Experimental Results on Bargaining Under Alternative Property Rights Regimes

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The effect of alternative property rights regimes on the choice between taking an object and acquiring it via a consensual exchange is experimentally explored in a two-period screening game. Results are generally consistent with equilibrium predictions, suggesting that property rights regimes have a significant impact on observed behavior.

1. Introduction

It has long been recognized that incomplete information is itself a bargaining or transaction cost which leads to inefficient delay in bargaining over the exchange of legal entitlements (see, e.g., Cooter, 1982; Samuelson, 1985; and Farrell, 1987). Recently, Ayres and Talley (1995) and Johnston (1995) have shown that by blurring up or creating uncertainty regarding the ownership of a legal entitlement, the law may actually improve incentives in incomplete information bargaining over its exchange. This result is related to the general incentive compatibility effect of uncertain ownership first demonstrated by Cramton, Gibbons, and Klemperer (1987), but what drives it is that under blurry or uncertain entitlements, ownership of an entitlement itself is unclear ex ante, so that a potential buyer may credibly threaten to bypass bargaining and instead simply take the entitlement and await a legal determination of its ownership. Such credible taking threats may reduce the incentive for potential sellers to hold out. Buyers may use the credible threat to take as an alternative to delay cost as a means of screening seller types (see Johnston (1995)).

In the canonical nuisance setting described by Coase (1960), for example, the law might clearly assign a property right to a resident to be free of harm caused by an adjacent factory's smoke (a regime which would obtain if the law held that the smoke was a trespass). In the alternative regime, the law might determine whether or not the resident

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had an entitlement to be free of harm caused by the factory's smoke by balancing the harm caused by the smoke against the value generated by the factory's operation. Such balancing would occur only *after* the factory commenced operation and spewed smoke upon its neighbor. Under such a legal regime (which is roughly equivalent to that which governs such disputes under the common law of nuisance), asymmetric information as to the magnitude of the resident's harm might well create an incentive for the factory simply to operate and cause harm without first getting the resident's consent (to "take" the entitlement), or to credibly threaten to do so. By contrast, were ownership of the entitlement definite rather than contingent upon the outcome of ex post balancing, taking would be credible only because the sanction for such a taking was weak (a low damage payment, for example).

At the very least, the recent work on incomplete and uncertain entitlements and bargaining implies that alternative entitlements regimes ought to affect not only equilibrium bargaining behavior, but the choice between bargaining and taking an entitlement. Existing experimental work in law and economics such as Hoffman and Spitzer (1982, 1985) has focused on testing Coasean predictions regarding the effect of alternative assignments of *definite* entitlements on bargaining efficiency and distribution. Related work has explored whether the way in which such definite entitlements are acquired affects subjects' sense of distributionally "fair" outcomes (Hoffman et. al., 1994) and how institutions affect bargaining outcomes (Croson and Mnookin, 1997). More recently, McKelvey and Page (1998) compare outcomes predicted by Coasean and Myerson−Satterthwaite (1983) theorems under complete versus incomplete information in two-party bargaining. Previous experimental work has not, however, tested predictions regarding the effect of alternative forms of legal entitlement—definite versus contingent—on bargaining and taking behavior. It is this gap in the literature which we address here.

Our experimental treatments are based on a game-theoretic analysis of bargaining versus taking in a two-period screening model developed by Johnston (1995). We find behavior consistent with equilibrium predictions in three of the four alternative entitlement regimes. We also examine comparisons across these regimes. While we confirm all of the predicted comparative results, we also find some *unpredicted* differences across regimes. These results suggest a role for further experimentation and behavioral research in this area. In the next section we describe our model and its predicted equilibria under our chosen parameters. We then describe the experimental treatments and present the results. We conclude by discussing directions for future research and the potential policy implications of the results.

2. The Model and Predicted Equilibria

We analyze the choice between bargaining for and taking a legal entitlement in a two-period screening model derived from Johnston

(1995). In the model, there is a single object. The uninformed player's valuation of the object, given by v, is common knowledge. For simplicity, it is assumed that the informed player's valuation of the object, V_i is uniformly distributed over three possible realizations, l, m, or h. This distribution is common knowledge but the realization is known only to the informed player. Period 2 payoffs are discounted by a (common) factor δ with $0 < \delta < 1$.

In the first period of the two-period game, the uninformed player chooses between taking (or "capturing") the object and offering to buy the object for a stated price p. If the uninformed player captures the object, then the legal system is costlessly invoked to determine whether the capture succeeds or not and the payoffs from capture. [One may think, for concreteness, of adjacent streamside owners (riparians); when one riparian draws water out of the stream, the other may seek to obtain a court ruling that the user has no right to divert the stream's flow in that manner or volume.] As the example indicates, the payoffs from capture are a function of the particular legal rights regime that is in effect. If the uninformed player has instead made an offer, then the informed player must decide between accepting and refusing the offer. If the offer is accepted, then the payoffs to the informed and uniformed player are given by p and $v - p$, respectively. If a first-period offer is rejected by the informed player, then the game moves to the second period, where the uninformed player moves first and chooses between capturing or conceding. If the uninformed player concedes in period 2, then the informed player's payoff is given by δV_i while the uninformed player receives a payoff of some $F > 0$. (This may be rationalized by imagining that the informed player's ability to realize value from the object is postponed by virtue of the uninformed player's challenge to possession, while the assumption that the uninformed player gets a positive payout F when it concedes means that the decision to capture instead of conceding has a positive marginal cost.) If the uninformed player chooses to capture in the second and final period, then payoffs are a function of the particular property rights regime in effect, but are discounted by δ.

This is a simple version of a screening model, but the phenomena it captures—the use of delay cost as a screening device—is in fact characteristic of much more general bargaining frameworks (including signaling models in which the informed player may make offers). We chose an experimental design to implement this model.

2.1 Predicted Equilibria Under Alternative Property Rights Regimes

As indicated by this general description, equilibria in this game are a function of the particular property rights regime which is in effect, for that regime determines the payoffs in the event of an unconsented taking or capture. We conducted experiments with four such regimes, holding the parameters v, V_i, and δ constant across regimes. In our experiments, we set $v = 8$, $l = 4$, $m = 6$, $h = 10$, and $\delta = 1/2$. The parameter values were chosen to generate unique and distinct Bayesian perfect equilibrium predictions under the alternative property rights regimes. We chose a discount rate that was easy for subjects to calculate accurately in real time.

2.1.1 Definite Entitlement Protected by a Property Right.

This regime is meant to capture what economists most often mean when they speak of "property rights": a world in which it is ex ante common knowledge that one or the other of the parties does in fact have a legal entitlement to the object ex ante, while the other does not, and any attempt to take an entitlement without consent will be severely punished by the law.[1] With sufficiently severe punishment, and definite ex ante ownership, taking the entitlement is not a credible action, and the entitlement will be exchanged, if at all, only via a consensual transaction.

For this regime, we suppose that the informed player has the definite legal entitlement to the object and that the punishment for unconsented taking is sufficiently severe that capture is never credible. With such a regime, our two-period model reduces to a particular, simplified version of the general model of incomplete information bargaining developed by Fudenberg, Levine, and Tirole (1983). Under our parametric assumptions, it is straightforward to see that by making a first-period offer of $p = \delta m = (1/2)(6)$, the uninformed player will induce both the l- and m-type informed entitlement holders to accept immediately (since rejection would simply be followed by concession and the same discounted payoff from the m type and a lower payoff for the l type), and that such a strategy is payoff maximizing for the uninformed player.

2.1.2 Definite Entitlement Protected by a Liability Rule.

This regime gives the uninformed player an entitlement to capture the object, provided that the player paid damages equal to the expected value of the object to the informed player. This regime would conventionally be understood as a "liability" rule in the law and economics literature. It conforms quite closely to what the government's eminent domain authority would look like were the government required to compensate at an average damage rate for any taking of private property. That is, one may also think of this regime as awarding an entitlement to the object to the informed player, but protecting that entitlement from unconsented takings only up to the average value. The rationale for using average value is that under the common law of trespass and nuisance, a plaintiff is entitled only to those aspects of loss which she can actually prove to the court. In particular, plaintiffs with high subjective value (enjoying

1. Such a regime represents the reduced form of the "property rights" regime introduced by Calabresi and Melamed (1972), in that the right to an injunction is in effect the right to impose a severe contempt sanction on any actor who takes without consent.

lots of consumer surplus in a competitive market) will virtually always receive damages which are less than their actual value. Courts typically do not even attempt to discern and compensate for subjective losses above market values. Indeed, the equitable remedy of an injunction is under the classical common law approach reserved for precisely those cases in which damages will be undercompensatory because subjective value is likely to greatly exceed market value. Nor, on the other hand, do common law courts attempt to determine if market-based compensation is actually more than the plaintiff's true value. We use average value because it has the same qualitative effects—severely undercompensating some plaintiffs, overcompensating others—as market-based compensatory damages.

With our parametric assumptions, the average value of the object to the informed player is 6.67. An immediate taking would consequently generate a (certain) payoff of $8 - 6.67 = 1.33$ to the uninformed player, and it has indeed typically been assumed in the law and economics literature that such a regime necessarily induces parties to bypass bargaining [see the discussion in Ayres and Talley (1995)]. However, this is generally false [see Ayres and Talley (1995), and Johnston (1995)], and does not hold for our parametric assumptions. Instead, by credibly threatening to take and pay average damages, the uninformed party can induce *all* three types of informed players to accept a first-period offer equal to the discounted value of average damages, or 3.33. Our parameters generate a case in which strict liability for average harm enables the uninformed party to obtain the object by consensual exchange.

2.1.3 Perfect Balancing (Perfect Contingent Entitlement).

Under perfect balancing, the law does not make a definite ex ante assignment of the entitlement to the object. Rather, the entitlement—ownership of the object—is contingent upon the outcome of an ex post inquiry by the legal decision maker into its relative valuation, an inquiry that is triggered by an unconsented taking of the entitlement from the party who begins in possession. The example of the polluting factory and its residential neighbor so common in economists' discussions of externalities illustrates a regime of contingent entitlements. Under American common law, whether or not a resident has an entitlement to be free of harmful pollution is not known ex ante, but depends instead on how a court will balance the utility of the factory's operation against the harm to the resident. In an ideal or perfect balancing regime, the court obtains better ex post knowledge than the parties had ex ante, and learns both the informed and uninformed player's value, awarding the entitlement to whichever player values the object most highly.

The effect of such a perfect balancing regime is to create a chance that the uninformed player in fact has the legal entitlement to the object, that if she takes the object, the court will find that it was hers all along, because she values it more highly than does the informed player who began with it. To be more precise, under a balancing regime, capturing the object will be credible if there is a sufficiently great chance that the capturer will be awarded the entitlement by the court.

As a general result [see Johnston (1995)], when the balancing regime is perfect—in the sense that when there is a capture, with probability one the court costlessly awards the entitlement to the player who values it most highly—then there is no incentive for the uninformed player to bargain. Instead, the object is taken immediately by the uninformed player. In a sense, perfect and costless ex post verification completely supplants private bargaining.[2] On our parametric assumptions, trade is ex ante efficient (that is, $8 > 20/3$), and hence the unique equilibrium under a perfect balancing regime is for the uninformed player to capture in period 1.

The difficulty with this hypothesized regime is that it supposes that the court can perfectly verify ex post (the informed player's value) what is only imperfectly observed by the other private party ex ante. This assumption of perfect ex post verifiability is rather unrealistic. We relax it in the next and final treatment.

2.1.4 Imperfect Balancing (Imperfect Contingent Entitlement). It may be unrealistic to think that the court can somehow obtain perfect ex post information regarding the players' relative valuation of an object when that knowledge was asymmetrically distributed between the players ex ante. At the same time, if legal fact-finding (ex post verification) is at all rational, then it would seem reasonable to suppose that the probability that the court awards the entitlement to one player increases, the bigger is that player's valuation relative to the other player's valuation. To formalize such a rational but imperfect ex post verification process, let $P_i = \Pr[i$ type informed player gets the entitlement], and let $P_l = 0$, $P_m = 5/6$, $P_h = 31/36$. These values capture a legal process which is biased against the uninformed player (for even when the informed player's value is only 6, she still wins with probability 5/6 against an uninformed player with value of 8). The legal process is nonetheless rational, in that the bigger the informed player's value, the higher is the probability that she gets the entitlement. It is, finally, much better at coarse, relative evaluations than absolute evaluations. The informed player's probability of winning is 0 when her value is much smaller than the uninformed player's, but at least 5/6 when her value is near the uninformed player's. One may think of this as the natural outcome of adversary incentives under a balancing test: lawyers' incentives are to compare their clients' value with the opponents'.

2. This result hinges on the assumption that there is no private cost when capture is unsuccessful.

In general, when ex post balancing is imperfect, the uninformed player's dominant strategy may be to bargain in the shadow of a credible taking threat. That is, rather than using delay to screen out the low-value types, the uninformed player may use a threat to take and be declared the entitlement holder as a way of inducing low-value types to agree to consensually exchange the entitlement without delay. For reasonable specifications of the legal balancing process (via the function P_i), such a strategy generates a higher payoff to the uninformed player than simply capturing immediately [see Johnston (1995)]. On the particular specification chosen for our experimental treatments, the unique Bayesian perfect equilibrium is for the uninformed player to offer $P_m(1/2)(6) = 2.5$ (which is the expected discounted payoff to an m-type informed player if she rejects the offer, and the informed player captures in period 2), and to then capture if the offer is refused. Both the l- and m-type players accept this offer. As can easily be verified, such a strategy generates an expected payoff of $416/108 \cong 3.85$ to the uninformed player, which exceeds the payoff of $376/108 \cong 3.48$ that she would obtain by capturing immediately.[3]

2.1.5 A Summary of Equilibrium Predictions. Table 1 summarizes the predicted equilibrium behavior for both the informed and uninformed player in our four alternative property rights environments. Observe

Table 1. Predicted Equilibrium Behavior Under Alternative Property Rights Regimes

Regime / Player	Uninformed Player	Informed Player
Definite property right	Offer $p = 3$	l, m accept; h rejects
Perfect balancing	Capture immediately	
Imperfect balancing	Offer $p = 2.5$; capture if p refused	l, m accept; h rejects
Liability for average harm	Offer 3.33; capture if p refused	All accept

3. Under the offer-in-the-shadow strategy, the uninformed player uses a credible threat to capture if the period 1 offer is refused to induce the l and m informed player types to accept a low period 1 offer (equal to $\delta P_m 6 = 2.5$). The return from this strategy is given by

$$(2/3)(8 - 2.5) + (1/2)(1/3)8P_h = (2/3)(5.5) + (4/3)(5/36) = 416/108.$$

The uninformed player's expected return from an immediate taking is given by

$$(1/3)(8)(3 - P_m - P_h) = (8/3)(3 - 5/6 - 31/36) = 376/108.$$

As can be seen, the return from the strategy of bargaining-in-the-shadow of a credible taking threat is higher than the return from an immediate taking, given the parameters used. As can also be verified, taking after rejection by only the h type is indeed credible in period 2, since $(5/36)8 > F = .5$.

that only under a blurry or imperfect balancing regime do we expect to observe equilibria involving two periods of play. Under both the definite property right and the definite property right with strict liability for average harm, we expect to observe an immediate consensual exchange, but inefficient exchange occurs only under the liability regime. Only under the perfect balancing regime does the model predict an immediate taking.

3. The Experiment

3.1 Experimental Design

We designed and ran a four-treatment between-subjects experiment to implement and test this model. Since we wanted to mimic the type of confrontation seen in a nuisance dispute, the experiment was framed and played as an adversarial card game between two subjects in which the winner earns money (like poker or other games).[4] The numbers on the cards of each player represented that player's value for the object in the model. Four different legal regimes were modeled by changing the rules of the card game; that is, by changing who wins or loses with what cards when one side captures the other's card.

In all treatments, the uninformed player (called Player Up in the instructions) was seated at a desk with a normal playing card face up. In all treatments, this card had the value 8 and this value was common knowledge, just as in the model.

The uninformed player then shuffled three other playing cards—a 4 (l), a 6 (m), and a 10 (h)—and presented them face down to the informed player (called Player Down in the instructions). The informed player chose one card at random, looked at it, and placed it face down on the desk. Thus, as in the model, the informed player's value for the entitlement was drawn from a commonly known uniform distribution $[l, m, h]$ and was private knowledge.

In all treatments, the possible moves were the same and were parallel to the model described in Section 2. First, the uninformed player chose either to make an offer to the informed player or to capture the other player's card. If the uninformed player captured, the game was over, and the outcome resolved differently under the four legal regimes (four treatments). If the uninformed player made an offer, the informed player could either accept or reject. If the informed player accepted the offer, the game was over; the uninformed player earned her value in dollars ($8) minus the accepted offer amount, while the informed player earned the offer which he had accepted. If the informed player rejected the offer, the discount rate δ was applied and all payoffs were cut in half. At this time, the uninformed player again had two choices. First,

4. Card game implementation of experiments has been used previously, and is thought to induce more competitive behavior than other implementations [see, e.g., Andreoni and Varian (1993)].

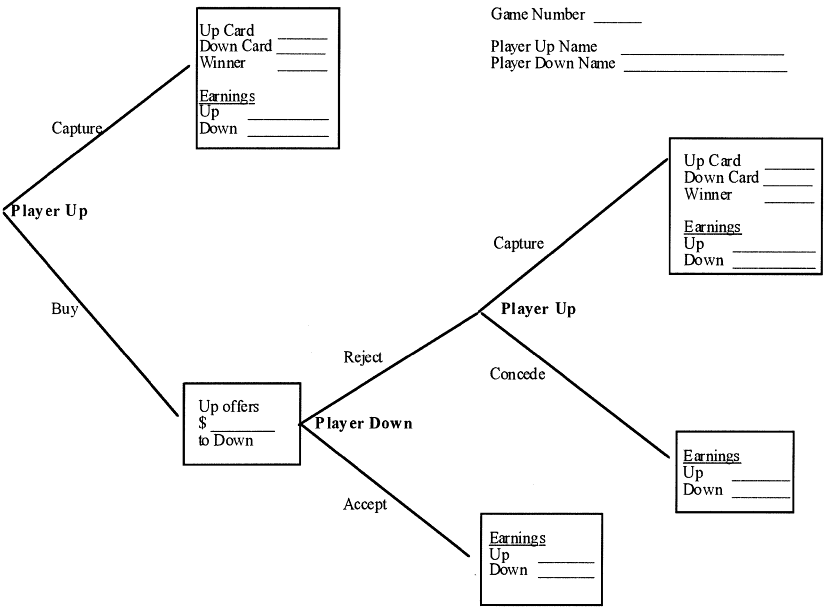

Figure 1. The game board.

she could capture with the same rules as before, but with payoffs cut in half, or she could concede (simply stop the activity), earning a nominal amount (50¢) while the informed player earned one-half of her card's value. Figure 1 shows the game as the subjects saw and played it.

Four different treatments corresponding to the four entitlements regimes described above were run; these treatments differed in what happened when the uninformed player captured. The discussion below refers to a capture in the first round; payoffs were multiplied by .5 if the capture occurred in the second round.

3.1.1 Definite Entitlement Protected by a Property Right. In this treatment, the entitlement belongs to the informed player, thus if the uninformed player captures, the informed player always wins. In the experiment, this was implemented by assuming that if the uninformed player chose capture, the informed player would automatically win, earning the value on their (face down) card while the uninformed player earned zero.

3.1.2 Definite Entitlement Protected by a Liability Rule. In this treatment, the entitlement again belongs to the informed player, but the legal regime allows the uninformed player to capture provided she pays damages equal to the expected value of the object to the informed player. In the experiment, this rule was operationalized by assuming that if the uninformed player captures, she wins, earning the value of her card ($8), less the expected (rather than actual) value of the informed player's card, which equals $6.67 on our parametric assumptions. Thus a capture move earned the uninformed player \$1.33 and the informed player \$6.67.

3.1.3 Perfect Balancing (Perfect Contingent Entitlement). In this treatment, the entitlement is contingent upon the valuations of the players. Here we assume the court balances perfectly. In the experiment, if the uninformed player captures, the informed player reveals his card, and the player with the higher-valued card wins, earning that amount in dollars. The other player earns zero.

3.1.4 Imperfect Balancing (Imperfect Contingent Entitlement). In this treatment, the entitlement is again contingent upon the valuations of the players, but we assumed an imperfect balancing process. As described above, if the valuations are too different, that is, the informed player's valuation is $l = 4$, then the court always decides in favor of the uninformed player. However, if the valuations are close, there is some randomness introduced into the process. If the informed player's valuation is $m = 6$, then the uninformed player wins with probability $1/6$. If the informed player's valuation $h = 10$, then the uninformed player wins with probability $5/36$. As above, when the uninformed player chose capture, the informed player revealed her card. Then, if necessary (i.e., for informed player card value equal to 6 or 10), two dice were rolled to determine the winner. The winner earned the value on her card and the loser earned nothing.

3.2 Experimental Procedures

All subjects were University of Pennsylvania undergraduate or graduate students; 34, 36, 30, and 144 subjects participated in the four treatments above, respectively. The final treatment has an increased subject size to counteract the addition of randomness in the experiment. Subjects were given written instructions which were also read aloud to create common information. Instructions can be found in the Appendix. Subjects were assigned to a role (uninformed player or informed player) and kept the same role throughout the experiment. In an experimental session participants played the same game multiple times, each against a different opponent. We used a zipper matching algorithm, so not only was each matching one-shot, contamination effects were avoided as well.[5] Subjects in all treatments played 18 games each against different counter-

5. In this algorithm, subjects are arranged in pairs and ordered. For example, imagine that there are 20 subjects arranged in 10 pairs. Call the subjects in pair 1, 1a and 1b, in pair 2, 2a and 2b, and so on through 10a and 10b. After each round, all b players shift one to the left, so the new pairings in round two are 1a–2b, 2a–3b, . . . , 10a–1b. In round three, the pairings are 1a–3b, 2a–4b, . . . , 10a–2b. This algorithm guarantees not only that subjects never meet the same opponent more than once (as a random pairing algorithm would not guarantee), but also that no subject plays against a subject who has played against someone who has played against him (contamination effects).

parts and were told they would receive as a monetary payout their result in one game chosen at random. Descriptive statistics will report the results of all the games pooled together, although statistical tests will use the more conservative measure of one observation per subject.

At the time the players had to make their decisions, they faced the game board, which looked like Figure 1. The equilibria of these games are characterized in Section 2 and will serve as our predictions for play. The next section presents those predictions more formally as hypotheses, and characterizes the results.

4. Results

In this section we present two types of experimental results. The first subsection describes the results from each treatment and compares them with the equilibrium predictions. The second subsection compares the experimental results between treatments and more closely addresses the question of the impact of varying regimes.

4.1 Within-Treatment Results

In this subsection we generate hypotheses based on the equilibrium predictions of each game. However, many of these predictions are endpoint predictions (e.g., the uninformed player always offers to buy the informed player's card), thus they are not statistically tested. Statistical tests of differences between treatments are provided in the next subsection.

4.1.1 Definite Entitlement Protected by a Property Right. The equilibrium in this treatment involves:

Hypothesis 1. The uninformed player always offers to buy the informed player's card.

Hypothesis 2. The uninformed player always offers \$3.00.

Hypothesis 3. The informed player accepts when his private value is low (4) or medium (6) (66% of the time).

Hypothesis 4. When an informed player rejects, the uninformed player always concedes.

The data from the experiment are consistent with these predictions.

Result 1. In 90% of the games, the uninformed player offered to buy (138/154). This result is consistent with equilibrium play.

Result 2. The average uninformed player's offer was \$3.80 (standard deviation 1.13). Although the offers made by the uninformed players were somewhat higher than expected, 38% of these offers were exactly \$4, an equal split of the \$8 profit the uninformed player would earn. We conjecture that even the card-game implementation of our experimental design was not enough to overcome the social norm toward fair divisions in bargaining games [see Roth (1995) for a review of other experiments which describe this norm].

Result 3. Informed players accepted 81% of the time. This is somewhat higher than the 66% of the time we expected informed players to accept; in part caused by the higher offers being made. Figure 2 depicts offers and responses in this treatment.

Result 4. When informed players rejected, the uninformed player conceded 96% of the time (25/26). In this treatment, the uninformed player lost automatically when choosing to capture, so we expected rational subjects would choose to concede and earn 50¢ rather than capturing and earning 0. Almost all subjects in this position chose to do so.

4.1.2 Definite Entitlement Protected by a Liability Rule. The equilibrium of this treatment involves:

Hypothesis 1. The uninformed player always offers to buy the informed player's card.

Hypothesis 2. The uninformed player always offers $3.33.

Hypothesis 3. The informed player always accepts.

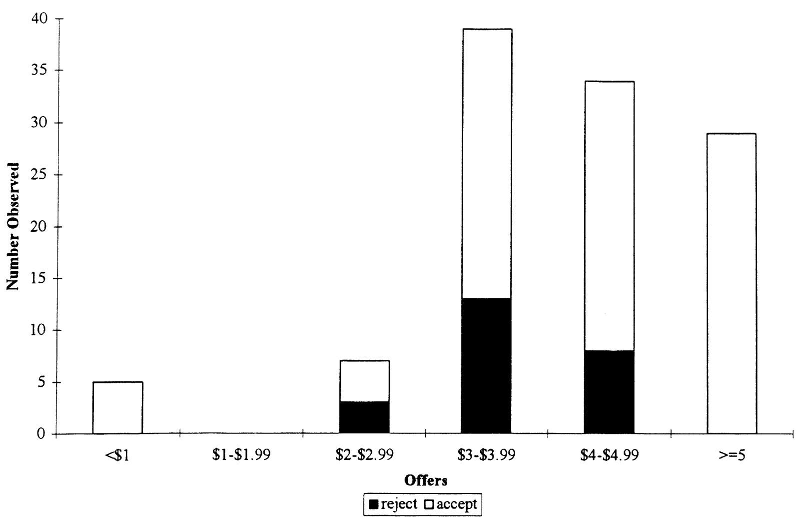

Figure 2. Offers and responses: definite entitlement protected by a property right.

The data from the experiment are also consistent with these predictions:

Result 1. In 99% of the games, the uninformed player offered to buy (164/166). This result is consistent with equilibrium play.

Result 2. The average uninformed player offer was $3.96 (standard deviation 0.72). Again, we found offers somewhat higher than expected, perhaps due to concerns for fairness. Fifty-nine percent of these offers exactly equalled $4.

Result 3. Informed players accepted offers 88% of the time (144/164). This result is also consistent with equilibrium play. Figure 3 graphs offers and responses in this treatment.

4.1.3 Perfect Balancing (Perfect Contingent Entitlement). The equilibrium of this treatment involves:

Hypothesis 1. The uninformed player always captures immediately.

The data from the experiment are consistent with this prediction:

Result 1. In 83% of the games, the uninformed player captured immediately (118/142). Consistent with the theory, a perfect court system supplants private bargaining. Figure 4 graphs offers and responses for this treatment for the remaining pairs (who did not capture).

4.1.4 Imperfect Balancing (Imperfect Contingent Entitlement). The equilibrium of this treatment involves:

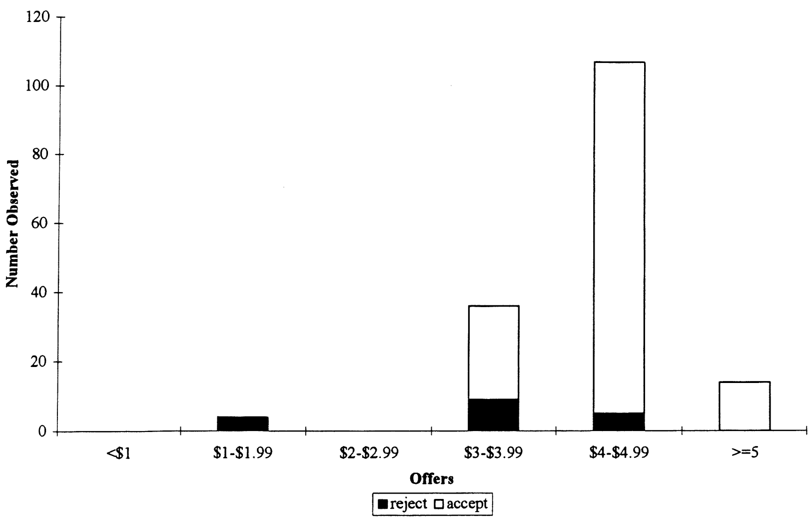

Figure 3. Offers and responses: definite entitlement protected by a liability rule.

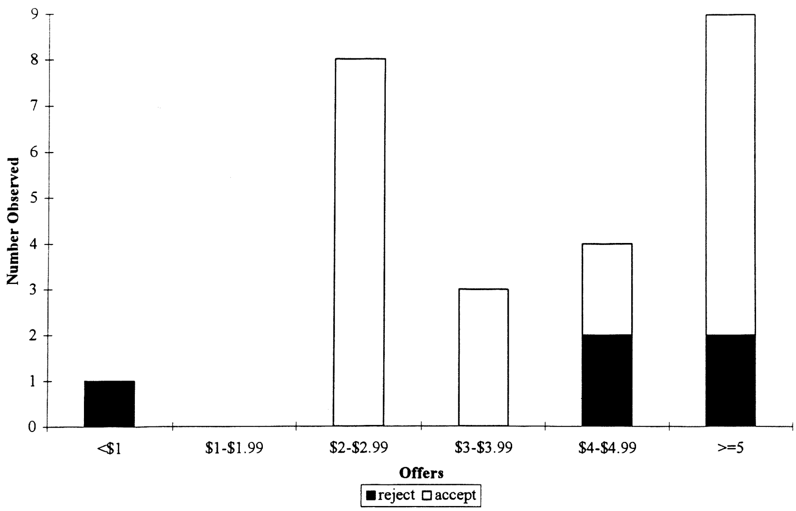

Figure 4. Offers and responses: perfect balancing (perfect contingent entitlement).

Hypothesis 1. The uninformed player always offers to buy the informed player's card.

Hypothesis 2. The uninformed player always offers $2.50.

Hypothesis 3. The informed player accepts when his private value is low (4) or medium (6) (66% of the time).

Hypothesis 4. When the informed player rejects, the uninformed player captures.

Experimental results were farthest from equilibrium in this treatment. In particular, we find:

Result 1. In 59% of the games, the uninformed player offered to buy (759/1282). While the majority of games involved the uninformed player trying to buy, this number is somewhat far from the equilibrium prediction. There are two possible explanations for the relative failure to buy in this treatment. The first is that the difference between expected payoff of this equilibrium and the immediate capture option was relatively small ($3.85 versus $3.48). The parameters were chosen in order to maximize the difference between treatments, not to strongly determine an equilibrium in this particular treatment. However, subjects who were debating between the two may have found reasons to choose capture. Second, the dice roll in the capture scenario may have influenced subjects' decisions. Previous research in psychology has demonstrated that subjects occasionally suffer from an illusion of control, believing that they can affect the roll of a die or that they are unusually lucky [see, e.g., Presson and Benassi (1996)]. If subjects in this experiment believed that the dice roll would inevitably fall their way, they may have been more eager to capture than expected.

Result 2. The uninformed player's average offer was $3.54 (standard deviation 0.94). As in previous treatments, we suspect the fairness norm leads to higher offers than predicted. Thirty-six percent of these offers were exactly $4.

Result 3. Informed players accepted offers 56% of the time (423/759). This result is not too far from the predicted 66% acceptance rate. Figure 5 graphs offers and responses for this treatment.

Result 4. In 80% of the games, the uninformed player captured in response to a rejected offer. This result is quite consistent with the equilibrium prediction of always capture after a rejection.

4.1.5 Summary of Within-Treatment Results. Overall, the experiment generated play consistent with the equilibrium predictions. In the first three treatments we observed uninformed player actions quite close to the prediction, although offers were somewhat higher than expected, perhaps due to fairness considerations. Informed player behavior was also extremely reliable.

In the fourth treatment (imperfect balancing), however, behavior was further from equilibrium. In particular, uninformed players were more willing to capture than was predicted by the model. This treatment was the most cognitively difficult for the players, since it involves a calculation of optimal strategies under uncertainty. We hypothesize that an

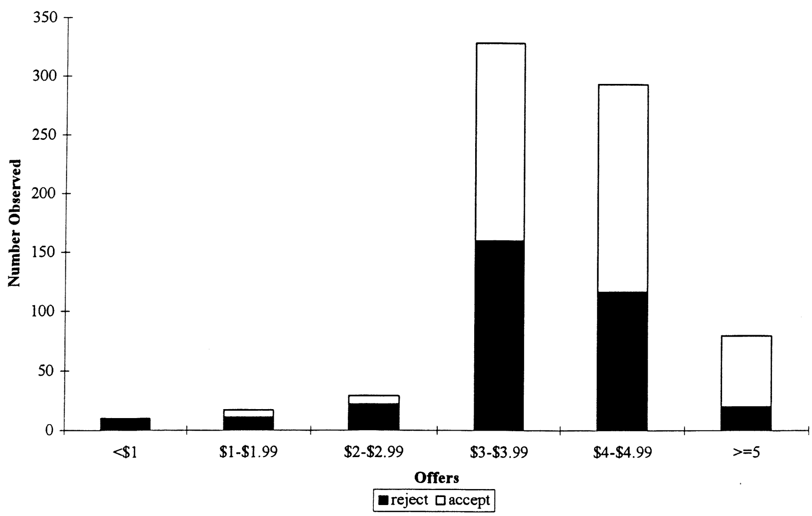

Figure 5. Offers and responses: imperfect balancing (imperfect contingent entitlement).

illusion of control over the random process increased capturing above the optimal, predicted level.

4.2 Results Across Treatments

This subsection provides some statistical comparisons of behavior across treatments. These comparisons are particularly interesting, as they enable us to draw conclusions about the costs and benefits of the different legal regimes from observed (in addition to theoretically predicted) behavior. These tests allow us to compare not just the point predictions of the treatments, but the comparative statics between the treatments. Thus, for example, we can incorporate the amount of noise each legal regime behaviorally generates into our comparisons and conclusions.

4.2.1 First-Stage Behavior: Capturing.

Comparing our equilibrium predictions of the four treatments, we generate our hypothesis of the comparisons between them. In particular, we predict that the amount of first move capture observed in the perfect balancing treatment will be significantly higher than in the other three.

Hypothesis 1. Pr(period one capture | property rights entitlement) = Pr(period one capture | damages entitlement) = Pr(period one capture | imperfect balancing) = 0 < Pr(period one capture | perfect balancing) = 1.

We can use a *t*-test of proportions to compare the proportion of capturing moves in each treatment. We find results quite consistent with our hypothesis.[6] As predicted, we find that the proportion of uninformed players who captured in the first period is significantly more in the perfect balancing treatment than in any of the other three treatments ($p < .001$ for all comparisons). However, we also find some additional, unhypothesized differences between the treatments.

We find significantly less capturing behavior in the damages entitlement treatment (1%) than in the property rights entitlement treatment (10%) or in the imperfect balancing treatment (41%) ($p < .001$ for both

6. The *t*-test examines differences in proportions between two samples. If p_i is the proportion of successful observations and n_i the number of observations in sample i, the *t*-statistic is given by

$$\frac{p_1 - p_2}{\sqrt{\dfrac{p_1(1-p_1)}{n_1} + \dfrac{p_2(1-p_2)}{n_2}}}.$$

We use the more conservative interpretation of one observation per individual for purposes of these statistical comparisons (n_i = 34, 36, 30, and 144) for the four treatments, respectively.

comparisons). We also find a significant difference between the uninformed player capturing behavior in the damages entitlement and imperfect balancing treatments ($p < .001$).

While the comparative statics predictions of behavior in these four treatments is as predicted, there are also some unpredicted differences between the treatments. These unanticipated differences have important policy implications, discussed in Section 5.

4.2.2 Second-Stage Behavior: Accepting Offers. Only three of the treatments' equilibria predict the game will reach the second stage. Of those treatments, the equilibria predict:

Hypothesis 1. Pr(p accepted | liability rule entitlement) = 1 > Pr(p accepted | property right entitlement) = Pr(p accepted | imperfect balancing entitlement) = .66.

The same t-test of proportion again finds results consistent with this prediction. The proportion of acceptances in the damages entitlement condition (88%) is (almost) significantly higher than that in the property rights entitlement (81%) condition ($p = .057$) and significantly higher than the imperfect balancing condition (56%, $p < .001$). However, we also find a significant difference between acceptances in the property rights entitlement and the imperfect balancing conditions ($p < .001$). As in the first analysis, while we find the predicted comparative statics differences, we also find additional, unanticipated differences with important implications.

4.2.3 Second-Stage Behavior: Conceding. In two of the four treatments, the equilibrium prediction involves a final move by the uninformed player. In particular, in the property rights entitlement treatment, the equilibrium predicts that all uninformed players reaching this stage will concede if her offer is rejected, while in the imperfect balancing treatment, the equilibrium predicts that all uninformed players will capture if the game reaches this stage.

Hypothesis 1. Pr(concede | property rights entitlement) = 1 > Pr(concede | imperfect balancing entitlement) = 0.

The same t-test of proportions finds results strongly consistent with this prediction. The proportion of concessions in the property rights entitlement condition (96%) is significantly higher than that proportion in the imperfect balancing treatment (19%, $p < .001$).

4.2.4 Summary of Between-Treatment Results. These results test the comparative statics of the theory. Overall they are extremely consistent; every difference between the treatments which was hypothesized was in fact observed.

However, we also observed some *unhypothesized* differences between the treatments. These results suggest that the choice of property rights regimes may have behavioral consequences which are not anticipated by theory. They also reinforce the importance of using experiments in combination with theory in order to study these questions by demonstrating what experiments can add to the discussion. Some explanations for the unhypothesized differences are outlined in the next, concluding, section.

5. Conclusion and Discussion

Perhaps the central implication of our experimental results is that the way in which the law defines property rights strongly influences the private choice between bargaining for consensual exchange and taking without consent. Ever since Coase's (1960) original insight that "externalities" problems occur because of a failure to define and assign legal entitlements (either to harm or take, or to be free of harm) there has been a tendency within the law and economics literature to assume that this is pretty much all that economists have to say about the problem: as long as property rights are assigned, exchange will occur. Game theorists, in contrast, have been ahead of the law and economics literature in investigating when and whether breakdown can occur even when property rights are clear and assigned (see, e.g., Myerson and Satterthwaite 1983).

Even the recognition that incomplete information and other transaction costs may cause the breakdown or inefficiency of exchange has led to few formal predictions [see Ayres and Talley (1995) and Johnston (1995)] regarding how such problems might be remedied by the law. Our results indicate that alternative legal approaches to defining and protecting entitlements lead to dramatic differences in behavior. All of the differences predicted by our equilibrium model were observed experimentally. The role played by legal uncertainty in altering predicted and observed behavior was especially significant. As predicted, under the perfect balancing regime—where the legal contest was such that the parties could count on the higher-valuing party getting the entitlement—the law supplanted private bargaining, inducing an immediate unconsented taking. When error was introduced into the legal contest—such that the higher-valuing party had a high chance of in fact losing the contest and not getting the entitlement—the uninformed party bargained under a credible threat to take. Especially in relative terms, blurring up the entitlement made the threat to take much more credible than under a definite entitlement protected against unconsented taking. While concession followed 96% of the time when an offer to buy such a definite entitlement was rejected, concession occurred with only a 19% frequency when an offer to buy a contingent entitlement was refused.

Our results suggest that legal *form*—whether the allocation of the entitlement is made certain ex ante, or instead depends on the outcome of an ex post contest—may be a more important determinant of the private choice between taking and bargaining than is the legal *remedy* for taking without consent. As predicted, we found that when the entitlement was clearly defined and assigned ex ante, bargaining occurred regardless of the remedy. Our results begin to give precise content to the concerns about property rules, liability rules, and information that animated the now-classic article by Calabresi and Melamed (1972). They suggested that when the court cannot be certain which party values the right more, it should protect entitlements with a liability rule, giving the claimant an option to buy at a judicially fixed price by taking and paying damages. Thus Calabresi and Melamed (1972) reasoned, when the claimant knows that it values the entitlement more than this amount, it will exercise the option. However, our results show that one must pay careful attention to the interaction between the court's ability to verify the parties' values, the parties' abilities to observe each others' values, and the institutional structure. We set up a condition with a liability rule reflecting the assumption that the court does not attempt to discern or compensate for subjective value, and therefore both overcompensates and undercompensates systematically. Based on this condition, we predicted that the option would never be exercised. In fact, it never was. Based on these results, we urge legal analysts to exercise caution in making policy recommendations and normative evaluations of legal rules based on the received Calabresi and Melamed (1972) wisdom. Instead, what our results show is that we need a more carefully nuanced theory, confirmed by repeated experimental observation, before we can advise courts with confidence. Our work begins this task.

In addition, we demonstrate some unhypothesized differences between these treatments. These differences highlight the importance of combining experimental and behavioral observation with theoretical modeling. These results give us new and important insight into the unanticipated impact of different legal regimes.

One of the results which was observed but not predicted was the significant tendency for the holder of a certain entitlement to be significantly more willing to sell it (offers were accepted with an 81% frequency) than was the holder of an uncertain, ex post entitlement (where offers were accepted only 56% of the time). Even as the imperfect ex post entitlement increased the probability that an offer would be made, it reduced the likelihood that the offer would be accepted. One explanation for this result is that people are accustomed to bargaining over objects which they own for sure, but are not accustomed to buying and selling gambles. In particular, the act of selling a gamble is one which presents a strong opportunity for regret; if the gamble would have won then the seller is worse off. Previous psychological research has demonstrated that subjects are reluctant to exchange lottery tickets, even when the exchange was an even one (the new ticket had exactly the same probabilities and prizes as the old) and when a small monetary inducement was offered. The authors attribute this reluctance to regret avoidance (Bar-Hillel and Neter, 1996).

The observed tendency for uncertainty in the definition of an entitlement to both increase the probability that an offer will be made and to decrease the probability with which it is accepted has important implications for empirical and experimental work on legal disputing behavior. The model of Priest and Klein (1984), for instance, predicts that moving from ex ante certain legal rights to ex ante uncertain rights should decrease the rate at which settlement offers are both made and accepted. Our observed result, however, suggests that uncertainty (in the form of blurring up the plaintiff's right to recover) might actually increase the probability that a settlement offer will be made (by the defendant), even as it decreases the probability that the offer will be accepted when made. A task for future work is to devise experimental settings in which this implication may be tested.

As for the possible implications of our predicted results, it bears emphasis that we did find, as predicted, that bargaining occurs under both definite and (imperfect) contingent entitlements. It is theoretically possible [see Johnston (1995)] that a move from definite to blurry entitlements may actually enhance bargaining efficiency by eliminating the incentive to use costly delay as a screening mechanism. Our chosen parameters did not generate an equilibrium involving costly delay, and this particular efficiency result remains to be explored in future work.

However, the positive findings from our experimental work thus far have a range of important potential consequences for the law. Balancing tests are ubiquitous in the law of property. The boundaries of intellectual property rights, for example, are not generally fixed in a clear way ex ante, but rather are determined ex post, by balancing the harm to the original inventor against the value to the (later) user [see, e.g., Merges and Nelson (1990)]. Not only private entitlements are fixed by nuisance law's balancing test. Under the Fifth Amendment's constitutional command that no "private property" shall be taken for "public use without just compensation," the government's obligation to pay damages when regulatory use restrictions lower the value of private property has traditionally been determined by balancing the benefit against the harm caused by the government regulation in light of the private property owner's reasonable expectations.[7] Our experiments to date have not attempted to capture the incentives facing a potentially

7. See *Penn Central Transportation v. New York City*, 438 U.S. 104 (1978). Although *Lucas v. South Carolina Coastal Council*, 505 U.S. 1003 (1992) is often taken as eliminating such balancing, this is true only when the regulation wipes out all economically viable use of the private property, or at least *Lucas* has been so interpreted by a number of courts [see, e.g., *K & K Construction Inc. v. DNR*, NW2d (Mich. 1998)].

budget-constrained government actor. Our results, however, suggest that this will be a profitable avenue for future research.

Appendix

Instructions

Welcome and thank you for participating in this session. During this session you will have the opportunity to earn up to $10, depending on your decisions and the decisions of others.

In this session, you will be playing a series of card games. Each game is played between two players, called Player Up and Player Down. If you are seated at a desk with a card face up, you are Player Up and will remain so throughout the session. If you are seated at a desk with three cards face down, you are Player Down and will remain so throughout the session.

In this card game you have the opportunity to win money. In this session, you will play the card game multiple times, each time with a different partner; you will never play the same partner twice. At the end of the session, we will choose a game at random. The amount of money you won in that game will determine your cash earnings for this session. We have provided you with a record sheet to keep track of what happened in each game you play and your earnings for each.

The game proceeds as follows. Both Players see Player Up's card; it is an 8 face-up on the desk. Then Player Up will shuffle three other cards, a 4, a 6 and a 10 and place them face down in front of Player Down. Player Down will choose a card at random from these three, will look at it and will place it face-down on the desk (the chosen card will not be shown to Player Up).

Once this has occurred, the game begins in earnest.

THE GAME

Player Up begins the game by trying either to CAPTURE or to BUY Player Down's card.

In Perfect Balancing (Perfect Contingent Entitlement)

If (s)he tries to CAPTURE, Player Down's card is shown, and the highest card wins the game. The winner earns, in dollars, the number on his/her own card and the loser earns zero dollars.

In Definite Entitlement Protected by a Property Right

If (s)he tries to CAPTURE, Player Down's card is shown, and Player Down always wins, earning, in dollars, the number on his/her own card while Player Up earns zero dollars.

In Imperfect Balancing (Imperfect Contingent Entitlement)

If (s)he tries to CAPTURE, Player Down's card is shown. If Player Down's card is a 4, then Player Up wins, earning in dollars the number on their card ($8), while Player Down earns zero dollars. If Player Down has a 6 or an 10, then there is a battle. In the battle two six-sided dice are rolled. If Player Down has a 6, Up wins if the roll is a 7 (if the numbers on the two dice sum to 7). The likelihood of this happening is

6/36 = 1/6. Otherwise Down wins. If Player Down has a 10, then Up wins if the roll is an 8 (if the numbers on the two dice sum to 8). The likelihood of this happening is 5/36. Otherwise Down wins. In either case, the winner earns, in dollars, the number on his/her own card, while the loser earns nothing.

In Definite Entitlement Protected by a Liability Rule

If (s)he tries to CAPTURE, Player Down's card is shown. Player Up earns, in dollars, the number on her card ($8) minus $6.67, while Player Down earns $6.67.

In all treatments

If (s)he tries to BUY, Player Up makes an offer of some amount of money, in dollars and cents, to Player Down. Player Down can then accept or reject Player Up's offer.

If Player Down accepts, Player Down earns the amount of money offered, and Player Up earns the number on his/her card ($8) *minus* the amount paid to Player Down.

If Player Down rejects, Player Up again has two choices. (S)he can either CONCEDE, or try to CAPTURE AGAIN.

If Player Up CONCEDES, (s)he earns 50¢, while Player Down earns the 1/2 times the number on his/her own card.

In Perfect Balancing (Perfect Contingent Entitlement)

If Player Up tries to CAPTURE AGAIN, Player Down's card is shown, and the highest card again wins. However, this time the winner earns, in dollars, 1/2 times the number on his/her own card.

In Definite Entitlement Protected by a Property Right

If Player Up tries to CAPTURE AGAIN, Player Down's card is shown, and Player Down always wins, earning 1/2 times the number on his/her own card, while Player Up earns zero.

In Imperfect Balancing (Imperfect Contingent Entitlement)

If Player Up tries to CAPTURE AGAIN, Player Down's card is shown. The same rules are followed as above, except the winner earns only 1/2 times the number on his/her own card, while the loser earns zero.

In Definite Entitlement Protected by a Liability Rule

If Player Up tries to CAPTURE AGAIN, Player Down's card is shown. Player Up earns, in dollars, 1/2 times the number on her card (1/2 times 8 = $4) minus $3.33, while Player Down earns $3.33.

In all treatments

Some other notes about the game.

It's perfectly all right to discuss with your counterpart what you intend to do in this game. However, no binding commitments can be made and no physical threats are allowed.

Player Down is strictly prohibited from showing his/her card to Player Up until and unless a capture attempt is made. However, Player Down may make any statements or claims about the card (s)he wishes.

In addition to the cards needed to play this game, you have two sheets; the DECISION SHEET and the RECORD SHEET.

When Player Up is ready to play, (s)he will circle the appropriate move on the DECISION SHEET and fill in any numbers required before handing it to their counterpart in the game, Player Down.

Player Down then responds to Player Up's play on that same DECISION SHEET by circling his/her responses. If Player Up has tried to CAPTURE, Player Down turns over his/her card. If Player Up has tried to BUY, Player Down responds by ACCEPTING or REJECTING the offer, etc.

Once the game ends, both players record the outcome on their RECORD SHEETS. Then, sit quietly until the experimenter tells you to change partners.

Turn now to the DECISION SHEET and RECORD SHEET attached to your instructions, we will go through these sheets with you to ensure you understand the procedures.

Questions?

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