective Record Sheet, and an experimenter recorded this information on his form. After all subjects in a room had made their decisions, the experimenters met in the hallway between the two rooms, silently copied information from one another's forms, and then returned to the rooms and wrote the results on the respective subject's Record Sheet.

The parameters for both experiments are the same. The "judgments" at trial J^L = \$1.50 for A_L players and J^H = \$4.50 for A_H players. Trial costs are $C_P = C_D$ = \$.75, so that total dispute costs are \$1.50. The probability that a plaintiff is A_H is $q = 1/3$. In both experiments, there is a new random and anonymous pairing each round. In both games, Player *A*'s payoff from the experiment is the sum of her payoffs from all rounds. Player *B*'s payoff from the experiment is lump sum minus the sum of his costs from all rounds; the lump sum is known in advance by player *B* but is never revealed to player *A*. In the experiment, we did not use verbiage like plaintiff, defendant, judgment at trial, court costs, etc.

4.1. The Screening Game

The sequence in a round of the screening game is as follows (this is very similar to the language and appearance used in the subjects' instruction):

1. Player *A* and Player *B* are randomly and anonymously paired.
2. A 6-sided die is rolled for each Player *A*. A roll of 1, 2, 3, or 4 is called outcome *L*. A roll of 5 or 6 is called outcome *H*. Only Player *A* knows the outcome of the die roll.
3. Player *B* decides on an offer to submit to Player *A*. This offer may be any number between (and including) $0.00 and $6.99.
4. Player *B*'s offer is then communicated to Player *A*. Player *A* is given a few moments to decide whether or not to accept the offer. Player *A*'s decision is then communicated to Player *B*.
5. If Player *A* accepts Player *B*'s offer, then the round is over for that pair.

   Players *A*'s Payoff for the round = Player *B*'s offer

   Player *B*'s Cost for the round = Player *B*'s offer.
6. If Player *A* does not accept *B*'s offer, both *A* and *B* incur a fee of 75. *A*'s payoff and *B*'s cost for the round depend on the die roll and the fees:

Under outcome L:	Player *A*'s Payoff for the round =	150 – 75 = 75
	Player *B*'s Cost for the round =	150 + 75 = 225
Under outcome H	Player *A*'s Payoff for the round =	450 – 75 = 375
	Player *B*'s Cost for the round =	450 + 75 = 525.

The information in step 6 was displayed in both rooms by the use of an overhead projector. The overhead made clear that the same information was displayed in both rooms.

4.2. The Signaling Game

The parameters and procedures for the signaling game are identical to the screening game, except that player *A* makes the take-it-or-leave-it offer to player *B*. The steps of a round are identical to the screening game except for the following modifications.

3'. Player *A* decides on an offer to submit to Player *B*. This offer may be any number between (and including) $0.00 and $6.99.

4'. Player *A*'s offer is then communicated to Player *B*. Player *B* is given a few moments to decide whether or not to accept the offer. Player *B*'s decision is then communicated to Player *A*.

5'. If Player *B* accepts Player *A*'s offer, then the round is over for that pair.

Players *A*'s Payoff for the round	=	Player *A*'s offer
Player *B*'s Cost for the round	=	Player *A*'s offer.

4.3. Predictions

In the screening game, the point predictions are:

1. Player *B* will make a low screening offer of 75 to player *A*.[10]

2. Player A_L accepts all offers greater than or equal to 75 and rejects all offers below 75. If prediction 1 is correct, this implies a 0% dispute rate for player A_L. Player A_L earns 75 per round and the defendant incurs a cost of 75 per round against this player.

3. Player A_H accepts all offers greater than or equal to 375 and rejects all offers less than 375. If prediction 1 is correct, this implies a 100% dispute rate for player A_H. Player A_H earn 375 per round and the defendant incurs a cost of 525 per round against this player.

For the signaling game matters are a bit more complicated, but here we will list the predictions of the unique equilibrium outcome that applies under the refinement D1. Note however that if D1 is not a valid refinement for our experimental game, then semi-pooling equilibria are possible. We discuss this further in the results section. Under D1, we have the following point prediction for the signaling game:

1. Player A_L offers 225 to player *B*.

2. Player A_H offers 525 to player *B*.

3. Player *B* accepts all offers of 225 or less. If prediction 1 is correct, player A_L has a 0% dispute rate, and earns 225 per round. The defendant incurs a cost of 225 per round against this player. All offers between (and including) 226 and 524 are rejected with

[10] An offer of 75 leave an A_L player with none of the joint surplus of settlement. For the purposes of exposition, we will ignore (here and elsewhere) the extra penny of surplus we might expect players to offer to ensure settlement under the predictions of the fully rational model. If fairness plays a role, then players may need to offer substantially more than one penny of surplus in order to ensure settlement.

100% probability. An offer of 525 is rejected with a probability of ϕ =2/3. Player A_H has a dispute rate of 2/3 and expected earnings of 425 per round.

Based on section 3.3 and the parameter values in our experiment, we have the following comparative static predictions when moving from the signaling game to the screening game:

1. For A_L: Her dispute rate is unchanged, her demand exceeds the offer of player *B* in the screening game by 150, and her payoff rises by 150 per round.

2. For A_H: Her dispute rate falls by 33 percentage points, and her expected payoff is 50 higher per round.

3. For *B*: His cost against A_L is 150 higher per round, and his cost against A_H is unchanged.

Since A_L players are encountered 2/3 of the time and A_H players 1/3 of the time, the predictions above imply the following:

4. The overall dispute rate in the signaling game is 11 percentage points lower than in the screening game.

5. Results

We will first present the results of the screening game. As noted earlier, previous experimental research has analyzed this game, but its inclusion allows us to compare the performance of its theoretical predictions with those of the signaling game.

5.1. The Screening Game

Table 2 shows player *B* offers and the player *A* rejection behavior in the screening game. Note that the median offer is 100. While this is clearly above the theoretical prediction of 75, it is also clearly a screening offer. This offer contains only 1/6 of the joint surplus from settlement and so is quite stingy relative to behavior in the standard ultimatum game. Overall, 87.1 percent of the offers are in the range 75-225. These offers are acceptable to A_L and unacceptable to A_H

and may therefore be considered sorting offers. About 80% of the sorting offers are in the range 75-125 and thus are fairly close to the point prediction of 75.

Table 2. Screening Game Offers and Rejection Rates

Player *B* offers						Rejection rate (%) by player *A* type		
Interval	Type[a]	n	%	Mean	Median	By *A*	By A_L	By A_H
< 75	< 0	6	1.5	48.7	50.5	100	100	100
75−100[b]	Sort	220	54.7	88.7	90	46.4	22.0	98.6
101−125	Sort	60	14.9	121.4	125	26.7	13.7	100
126−150	Sort	29	7.2	144.5	150	48.3	0	93.3
151−175	Sort	9	2.2	169.4	175	55.6	0	100
176−200	Sort	18	4.5	195.5	200	33.3	0	100
201−225	Sort	14	3.5	217.6	200	28.6	0	100
226−374	> 150	24	6.0	278.0	275	33.3	0	88.9
375−525	Pool	21	5.5	400.0	376	9.1	0	22.2
21−555	Total	402	100	136.4	100	40.5	16.1	92.2
75−225	Sort	350	87.1	111.6	100	42.0	16.6	98.2
≥ 375	Pool	22	5.5	400.0	376	9.1	0	22.2

[a] "< 0" and "> 150" means the offer contains, respectively, negative surplus and more than 150 of surplus for an A_L recipient. "Sort" denotes sorting offers containing surplus ≥ 0 for type A_L but < 0 for type A_H, and "Pool" denotes pooling offers with surplus ≥ 0 for both type A_L and type A_H.

[b] There are eleven offers of 75; one player *B* submitted seven, another submitted three, and a third submitted one. The rejection rate on these 11 offers is 54.5%.

About 13% percent of *B*'s offers are outside of the sorting range. Offers of 375 or above are in the pooling range, and this constitutes 5.5% of all offers. While these offers are contrary to theory it is not surprising that some players would experiment with offers in this range. The remaining offers, which constitute 7.5% of the total, are quite poor from player *B's* perspective. There are a very small number (1.5%) of offers which are below 75. These offer negative surplus

to A_L players, and not surprisingly all these offers are all rejected. More common (6% of the total) are offers between 226 and 374. These offers are too low to be accepted by A_H players, but result in a negative surplus for player *B* when accepted by an A_L player. Overall, while there are some important deviations from the theory, the predictions on player *B*'s offers give a pretty good guide to the central tendencies of his behavior.

Next, we turn to player *A*'s rejection behavior. The overall dispute rate for A_L players is 16.1%, while the theoretical prediction is 0%. This level of excess disputes is in line with previous screening experiments.[11] The dispute rate for A_H players is 92.2%, while the theoretical prediction is 100%. Part of this result from the pooling offers received by A_H. Their rejection rate on offers less than 375 is 97.5%, which is quite close to the theoretical prediction.

The excess disputes among the A_L players are all in the 75-125 interval. Offers of 126 and above were always accepted by these players. The dispute rate is 22% for offers in the range 75-100 and falls to 13.7% in the range 101-125. The rejection rate in these intervals is clearly one factor driving player *B* offers above the theoretical prediction of 75, but it cannot explain why player *B* would make an offer in excess of 125. Even if we ignore the pooling offers (those above 375), 17.4% of the player *B* offers are too generous, given the rejection behavior by player *A*.

The excess rejections by player *A* are concentrated in a region where fairness concerns may be of importance, i.e., player A_L rejects 15-20% of the offers that exceed but are still close to her dispute payoff of 75. A_L players reject all offers less than 75 (though this constitutes just 1% of the offers), while A_H players reject 97.5% of offers below 375. All told, rejection behavior is very much in line with the predictions of theory with fairness concerns playing some role not present in the standard theory.

[11] See Pecorino and Van Boening (2001, 2004).

5.2. The Signaling Game

The signaling game offers of A_L players are shown in Table 3. These players are predicted to make an offer of 225, and 62.7% make an offer of 225 or less, with a mean of 203.6 and a median of 220 within this range. The median offer is quite close to the theoretical prediction. Fairness appears to play an even smaller role in these offers than in the corresponding offers by player *B* in the screening game: A_L offers in the 200-225 range are rejected by *B* 11.3% of the time, while in the screening game, *B*'s offers in the 75-100 range are rejected 22% of the time by A_L. Some A_L players bluff by making an offer in the range 375-525. Clearly, these offers are designed to be confused with offers from A_H players. While these bluffs are not predicted in the unique equilibrium which satisfies D1, it is not that surprising that some A_L players experiment with these offers. Seventy percent of these 43 offers occur in rounds 1-6.

More puzzling are the 21.7% of A_L's offers that are between 226 and 374. Player *B* should infer that such offers would never be made by A_H, because they are lower than A_H's dispute payoff of 375. Thus, *B* should always reject these offers and A_L should never make them. A possible, albeit somewhat unsatisfactory explanation is that A_L is trying to bluff, but she does not fully understand what constitutes a bluff. The interval mean (306.4) and median (300) are at the midpoint of 226-374, suggesting that these offers are not inadvertent, and 21 of the 34 different *A* players in our five signaling sessions submitted at least one offer in this range while type A_L. (We also note that 77% of these sixty A_L offers occur in periods 1-6.) Player *B*'s response to these offers is also a bit puzzling, as theory predicts a 100% rejection rate on offers in this range, but *B* only rejects 55% of these offers. Even if we restrict the analysis to periods 7-12, where there are fourteen offers in the 266-374 range, *B*'s rejection rate is only 43%. We comment further on *B*'s behavior below.

Table 3. Signaling Game Player A_L Offers and Rejection Rates

Player A_L Offers						Player B rejection rate (%)
Interval	Type[a]	n	%	Mean	Median	
< 75	> 150	0	0	---	---	---
75−99	Reveal	4	1.4	85.3	85.5	0
100−124	Reveal	4	1.4	107.5	105	0
125−149	Reveal	3	1.1	128.3	130	0
150−174	Reveal	10	3.6	150.0	150	0
175−199	Reveal	11	4.0	185.4	185	9.1
200−225[b]	Reveal	141	51.1	216.5	220	11.3
75−225	Reveal	173	62.7	203.6	220	9.8
226−374	< 0	60	21.7	306.4	300	55.0
375-525[c]	Bluff	34	12.3	???	???	???
> 525	< 0	9	3.3	???	???	100
80−650	Total	276	100	256.4	225	33.3

[a] "< 0" and "> 150" means offer contains, respectively, negative surplus and more than 150 of surplus (but not bluffing) for player *B*. "Reveal" denotes offers containing surplus ≥ 0 for player *B* and reveal player *A* is type A_L, and "Bluff" denotes offers by A_L that mimic the theoretical offers from type A_H.

[b] There are thirty-six offers of 225; they were submitted by eleven different players A_L. The rejection rate on these thirty-six offers is 16.7%

[c] There is one offer of 525; it was rejected.

The A_H offers in the signaling game are presented in Table 4. Ninety percent of these offers are in the interval 375-525, but the mean in this interval is 454.9 and the median is 450, so both are well below the theoretical prediction of 525. This implies that (on average) A_H players are much less aggressive relative to the theoretical predictions than the A_L players who make revealing offers (225 or less): a revealing A_L offers *B* a cost about 5-20 less than his 225 cost under a dispute, but A_H offers about 75 less than *B*'s 525 dispute cost. Also note that the A_L offers greater than 375 have a mean of 456.6, and by this measure are indistinguishable from the

A_H offers. [PERHAPS WE WANT THE MEAN AND MEDIAN FOR AL OFFERS BETWEEN 375-525?]The medians however differ a great deal, with the median offer by an A_H player equal to 450 compared to 400 for A_L players who bluff.[12]

Table 4. Signaling Game Player A_H Offers and Rejection Rates

Player A_H Offers						Player *B* rejection rate (%)
Interval	Type[a]	n	%	Mean	Median	
< 375	> 150	5	3.8	299.4	311	40.0
375−399	Reveal	6	4.5	377.8	375	66.7
400−424	Reveal	34	25.8	407.6	400	58.8
425−449	Reveal	6	4.5	430.7	426.5	66.7
450−474	Reveal	27	20.5	451.1	450	63.0
475−499	Reveal	12	9.1	481.7	476.5	66.7
500−525[b]	Reveal	34	25.8	513.8	520	100
> 525	< 0	8	6.1	650.6	660	100
150−699	Total	132	100	460.9	450	73.5
375−525	Reveal	119	90.2	454.9	450	73.1

[a] "< 0" and "> 150" means offer contains negative surplus and more than 150 of surplus, respectively, for player *B* given that player *A* is type A_H. "Reveal" denotes offers containing surplus ≥ 0 for player *B* and reveal player *A*'s type as A_H.

[b] There are seven A_H offers of 525; they were submitted by six different A_H players. The rejection rate on these seven offers is 100%.

While the offer behavior in Tables 3 and 4 is not strictly compatible with a semi-pooling equilibrium, it is at least roughly consistent with such an equilibrium. Sixty-three percent of A_L offers are low revealing offers, while 12.3% are "bluffs" that are similar to A_H offers. Table 5 offers a closer look at the A_L offers that fall in the bluffing range (375-525). The A_L offers are

[12] For offers in the 375-499 range, we observe a 62% rejection rate on those submitted by A_H and an 83% rejection rate on those submitted by A_L (see Table 5 below). If *B* is unable to distinguish between the player types, then we would expect these rejection rates to be roughly equal. For all offers $\geq$ 375, the corresponding rejection rates are 74.8% and 88.4%.

concentrated in the lowest two intervals (16/34 or 47% in the 375-399 interval, and 6/34 or 18% in the 399-424 interval). By contrast, A_H offers are concentrated in three middle intervals: 27% (34/127) are in the 400-424 interval, 21% (27/127) are in the 450-474 interval, and 27% (34/127) are in the 500-525 interval.

Table 5. Bluffing Range Offers (Offers ≥ 375)

	A_L offers		A_H offers		All offers	
Interval	n	Rejection rate (%)	n	Rejection rate (%)	n	Rejection rate (%)
375−399	16	75.0	6	66.7	22	72.7
400−424	6	83.3	34	58.8	40	62.5
425−449	2	100	6	66.7	8	75
450−474	4	100	27	63.0	31	67.7
475−499	2	100	12	66.7	14	71.4
500−525	4	100	34	100	38	100
375−499	30	83.3	85	62.4	115	67.8
375−525	34	85.3	119	73.1	153	75.8
375−699	43	88.4	127	74.8	170	78.2

Player *B*'s rejection rates on offers between 375 and 499 range from 62.6% to 72.7%. *B* rejects all thirty-four offers in the 500-525 interval. Given the rejection rates on all offers for each of the intervals on Table 5, the expected value to A_L of bluffing in these ranges is similar to the expected value of making a revealing offer.[13]

In the unique equilibrium predicted by D1, there is no bluffing by A_L and A_H makes an offer of 525. These implications are clearly rejected by the data. Some A_L bluff, and the A_H offers are spread throughout the 375-525 interval. The reason D1 fails empirically is clear: All offers

[13] From Table 3, there is a 9.3% rejection rate on offers in the 200-225 range, and the median offer in this range is 220. This suggest an expected value of approximately 200 for an offer of 220. For bluffs in the interval between 375-499, a rough estimate of the expected value is (median offer in each range)×(1-rejection rate) + (rejection rate)×75. These computations are generally in the neighborhood of 200.

from 500-525 are rejected with a 100% probability. Given this, A_H players have an incentive to experiment with lower offers. Since offers below 500 are sometimes accepted, A_H players will deviate from the offer of 525. However, A_H players are unable to converge on a single offer below 525 in this process as required by a semi-pooling equilibrium. In other words, they realize they need to drop the offer below 500 to have it accepted, but the do not know how low they need to go. Furthermore, since rejection rate are still high in this range, some players who were not lucky enough to have an offer of, say, 475, accepted, might continue to drop their offer until it was accepted. Thus, given the high rejection rates, it is not surprising that different players might find different stopping points as they reduced their offers below 500.[14]

If A_H is dropping his offer below 525, player *B* has a strict incentive to accept these offers, unless some A_L players bluff. Thus, given the failure of the prediction implied by D1, the bluffing by the A_L players is required for a semi-pooling equilibrium. Player *B* will not accept offers of 500 or greater, because they offer little surplus even if they are made by A_H, and there is some chance that the offer represents a bluff. Empirically, about 90% (34/38) of the offers are between 500 and 525 are made by A_H players. Even if there is a 90% chance that an offer of 500 is made by an A_H player, the expected value maximizing choice for player *B* is to reject the offer.[15] Thus, player *B*'s rejection of these high offers is well founded empirically. While D1 is a useful refinement from a theoretical perspective, the evidence here suggests that this refinement has a limited empirical content, at least in this current context.

Offers between 226 and 374 should always be rejected by *B*. This prediction follows from a simple dominance argument. A_H should never make such an offer, as it is below her

[14] As mentioned above, the A_H offers are concentrated in three intervals 400-424, 450-474, and 500-525. The offers tend to be clustered at the lower ends of these intervals: the respective interval means and medians are 407.6 and 400, 451.1 and 450, and 513.8 and 520.

[15] The expected cost of a rejection is .9(525) + .1(225) = 495 which is less than the cost of 500 for an acceptance.

dispute payoff of 375.[16] Thus, *B* should conclude the offer is from A_L and reject it (if *B* accepts an offer in this range from an A_L player, then his resulting cost is higher than the 225 he incurs if he rejects it). However, from Table 3, the rejection rate on these offers is only 55%.[17] Over 90% of these 226/374 offers are made by A_L players, so rejection is empirically justified. As noted above, *B*'s rejection rate actually *falls* as the experiment progresses (in periods 7-12, *B*'s rejection rate is 43% on offers in this range). In many ways, this low rejection rate by *B* is the most troubling result for theory observed in our paper, because it is not a prediction stemming from the refinement D1, but instead follows from a dominance argument which is much more fundamental to game theory.

5.3. A Comparison Across the Two Games

The theoretical prediction is that in the signaling game A_L will demand 150 more than player *B* offers in the screening game. For offers in the range 75-225, the actual increase is 92 when evaluated at the mean and 120 when evaluated at the median.[18] Thus there is a substantial increase in the settlement offer, though not quite as much as predicted by theory. This is consistent with the idea that fairness concerns play some role in reducing what each player can extract when she has the ability to make the offer. Nevertheless, the results indicate that there is a substantial value to having the offer, as theory predicts.

Other comparative static predictions concern the dispute rate, and these results are summarized in Table 6. For offers in the range 75-225, the dispute rate for A_L players falls by 6.8 percentage points when we move to the signaling game. Similar offers are rejected less often in

[16] Six percent (4/64) of the observed offers in the 226-374 interval were made by A_H.

[17] Further analysis of the data reveals that in the 226-374 range, *B*'s median rejected offer is 321 and the median accepted offer is 300.

[18] Recall that in the range 75-225, offers are sorting in the screening game and revealing in the signaling game.

the signaling game. Offers of 75-100 in the screening game give the same surplus as offers of 200-225 in the signaling game, yet the offers in the signaling game are rejected 11.3% of the time, while the corresponding offers in the screening game are rejected 22% of the time. Similarly, offers of 175-199 in the signaling game are rejected 9.1% of the time, while the corresponding offers (101-125) are face a rejection rate of 13.7% in the screening game. Why are offers with similar surplus rejected more often in the screening game? In the screening game these are merely tough offers by player *B*. In the signaling game, these offers leave the same amount of surplus, but they also convey information; they tell player *B* that he is paired with an A_L player. A revealing offer saves player *B* from the difficult decision of how to respond to a bluff. In exchange for receiving this information, player *B* seems more willing to accept stingy offers in the signaling game.

Table 6: Dispute Rates: Signaling vs. Screening

		Difference in dispute rates[a] (Percentage points)	
Player type	Offer Range	Predicted	Observed
A_L	75-225	0	-6.8
A_L	All offers	0	+16.7
A_H	All offers	33	-18.7
Total	All offers	-11	+5.8

[a] Signaling game dispute rate minus screening game dispute rate

Overall, the A_L dispute rate is higher in the signaling game. This occurs due to the high dispute rate on offers greater than 225. Contrary to the predictions implied by D1, bluffing occurs, and this has important implications for the dispute rate. The overall dispute rate is higher in the signaling game even though the dispute rate for A_H players falls as predicted (although not as much as predicted). The 5.8 percentage point increase in the dispute rate for the signaling

game contrasts with the predicted 11 percentage point fall in this rate. This is the result of the bluffing activity of the A_L players which in turn stems from the failure of the predictions implied by D1.

There is one other point worth noting in making a comparison across the two games; there are many more poor offers made in the signaling game. As explained earlier, offers between 226-374 are very poor offers in both games. In the screening game 6% of player *B*'s offers fall in this in-between range. In the signaling game, 21% of A_L offers fall in this range. In the screening game, these offers are always accepted by A_L and almost always rejected by A_H, and these responses accord with theory. In the signaling game, these offers are accepted 45% of the time when theory suggests they should always be rejected. Thus, not only are more poor offers made in the signaling game, but these offers frequently engender a suboptimal response by the recipient. We believe that these differences across the games reflect the fact that the decisionmaking faced by the players is more difficult in the signaling game, and that this results in a greater percentage of poor decisions being made in this game.

6. Conclusion

Our results on the screening game are in line with previous experiments. While point predictions are missed, the theory does a good job in predicting the central tendencies of the offers and of the rejection behavior. As in previous experiments, player *B* generally makes screening offers. In fact, 87% of the offers clearly fall into this category. The median screening offer contains 1/6 of the joint surplus from settlement suggesting that fairness plays a relatively small role in this stylized bargaining environment. This is also consistent with previous experiments. Overall, the screening model has fairly good predictive ability.

Using the same parameter values as in the screening game, we switched the identity of the player making the offer to create a signaling game. To the best of our knowledge, this has not been done previously in the context of a experimental setting which can which can be interpreted as stylized legal bargaining. We believe that the problem posed to the experimental subjects is much more difficult in the signaling game than in the screening game. In the screening game, the recipient of the offer is the informed party and has a fairly trivial decision to make in deciding whether or not to accept the offer. The player making the offer has a more difficult decision, but latching onto the idea of a screening offer does not appear to an extremely difficult task. In contrast, in the signaling game, both the sender and the recipient of the offer have difficult problems to solve. In the case of the senders, A_L players have to decide whether they should bluff and then decide what offer would constitute a good bluff, while A_H players have to decide how much below 525 they need to shade their offer in order to ensure a reasonable chance of acceptance. In the case of the recipient, player *B* has an extremely difficult decision to make when he is faced with an offer above 375, because he cannot be sure whether the offer is from an A_H player or a bluffing A_L player.

Given these difficulties, we expect less adherence to theory in the signaling game compared to the screening. Whether this is true is (to some degree) a matter of judgment, but some things are abundantly clear in the results. First, the refinement D1 can be rejected as descriptive of player's belief formation, since the corresponding implications for player behavior are clearly violated. This is not terribly surprising, and in and of itself does not imply any violations of basic rationality. More disturbing is the acceptance of offers that should have been rejected using dominance arguments. This does appear to violate the rationality assumptions in a nontrivial way. The theoretical rejection function for player *B* is discontinuous and non-

monotonic. Theory predicts that the rejection rate jumps from 0% at 225 to 100% between 226 and 374, and then falls below 100% for offers above 375.[19] The empirical rejection function is 0% for demands below 175 and then rises monotonically up to up to offers of 375. The rejection rate fluctuates between 62.5-72.7% until the offers reaches 500, where the rejection rate jumps up to 100%. Empirically, it may be difficult for subjects to match the prediction for a rejection function which is both discontinuous and non-monotonic.

Other aspects of subject behavior appear to be in reasonable conformance with theory. Rejection behavior on offers below 225 and offers over 375 is roughly in line with theory, at least if we abandon the implications of D1. Aside from the "in-between" offers discussed above, the offer behavior of the *A* players is roughly in line with theory. A high percentage of A_L players make a revealing low offer, while almost all A_H players make offers which separate them from these A_L players. Twelve percent of A_L players bluff, by making an offer that mimics those of the A_H players. The bluffing A_L players and the A_H players do not converge on a single offer as they would in a semi-pooling equilibrium, but it would have been rather miraculous if they had. There is a continuum of such equilibria, and player feedback was limited to their own bargaining experience.[20]

Clearly, the signaling model deserves more experimental attention. It is one of the two informational based models of pretrial bargaining, and it is therefore vital to gain further insights into how well the predictions of the model are reflected in actual behavior.

[19] This differs from the prediction when D1 is imposed, but D1 is clearly rejected by the data.

[20] Furthermore, if player *B* accepted a high offer, he would never learn whether it was a bluff or not.

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