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by

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Experimental Tests of the Coase Theorem With Large Bargaining Groups*

by

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Comments are invited

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I. Introduction

In a recent paper[1], we reported the results of experimental tests of the Coase Theorem[2] with two and three parties to a bargain. Those results generally provided strong support for Coase's proposition, particularly where the parties bargained under full information. Without full information, the three-person experiments provided much less support for the Coase proposition.

In the two-person experiments we proceeded as follows. First, we brought two people who were not close friends into a room and called one of them "A" and the other "B". Then we told them that their task was to choose a number from a list

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[1] Elizabeth Hoffman and Matthew L. Spitzer, The Coase Theorem: Some Experimental Tests, 25 J. Law & Econ. (1982). This paper also reviews the law and economics literature on the Coase Theorem and the experimental literature on bargaining in non-zero-sum games.

[2] The title, "Coase Theorem" is generally applied to a proposition first put forward by Ronald Coase in The Problem of Social Cost, 3 J. Law & Econ. 1 (1960). Coase posited that a change in a liability rule will leave the agents' production and consumption decisions both unchanged and economically efficient within the following (implicit) framework: a) two agents to each bargain, b) perfect knowledge of one another's (convex) production and profit or utility functions, c) competitive markets, d) zero transactions costs, e) costless court system, f) profit-maximizing producers and expected-utility maximizing consumers, g) no wealth effects, h) agents will strike mutually advantageous bargains in the absence of transactions costs. While the theorem is "true" given these assumptions, criticism has focused on its applicability in a wider environment in which the assumptions are generally not met. See Hoffman and Spitzer, Ibid, for a discussion of that literature.

of numbers. Depending on which number was chosen, we would pay them different amounts of money. Table 1, below, gives a payoff chart, showing how much each subject would receive for each possible number between 1 and 7. Thus, if 1 were chosen, A would be paid nothing and B would be paid $12.00. If 2 were chosen, A would be paid $4.00 and B would be paid $10.00. Finally, if 7 were chosen, A would be paid $12.00 and B would be paid nothing.

Table 1

Two-person Payoff Chart

Number	A's Payoff	B's Payoff
1	$0.00	$12.00
2	4.00	10.00
3	6.00	6.00
4	7.50	4.00
5	9.00	2.50
6	10.50	1.00
7	12.00	0.00

Next, we chose one of the participants, by a coin flip, to be "controller." The controller had the absolute "legal" right to choose whichever number he or she wished, regardless of the other participant's wishes. The other subject, who had lost the coin flip, was allowed to try to influence the controller to choose a mutually agreeable number, per-

haps by offering to pay part of his or her earnings to the controller. We provided a standard form contract to the subjects to facilitate agreements and guaranteed the contract would be enforced if both participants signed.

Notice that, within the payoff structure listed above, number 2 provides the highest total joint payoff to A and B: $14.00. The Coase Theorem predicts that regardless of how property rights are initially distributed, the parties will contract so as to maximize profits. In other words, within the context of this experiment, regardless of who wins the coin flip, subjects will agree to choose number 2. Hence, we were able to use the rate at which the parties chose number 2 as the predictive power of the Coase Theorem.

We ran experiments in which the subjects were provided with both their own and the other subject's payoff schedules (termed "full information" experiments) and others in which the subjects were shown only their own payoffs (termed "limited information" experiments). We also ran experiments with both information structures and three parties to a bargain. In those experiments, one party bargained against the other two. Either the one, alone, was controller or the two, together, were joint controllers.[3] The results for all of the two-person experiments and the three person experi-

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[3] For full details of the experimental procedure, see Hoffman and Spitzer, Ibid.

ments with full information provided strong support for the Coase Theorem. Subjects chose the joint profit maximizing outcome (number 2, above) over 92% of the time in each of the three experimental treatments. However, the results of the three-person experiments with limited information gave less support. When the two-subject pair won the coin flip and became "joint controllers," subjects chose the joint profit maximizing outcome only 60% of the time.

These results are important because they establish that, at least in a experimental setting, agents will strike mutually advantageous bargains within the simple framework first proposed by Coase. Moreover, they suggest that simply relaxing the assumption of two parties to a bargain will not immediately lead to bargaining breakdown. On the other had, the erosion of efficiency with three agents and incomplete information suggests that the Coase proposition might not have as wide policy application as its supporters claim.[4]

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[4] The Coase Theorem is the cornerstone of laissez-faire legal and economic policy dealing with contract and tort law. Supporters of this position view the Coase Theorem as demonstrating that parties to external harm or benefit will strike mutually advantageous bargains to limit harm or extend benefits to efficient levels in the absence of government intervention. Thus, for example, homeowners harmed by pollution will strike bargains with polluters. All those who would benefit from a reduction in pollution will form a united group to bargain for such a reduction, at some cost to each homeowner. See Richard A. Posner, Economic Analysis of Law, (2nd ed. 1977) for a more complete statement of the laissez-faire position and a discussion of the literature on the subject.

This paper reports the results of experiments designed to test the Coase proposition for large groups. Using an experimental design similar to that described above, we conducted experiments with both four and ten parties to a bargain under full and limited information and with twenty parties to a bargain under limited information. The results provide continued overwhelming support for Coase's proposition. Overall, 93% of the decisions were efficient and there was no deterioration as the bargaining groups got larger. If anything, efficiency improved with larger groups. On the other hand, there was some deterioration in moving from full to limited information. Virtually 100% of the full information bargains were efficient, but efficiency was closer to 90% with limited information.

II. Experimental Design

A. General

In all the experiments the bargaining was face-to-face and public and involved more money than most students can earn for an hour's work in their next best alternative employment. Side payments were allowed and contracts were in writing and strictly enforced. All payments were made in public. Subjects were given no motivational instructions: i.e. they were not told what their objectives should be in choosing a number or in forming contracts.

B. Four Person, Coin Flip Experiments

We began this experimental project as an extension of the experimental design we had used for the two and three person experiments, outlined above [5]

1. 2 x 2 Joint Controllers

a. Full Information: Instructions

As the subjects arrived at a designated room they were randomly assigned the letters A, B, C, or D. Each foursome was placed in a separate room with the monitor being the only other person present. The monitor provided the following set of instructions to the subjects, who first read them silently and then listened to the monitor read them aloud.

INSTRUCTIONS

General

You are about to participate in an experiment in decisionmaking. The purpose of the experiment is to gain insight into certain features of complex economic processes. If you follow the instructions carefully you might earn a considerable amount of money. You wil be paid in cash at the end of the experiment.

Specific Instructions to Participants

You will be asked to make several choices. Each choice will involve choosing a number. The cash value to you of the number is given in the set of payoff sheets attached to your instructions (see pp.). For example, if $10 were next to number 2 on your payoff sheet and if number 2 were chosen, then you would be paid $10. In the example shown below, for instance, you

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[5] Hoffman and Spitzer, Supra, note 1.

might be person C. Your payoff sheets list not only the value of each number to you, but also the value of each number to each of the other participants.

You four people will participate together. You will be divided into two groups of two people each. A and B will be one group, while C and D will be the other group. One of the two groups will be chosen (by a flip of the coin) to be "joint controllers."

If you are in a group which has been chosen to be the joint controllers, then you may, if you wish, attempt to choose the number by yourself. (This is done by filling out one of the attached forms and handing it to the monitor). If A and B are joint controllers, then the joint controller who chooses the higher number will determine the number. If, for example, A chooses number 2 and B chooses number 1, then the monitor will set the number at 2 and pay the participants accordingly.

If C and D are joint controllers, then the joint controller who chooses the lower number will determine the number. If, for example, C chooses 1 and D chooses 3, then the monitor will set the number at 1 and pay the participants accordingly. The remaining participants (the ones who are not joint controllers) may attempt to influence either or both of the joint controllers to reach an acceptable group decision: any party may offer to pay all or part of his or her earnings to any of the remaining parties.

In order to reach a group decision, the procedures outlined below must be followed. Both joint controllers must join in a group decision before it will become effective. Otherwise, the number will be chosen in accord with the procedure described in the preceding paragraph (i.e. if A and B (C and D) are joint controllers, the joint controller choosing the higher (lower) number sets the number). The remaining participants may also be party to a group agreement. All of the parties to a group agreement must sign, and if any portion of any participants earnings is to be paid to someone else, then the participant agreeing to pay must sign the agreement form before the agreement will be enforced by the monitor. No physical threats are allowed. If any party makes a physical threat, the threatened party will be paid his or her maximum payoff and the threatening party and all other parties will get nothing. When a group agreement is reached and the forms are signed, the monitor will end the experiment and pay the participants.

Examples

1. Assume that A and B are joint controllers.

Number	A's payoff	B's payoff	C's payoff	D's payoff
1	$40	$30	$30	$25
2	50	50	10	20

If C and D agree on number 1, but A and B choose number 2, then number 2 has been chosen and the monitor will pay accordingly.

If A and B sign an agreement form choosing number 1 and directing the monitor to pay all of C's payoff to B, the monitor will disregard the agreement, unless C also signs it.

If A, B, and C sign an agreement form choosing number 1 and directing that $10 of A's payoff be paid to C, the monitor will terminate the experimental period, pay A $30 (representing the $40 payoff less the $10 transfer to C), pay B $30, pay C $40 (representing a $30 payoff plus the $10 transfer from A) and pay D $25.

2. Assume that C and D are joint controllers.

Number	A's payoff	B's payoff	C's payoff	D's payoff
1	$40	$30	$30	$25
2	50	50	10	20

If A and B sign an agreement form, choosing number 2, C chooses number 1, and D chooses number 2, then number 1 has been chosen and the monitor will pay accordingly.

If D and C sign an agreement form choosing number 1 and directing that A's payoff should be split equally among them, the monitor will disregard the agreement unless A also signs it.

If A, B, C, and D sign an agreement from choosing number 1, and directing that $10 of A's payoff be transferred to C and $5 of B's payoff be transferred to D, then the monitor will terminate the experiment, pay A $30 (representing a $40 payoff less the $10 transfer to C), pay B $25 representing a $30 payoff less the $5 transfer to D), pay C $40 (representing a $30 payoff plus the $10 transfer from A), and pay D $30 (representing a $25 payoff plus the $5 transfer from B).

Are there any question? We would like you to answer the questions on the attached page. These should help you understand the instructions.

QUESTIONS

1. Number _____ makes me the most money.
   Number _____ makes me the least money.

2. If C and D are joint controllers and if C chooses number 4, and D chooses number 3, I make_____.

3. If A and B are joint controllers and if B chooses 2 and A chooses 1, I make_____.

4. If A and B are the joint controllers and they reach an agreement with D and C which chooses number 2 and directs B to pay A $3, I make_____.

5. If D and C are joint controllers and they reach an agreement with A in which the number is set at 1 and A agrees to pay B and C each $.50, I make_____.

6. Joint controllers, acting together, can set the number by themselves, without regard to what the other participants want, True or false?_____.

PAYOFF SHEETS

Decision #1

Number	A's Payoff	B's Payoff	C's Payoff	D's Payoff
1	$0.00	$0.00	$8.00	$8.00
2	2.50	2.50	6.50	6.50
3	6.50	6.50	4.50	4.50
4	8.00	8.00	0.00	0.00

Decision #2

Number	A's Payoff	B's Payoff	C's Payoff	D's Payoff
1	$0.00	$0.00	$8.50	$8.50
2	1.50	1.50	6.50	6.50
3	3.00	3.00	5.00	5.00
4	7.00	7.00	3.50	3.50
5	8.50	8.50	0.00	0.00

Decision #3

Number	A's Payoff	B's Payoff	C's Payoff	D's Payoff
1	$0.00	$0.00	$7.50	$9.50
2	4.00	3.00	6.00	8.00
3	6.00	4.50	3.00	2.00
4	8.00	7.00	1.00	0.00

GROUP AGREEMENT FORM

Number Chosen _____

$_____ from _____'s payoff to be paid to _____

$_____from _____'s payoff to be paid to _____

$_____from _____'s payoff to be paid to _____

$_____from _____'s payoff to be paid to _____

Signed: _____
A

_____
B

_____
C

_____
D

These instuctions told subjects that they had to choose one of a given set of numbers and that they would be paid different amounts of money, in cash, depending on which number were chosen. Notice that each payoff schedule has a unique and clearly identifiable joint-profit maximizing number, which pays to each participant at least $1 more than the next best alternative. In this formulation, the numbers are analogous to pollution levels in an externality problem. For example, subjects A and B might represent upstream factories which pollute a river and C and D might represent downstream users who need clean water. The subjects were

told that two of them would be chosen joint controllers and either joint controller could unilaterally choose either the higher (A and B joint controllers) or lower (C and D joint controllers) number. This power is analogous to a right to pollute (A and B joint controllers) or a right to an injunction forbidding pollution and guaranteeing clean water (C and D joint controllers) in an externality situation. The subjects were also allowed to transfer, by contract, payoffs from any party to any other party.[6] This feature of the experiment directly mimics the contract mechanism which is central to the Coase Theorem.

After reading the instructions and examining their payoffs, subjects were tested on their understanding of the rules and the consequences of any decisions they might make.[7] After all four subjects had answered all of the questions correctly, and after the monitor had answered all of the subjects' remaining uncertainties about the rules of the game, the monitor flipped a coin and the winning pair of subjects was designated joint controllers. The subjects were then instructed to proceed with the experiment (by choosing a number). Three experimental sessions were conducted using this design. In each experiment the subjects made three decisions sequentially.

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[6] Payoff sheets are included with the instructions.

[7] Tests are included with the instructions.

b. Limited Information

The next set of instructions were identical to those given above, except that subjects were only told their own payoffs. They were allowed to reveal their payoffs to the other participants, but they did not have to. Where the above instructions stated, "Your payoff sheets list not only the value of each number to you, but also the value of each number to each of the other participants," the instructions for the limited information experiments stated, "Your payoffs list only the value of each number to you. The other participants are free to reveal to you anything they wish about their payoffs." Otherwise, these experiments were exactly the same as the first. Fifteen experimental sessions with three sequential decisions were conducted with this experimental treatment.

2. 1 x 3 Joint Controllers

The next set of experiments modelled an externality situation in which one polluter, such as a factory or power plant, affects several (three) homeowners or other businesses. These experiments were similar to the 2 x 2 joint controller experiments and were also conducted under full and limited information.

a. Full Information

The first two paragraphs of these instructions were identical to the 2 x 2, full information, instructions reproduced above. Beginning with paragraph 3, the 3 x 1, full information, instructions proceeded as follows.

> You four people will participate together. You will be divided into two groups. A alone will be one group, while B, C and D will be the other group. One of the groups will be chosen (by a flip of the coin) to be the controlling group. That is, either A alone will be the "controller" or B, C and D together will be "joint controllers."
>
> a) If A is chosen as controller, then the controller may, if he or she wishes, choose the number by himself or herself and inform the monitor, who will stop the experiment and pay all four participants. The other three participants may attempt to influence the controller to reach a mutually acceptable group decision; any of the other participants (B, C and D) may offer to pay part or all of his or her earnings to the controller (A).
>
> b) If B, C and D are chosen as joint controllers, then any joint controller may, if he or she wishes, attempt to choose the number. (This is done by filling out one of the attached forms and handing it to the monitor.) The joint controller who chooses the lowest number will determine the number. If, for example, two joint controllers choose number 2 and the other joint controller chooses number 1, then the monitor will set the number at 1, and pay the participants accordingly. The remaining participant (A) may attempt to influence any of the controlling parties (B, C, and D) to reach an acceptable group decision; any party may offer to pay all or part of his or her earnings to any of the remaining parties.
>
> In order to reach a group agreement, the procedures outlined below must be followed:
>
> a) If A has been designated the controller, then any of the other participants can join the controller in a group decision by filling out and signing one of the attached agreement forms. All of the parties to a group agreement must sign, and

if any portion of any participant's earnings is to be paid to someone else, then the participant agreeing to pay must sign the agreement form before the agreement will be enforced by the monitor. Otherwise, the controller can choose the number alone.

b) If B, C and D have been chosen joint controllers, then all three joint controllers must join in a group decision before it will become effective. Otherwise, the number will be chosen in accord with the procedure described in the preceding paragraph (i.e. the joint controller choosing the lowest number sets the number). The remaining participant (A) may also be a party to a group agreement. Again, all of the parties to a group agreement must sign, and if any portion of any participant's earnings is to be paid to someone else, then the participant agreeing to pay must sign the agreement form before the agreement will be enforced by the monitor. No physical threats are allowed. If any party makes a physical threat, the threatened party will be paid his or her maximum payoff, and the threatening party and all other parties will get nothing. When a group agreement is reached and the forms are signed, the monitor will end the experiment and pay the participants.

Examples

1. Assume A is the Controller.

Number	A's payoff	B's payoff	C's payoff	D's payoff
1	$25	$50	$60	$65
2	80	50	10	5

If B, C and D agree on number 1, but A chooses number 2, then number 2 has been chosen and the monitor will pay accordingly.

If A, B and D sign an agreement form choosing number 1 and directing that all of C's payoff be paid to A, the monitor will disregard the agreement unless C also signs it.

If A, B, C and D sign an agreement form choosing number 1 and directing that $20 of C's payoff and $30 of D's payoff be paid to A, the monitor will terminate the experimental period and pay A $75 (representing the $25 payoff plus the $20 transferred from C plus the $30 transferred from D). The monitor will also pay B $50 (B's payoff), C $40 (reprenting the $60 payoff less the $20 transferred to A), and pay D $35 (representing the $65 payoff less the $30 transferred to A.

2. Assume B, C and D are joint controllers.

Number	A's payoff	B's payoff	C's payoff	D's payoff
1	$25	$50	$60	$65
2	80	50	10	5

If A and B sign an agreement form choosing number 2, but C and D choose number 1. then number 1 has been chosen and the monitor will pay accordingly.

If B, C, and D sign an agreement form choosing number 1 and directing that all of A's payoff be paid to B, the monitor will disregard the agreement unless A also signs it.

If A, B, C and D sign an agreement form choosing number 1 and directing that $10 of C's payoff be paid to A and $5 of D's payoff be paid to B, the monitor will terminate the experimental period and distribute the following payoffs. A will receive $35 (representing the $25 payoff plus the $10 transferred from C). B will receive $55 (representing the $50 payoff plus the $5 transferred from D). C will receive $50 (representing the $60 payoff less the $10 transferred to A). D will receive $60 (representing the $65 payoff less the $5 transferred to B).

Are there any questions? We would like you to answer the questions on the attached page. These should help you understand the instructions.

QUESTIONS (refer to the decision on p.)

1. Number _____ makes me the most money.
   Number _____ makes me the least money.

2. If A is the controller and he or she chooses number 2, I make _____.

3. I B, C and D are joint controllers and if B chooses 2, C chooses 1 and D chooses 3, I make _____.

4. If A is the controller and signs an agreement with D and C which chooses number 2 and directs D to pay A $2 and C to pay A $3, I make _____.

5. If B, C and D are joint controllers and they sign an agreement with A in which the number is set at 3 and A agrees to pay B and C each $1.00, I make _____.

6. The controller acting alone or the joint controllers, acting together, can set the number by themselves, without regard to what the other participants want? True or false _____.

PAYOFF SHEETS

Decision #1

Number	A's Payoff	B's Payoff	C's Payoff	D's Payoff
1	$0.00	$8.00	$8.00	$8.00
2	1.50	6.00	6.00	6.00
3	13.00	5.00	5.00	5.00
4	14.50	1.00	1.00	1.00

Decision #2

Number	A's Payoff	B's Payoff	C's Payoff	D's Payoff
1	$0.00	$7.00	$7.00	$7.00
2	1.50	6.50	6.50	6.50
3	11.00	5.00	5.00	5.00
4	13.00	1.00	1.00	1.00

Decision #3

Number	A's Payoff	B's Payoff	C's Payoff	D's Payoff
1	$0.00	$6.75	$7.25	$8.00
2	10.00	4.00	5.50	6.50
3	11.50	2.00	2.00	2.50
4	14.50	0.00	0.00	0.00

The agreement form was also exactly the same as that shown with the first set of instructions given above. Twenty five experiments of three decisions each were run using this experimental treatment.

b. Limited Information

The next set of experiments was identical to the immediately preceding set except that subjects were told only their own payoffs. Where the previous instruction said, "Your payoff sheets list not only the value of each number to you, but also the value of each number to each of the other

participants," these instructions said, "Your payoff sheets list only the value of each number to you. The other participants are free to reveal to you anything they wish about their payoffs." Otherwise, these instructions were identical to the 3 x 1, full information, instructions given above. We ran eighteen experiments of three decisions each using this experimental treatment.

C. Game Trigger Experiments

The subjects in the experiments described above almost always chose the joint profit maximum, thereby strongly supporting Coase, but they seldom chose payoff divisions which gave the controller or contollers at least their individual maxima. More than half the time they split the payoffs equally, as though controllers were not self-regarding economic actors. Our previous paper on the Coase Theorem[8] discusses this problem and its implications for the reliability of the Coase Theorem. The crucial question is, if subjects fail to choose the payoff divisions predicted by Coase, have we provided a good test of the Theorem?

In order to elicit more self-regarding payoff divisions, we developed a new experimental design and set of instructions. We hypothesized that subjects who won the coin flip did not feel they had the morally justifiable right to

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[8] Hoffman and Spitzer, Supra, note 1.

exercise the entitlement of the controller's position. Having no morally justifiable right to exercise the entitlement, they bargained to the Nash equilibrium of a symmetric game (i.e. an equal split of the payoffs). We decided to induce feelings of moral justification in the controller by making him or her "earn" the entitlement by winning a simple game. We then told the controller he or she had actually earned that right by winning the game.[9]

1. Two-person, 1 x 1 Experiments

We first tested this new experimental design in the basic two-person setting. We ran two-person experiments with both full and limited information crossed with both sequential decisions and non-sequential decisions. In the sequential decisions two subjects made two decisions together. In the

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[9] In another paper, Elizabeth Hoffman and Matthew L Spitzer, Entitlements, Rights and Fairness: Some Experimental Results, Xerox, we report the results of two person, full information experiments designed to test the effect of this change in instructions on both experimental outcomes and payoff divisions. We find that the instructions have no effect on experimental outcomes: nearly 100% of the choices are the efficient ones predicted by Coase. Thus, the Coase theorem continues to be confirmed in the two person, full information context. However, the instructions do have a significant effect on the payoff divisions. The combination of having to win a game to become controller and of having the monitor reinforce the moral authority imparted by that win leads subjects to divide the payoffs so as to give the controller at least his or her individual maximum more than half the time. In contrast, the combination of coin flip and no reinforcement led to only about 1/4 individually rational payoff divisions.

non-sequential decisions each pair of subjects only made one decision together.

a. Sequential

(1) Full Information: Instructions

The first paragraph is identical to that in both sets of experiments above. After that the instructions read as follows.

> Specific Instructions to Participants
>
> You are person _____. The other participant is _____.
>
> This experiment requires that two decisions be made. Each decision will involve choosing a number. The number chosen will correspond to an actual dollar amount which will be paid to you at the end of this experiment. The numbers and corresponding payoffs for the first decision are on page five of these instructions; the numbers and payoffs for the second decision are on page six. Pages five and six list not only the value of each number to you (under column ____), but also the value of each number to the other participant (under column _____).
>
> Before each decision, both participants A and B will play a game. Whoever wins this game earns the right to be designated "controller" for that decision. The rules of this preliminary game are as follows.
>
> / / / / / / / / / / /
>
> Above here is a picture of 11 vertical hash marks. Each player must, on each turn, cross out 1, 2, 3, or 4 hash marks. After a player has crossed out as many hash marks as he or she wishes, it is the other players turn to cross out 1, 2, 3, or 4 hash marks. The game continues until all hash marks have been crossed out. The person who crosses out the last hash mark loses the game. A will go first on the first decision, B will go first on the second decision.

Example: A goes first and crosses out 4 marks

/ / / / / / / / / / /

Then B crosses out 4 marks

/ / / / / / / / / / / /

The A crosses out 2 marks

/ / / / / / / / / / / /

B must cross out the last mark on his turn, so B loses the game, and A has earned the position of controller.

If you win the game and are designated controller, you may, if you wish, choose any number you like by filling out the form on page seven and giving it to the monitor. However, if you lose the preliminary game and are not designated controller, you may still attempt to influence the controller to form a joint agreement and choose some other number. In order to induce the controller to reach an acceptable joint agreement, you may offer to pay part of your earnings to the controller.

Example: Assume that A wins the preliminary game and earns the position of controller for the first decision. Assume also the following payoffs for A and B.

Number	A's Payoff	B's Payoff
1	$4	$1
2	5	2
3	3	5

Once A has become controller, he or she may choose number 2 without consulting B. However, B may attempt to persuade A to join in a joint decision to choose another number or division of payoffs. If a joint agreement is reached both parties must sign the agreement form on page seven, stating both what the chosen number will be and how much money will be transferred from one participant's earnings to the other's. For example, A and B might sign the agreement form on page seven choosing number 3 and directing that $2.00 be paid from B to A. Once the agreement form is signed the monitor will note that for this decision A is to be paid $5.00 at the end of the experiment, representing the $3.00 original payoff for number 3 plus the $2.00 transferred from B, and that B is to be paid $3.00, representing the $5.00 original payoff less the $2.00 transferred to A.

The monitor can only enforce written decision recorded on the form set out on page seven. You are, however, free to make any other sort of informal agreement that you wish.

No physical threats are allowed. If any party makes

a physical threat, the threatened party will get his or her maximum payoff and the threatening party will get nothing.

Are there any questions? We ask you to answer the questions on the attached sheet to make sure you understand the instructions.

QUESTIONS
(Refer to you payoffs on page 5)

1. Number _____ makes me the most money. Number _____ makes me the least money.

2. If I become controller, I can make $_____ even if the other person doesn't agree.

3. If A and B reach a joint decision to choose number 4 and B pays A $2.00, I make _____.

4. If I am the controller, I may choose the number which corresponds to my maximum payoff without making a joint agreement with the other participant, true or false? _____

5. Which of the following do you prefer? _____
   a. $1.50 for sure.
   b. a fair coin toss which pays $0.00 for heads and $11.00 for tails.

The payoffs and agreement form were identical to those used in previous two person experiments.[10] Eleven pairs of subjects made two decisions each using this experimental treatmant.

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[10] see Hoffman and Spitzer, Supra, note 1.

(2) Limited Information

These instructions are identical to the full information instructions given above, with one exception. Where the full information instructions state, "Pages five and six list not only the value of each number to you (under column _____), but also the value of each number to the other participant," the limited information instructions state the following. "Your sheet will list only the value of each number to you. It will not list the value to the other participant. You may keep may keep your payoff sheet private or reveal your payoffs to the other participant as you choose." Ten pairs of subjects made two decisions each using this experimental treatment.

b. Non-sequential

(1) Full Information: Instructions

The first paragraph is identical to all three sets of instructions given above. After that the instructions read as follows.

> Specific Instructions to Participants
> You are person _____. The other participants are numbered ___, ____, and ____. When the experiment begins, participants 1 and 2 will be one pair and participants 3 and 4 will be another pair. Each pair will then hand over a decision to the monitor after following rules outlined below. The participants will be re-paired (1,3) (2,4) and each new pair will hand over a second decision to the monitor. The participants will be re-paired a third time (1,4) (2,3) and each

pair will hand over a third decision to the monitor. In summary, you will each individually participate in three decisions -- exactly one decision with each of the other participants.

Within each pair, the participant whose last name is first alphabetically will be designated person A, and the other participant will be designated person B. For the purposes of these instruction, assume that you are person A.

Each decision will involve choosing a number. The number chosen will correspond to an actual dollar amount which will be paid to you at the end of this experiment. At the beginning of each decision the monitor will give you a payoff sheet listing numbers with corresponding dollar values. Your sheet will list not only the value of each number to you, but also the value of each number to the other participant.

The remainder of these instructions are identical to the two-person, full information, sequential instructions given above. The third set of payoffs was similar to the two sets used in the two-person sequential experiments. Eight groups of four subjects each made three non-sequential decisions using these experimental instructions.

(2) Limited Information

These instructions were identical to the full information instructions given immediately above, except for the statement regarding information. The same substitution was made as in the two-person, sequential instructions. Six groups of four subjects each made three non-sequential decisions using these experimental instructions.

2. Three-person, 1 x 2, Non-sequential

We next tested this new experimental design with three person, 2 x 1 experiments. We were particularly interested in replicating these experiments because the limited information environment was likely to be quite unfavorable to the Coase Theorem. In our previous set of experiments, this particular experimental treatment had yielded significantly fewer efficient outcomes than did all of the other experimental treatments. To put additional stress on the Coase Theorem, we also ran these experiments in the non-sequential mode. In other words, each group of three people (who did not know one another) made only one decision together. Thus, there was no incentive for controllers to just joint maximize and split the payoffs in hopes of receiving similar treatment in subsequent decisions.

a. Full Information: Instructions

The first paragraph is identical to all the instructions given above. After that the instructions read as follows.

> Specific Instructions to Participants
>
> You are person _____. Each of the other eight participants has likewise been assigned some other number between 1 and 9.
>
> This experiment requires that you each individually participate in four decisions--exactly one decision with each of the other participants. To this end, you will be grouped four times into sets of three people, as follows:

Decision 1:	(1,8,6)	(2,4,9)	(7,5,3)
Decision 2:	(1,5,9)	(4,8,3)	(7,6,2)
Decision 3:	(1,2,3)	(4,5,6)	(7,8,9)
Decision 4:	(1,4,7)	(2,5,8)	(3,6,9)

For each decision, all participants will assemble in their appropriate group. Each group will then accompany a monitor to a separate room and, after following the rules outlined below, hand over a decision to the monitor. All participants will then form new groups and repeat the decision-making process.

Within each group, participants will be designated A, or B or C by the alphabetical order of their last names.

For Decision 1:	alphabetically	1st	within the group	is	A
" 2:	"	2nd	"		A
" 3:	"	3rd	"		A
" 4:	"	1st	"		A

If the person whose last name is alphabetically first is A, the person whose last name is alphabetically second is B, and so on. FOR THE PURPOSES OF THESE INSTRUCTIONS, ASSUME THAT YOU ARE PERSON A.

Each decision will involve choosing a number. The number chosen will correspond to an actual dollar amount which will be paid to you at the end of this experiment. The numbers and corresponding payoffs for the first decision are on page ___ of these instructions; the numbers and payoffs for the second decision are on page ___; those for the third decision are on page ____ ; and on page ____ for the fourth decision. All nine participants have the same information on pages ____ through _____. Pages ____ through _____ list not only the value of each number to you (under column A), but also the value of each number to each of the other participants (under columns B and C).

Before each decison, participants A, B and C will play a game. A playing for himself/herself will be one team; B and C playing together will be the other team. Whichever team wins this game earns the right to be designated "controller" for that decision. The rules of the preliminary game are as follows.

/ / / / / / / / / / / / / / / / / / /

Above here is a picture of 17 vertical hash marks. Each team must, on each turn, cross out 1, 2, 3 or 4 hash marks. After a team has crossed out as many hash marks as it wishes, it is the other team's turn to cross out 1, 2, 3 or 4 hash marks. The game contiues until all hash marks have been crossed out. The team that crosses out the last hash mark loses the game.

Team A will go first on the first decision, team B/C will go first on the second decision, team A will go first on the the third and team B/C will go first on the fourth.

Example: A goes first and crosses out 4 marks

/ / / / / / / / / / / / / / / / /

Then B/C crosses out 4 marks

/ / / / / / / / / / / / / / / / /

Then A crosses out 4 marks

/ / / / / / / / / / / / / / / / /

Then B/C crosses out 4 marks

/ / / / / / / / / / / / / / / / /

Team A must cross out the last mark on its turn, so team A loses the game, and team B/C has earned the position of controller for that decision.

If A is the controller for the decision, A may, if s/he wishes, choose any number s/he likes by filling out the form on page ___ and giving it to the monitor. However, B and/or C, individually or jointly, may attempt to infuence the controller to reach a mutually acceptable group decision choosing another number or division of payments. Either or both of the other participants may offer to pay all or part of his or her earnings to the controller.

If team B/C is the controller for the decision, team B/C may, if it wishes, choose any number it likes by filling out the form on page ___ and giving it to the monitor. If B and C cannot agree on a number to choose together, the member of the controlling team who chooses the lowest number will set the number and corresponding payoffs for participants A, B and C. A may try to influence either or both members of the controlling team to reach a mutually acceptable group decision by offering to pay all or part of his or her earnings to both of the remaining parties.

All of the parties to a group agreement must sign the form on page ___, and if any portion of any participant's earnings is to be paid to someone else, then the participant agreeing to pay must sign the agreement form before the monitor will enforce it. The monitor can only enforce written decisions recorded on the form set out on page _____. You are, however, free to make any other sort of informal agreement that you wish.

Example : Assume A is the controller and the following payoffs.

Number	A's Payoff	B's Payoff	C's Payoff
1	$4	$3	$3
2	5	1	1

If B and C agree on number 1, but A chooses number 2, then number 2 has been chosen and the participants will be paid accordingly.

If A and B sign an agreement form choosing number 1 and directing the monitor to pay all of C's payoff to B, the monitor will disregard the agreement unless C also signs it.

If A, B and C sign an agreement form choosing number 1 and directing that $.50 of B's payoff be paid to A and $.50 of C's payoff be paid to A, the monitor will note that for this decision A is to be paid $5.00 (representing the $4.00 original payoff for number 1 plus $.50 transferred from B and $.50 transferred from C), and that B and C are each to be paid $2.50 (representing the $3.00 original payoffs for number 1 less $.50 each transferred to A).

Example: Assume that team B/C is the controller and the following payoffs.

Number	A's Payoff	B's Payoff	C's Payoff
1	$2	$3	$3
2	4.50	2	2

If B and C agree on number 1, but A chooses number 2, then number 1 has been chosen and A, B and C will be paid accordingly.

If B and C sign an agreement form choosing number 1 and directing that A's payoff be split equally among them, the monitor will disregard the agreement unless A also signs it.

If A, B and C sign an agreement form choosing number 2, and directing that $1.00 of A's payoff be paid to B and $1.00 of A's payoff be paid to C, the monitor will note that for this decision A is to be paid $2.50 (representing the $4.50 original payoff less the $1.00 transferred to B and $1.00 transferred to C), and that B and C are each to be paid $3.00 (representing the $2.00 original payoff for number 2 plus $1.00 each transferred from A.

NO PHYSICAL THREATS ARE ALLOWED. If any party makes a physical threat, the threatened party will be paid his or her maximum payoff, and the threatening party will get nothing.

Are there any questions? We would like you to answer the questions on the next page. These should help you understand the instructions.

QUESTIONS

(Please refer to your payoffs on page _____. Continue to assume that you are person A).

1. Number _____ makes me the most money.
   Number _____ makes me the least money.

2. If I become controller, I can make $_____ even if the other participants don't agree.

3. If team B/C is controller and B chooses 2 and C chooses 1, I make $_____.

4. If I am controller and I reach an agreement with B and C which chooses number 2 and directs B to pay A $2.00 and C to pay A $3.00, I make $_____.

5. If team B/C is controller and A, B and C reach an agreement choosing number 1 and directing A to pay B andC each $.50, I make $_____.

6. If I am controller, I may choose the number which corresponds to my maximum payoff without making a joint agreement with the other participants, true or false? _____

7. Which of the following do you prefer? _____
   a. $1.50 for sure
   b. a fair coin toss which pays $0.00 for heads and $11.00 for tails.

The payoffs for these experiments were similar to those used in previous three person experiments[11] and the agreement forms were identical. Twenty four experimental decisions were made using this experimental treatment.

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[11] Hoffman and Spitzer, Supra, note 1.

b. Limited Information

As in the previous full information/limited information pairs of experiments, the only difference between these instructions and the instructions just reproduced above was the wording describing how much information each subject had at the beginning of the experiment. Where the previous instructions said, "The numbers and corresponding payoffs ... but also the value of each number to each of the other participants (under columns B and C." the limited information instructions had the following sentences in place.

> At the beginning of each decision, the monitor will give you a payoff sheet containing these numbers and their corresponding payoffs. The payoff sheets for A, B and C will each be different. Your payoff sheet will list only the value of each number to you. You will not, at the outset, know the value of each number to the other participants. For example, if you are A, your payoff sheet will list only A's payoffs (under column A), and not B's and C's. For this reason, you may wish to keep the contents of your payoff sheets private, treating them as you would a hand of cards. You are, however, free to reveal to each other anything you wish about your payoffs.

Otherwise the two sets of instructions were identical. Twenty four experimental decisions were made using this experimental treatment.

3. Four Person, Non-sequential

a. 3 x 1 Controllers, Full and Limited Information

The next two sets of experiments were almost identical to the previous two sets, except that there were four parties to each bargain instead of three. Since the instructions were virtually identical except that team B and C in the previous experiments becomes team B, C and D in these experiments, we will not reproduce them here.[12] Twelve full information and twelve limited information decisions were made using this experimental treatment.

b. 2 x 2 Controllers, Limited Information

The next set of instructions was very similar to the previous two limited information instructions. The difference was that there were two teams of two subjects each: A and B was one team and C and D was the other. Either A or B could set the number by choosing a higher number; C or D could set the number by choosing a lower number. In general, the instructions copied the two sets above, except where they referred to the mechanics of what each team could do once it became controller. To replace those sentences these instructions copied the four person, 2 x 2, coin flip instructions

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[12] Copies of these instructions and any other instructions not reproduced in this paper are available from the authors.

reproduced above.[13] We conducted twelve non-sequential experimental decisions using this experimental treatment.

4. Ten Person, Sequential

After completing the three and four person experiments, we next conducted experiments with ten subjects. The Coase Theorem was quite clearly robust in "small" groups and we wanted to see if it continued to work for much larger groups. To run ten person experiments we returned to the sequential experimental design.

a. 5 x 5 Controllers

(1) Full Information: Instructions

The instructions for the first set of ten person experiments we ran were very similar to the three and four person, game trigger, experiments outlined above. The first paragraph of these instructions was identical to that in all previous experiments. Under Specific Instructions to Participants, the following paragraph was substituted for the detailed description of the organization of the non-sequential experiments.

> You are person _____. Each of the other nine participants has likewise been assigned some other letter between A and J.

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[13] See pages 6-10.

> This experiment requires that two decisions be made. Each decision will involve choosing a number. The number chosen will correspond to an actual dollar amount which will be paid to you at the end of this experiment. The numbers and corresponding payoffs for the first decision are on page ____; those for the second decision are on page ____. All ten participants have the same information on pages ___ and _____. These payoff sheets list not only the value of each number to you (under column ____) but also the value of each number to each of the other participants (under columns _____ _____ _____ _____ _____ _____ _____ _____ _____).

The descriptions of the game to decide the controller and the bargaining process were the same as in the four person 2 x 2 experiments, except that the teams were A-E and F-J. Six groups of ten subjects made two decisions each using these experimental instructions.

(2) Limited Information

As always in these experiments, the only change we made in the above experiments when we used limited information was that we substituted "You each may have different information on pages ___ and ___. These payoff sheets list only the value of each number to you (under column _____). The other participants (_____ _____ _____ _____ _____ _____ _____ _____ and _____) are free to reveal to you anything they wish about their payoffs." for the last two sentences of the two paragraphs reproduced above. Otherwise the two sets of instructions are identical. Six groups of ten sub-

jects made two decisions each using these experimental instructions.

b. 9 x 1 Controllers, Full and Limited Information

The next two sets of experiments were identical to the previous two sets except that the teams were now A alone and B-J. A could choose any number he or she liked. Any member of team B-J could choose the lowest number. Five groups of ten subjects made two decisions each with full information; five groups each made two decisions with limited information.

5. Twenty Person, 19 x 1, Limited Information, Sequential

Having completed the ten person experiments, it was clear that the Coase Theorem was quite robust, even in moderately large groups. We decided to double the group size once again and focus only on the treatment showing any deviation from complete efficiency: one controller against many under limited information. We concluded, on the basis of the four and ten person experiments, that if the Coase Theorem was robust under that experimental treatment, we could be reasonably certain it would be robust with equal size bargaining groups or full information. We would only conduct the experiments in the other treatment cells if this

cell failed to support the Coase Theorem.

Once again these instructions were identical to the ten person, 9 x 1, limited information, instructions described above, except that the teams were A alone and B-T. Four groups of twenty subjects made two decisions each using these experimental instructions.

D. Subjects

Subjects were undergraduate economics and management majors and management graduate students at Purdue University; upper level undergraduate economics majors at Northwestern University; and law students, undergraduate arts and sciences students and university staff at the University of Southern California. They were recruited in classes and by telephone and told only that they would participate in an economics decision. They were promised $4.00 per hour plus their earnings. Extra subjects were recruited in case of no-shows and paid at least $2.00 just for showing up. All subjects were inexperienced in this particular kind of experiment and friends were not allowed to participate together. After each experiment, we explained the nature of the experiment and the scientific importance of not telling their friends about it. Later subjects appeared to be as naive about the experiment as earlier subjects had been and there did not seem to be a time trend in the results.

III. Experimental Results

Table 2 summarizes the results of all 445 experimental decisions. Notice first that the Coase Theorem is very strongly supported in all size bargaining groups analyzed here. If anything, larger bargaining groups were more likely to choose the joint profit maximum than small groups were, at least in this set of experiments. Overall, 93% of the experimental decisions chose the profit maximizing outcome; 98% of the ten and twenty subject decisions chose it.

Comparing full and limited information, efficiency is somewhat lower (91%) with limited than with full information (94%). However, it seems equally important to note that efficiency is 90% or better for all but a few experimental treatments. Surprisingly, the only deviations from nearly 100% efficiency are among the four person coin flip experiments, which had the highest proportions of equal split payoff divisions. In fact, in general, these results strongly suggest that efficiency is compatible with self-regarding payoff divisions. The game trigger experiments were more efficient (94%) than the coin flip experiments (91%). The game trigger experiments also yielded far more (81%) self-regarding divisions than the coin flip experiments (only 33%).

IV. Implications of the Results for Analysis of Non-laboratory Environments

In this section we explore the applicability of our results to non-laboratory settings and then consider some implications of our findings for the choice of common law remedies, such as damages or injunctions.

A. Applicability of Results

To what extent do our experimental results supporting the Coase Theorem extend to nonlaboratory environments?[14] To answer this question we will explore two different types of reasons for not using these results. First, subjects might behave differently in the laboratory than in naturally occuring environments. Second, the experimental treatments used might not capture essential aspects of nonlaboratory environments.[15]

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[14] Of course, before a policy analyst can apply our results to nonlaboratory settings with confidence, he would have to replicate the laboratory experimental results several times. This would be particularly important for the large group experiments (10 and 20 subjects). There is a large experimental literature on 2, 3 and 4 person experiments and their results dovetail nicely with ours. There is no analogous experimental literature on 10 and 20 person bargaining groups, however.

1. Laboratory Effects

Our subjects might have behaved (bargained) differently than people in nonlaboratory settings for two reasons. First, subjects might regard money differently in a laboratory setting. Second, subjects might have different attitudes towards bargaining in a laboratory setting. These differences might be produced either by observer effects, or by some substantial difference between our subject pool (mainly young well-educated adults) and the people to whom the results will be applied. Before considering whether either of these possible differences caused different behavior, we must ask whether any evidence of laboratory effects appears in the data. The only evidence of such effects is the non-self-regarding nature of many of the controllers' decisions.

We commonly assume that people generally act in a self-

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[15] We should note, however, that if our experimental results had indicated substantial departures from efficiency, we would be able to say that the Coase Theorem was not supported, and was, perhaps, wrong. If a theory cannot work in a laboratory experiment that has been designed to focus on the assumptions underlying the theory, it is unlikely the theory will work in a naturally occuring enviroment, where many of the assumptions of the theory cannot be met in practice. If the Coase Theorem had failed in the laboratory setting, then we would have no cause to believe it would be valid in the field. Analogously, we have cast serious doubt on any theory of bargaining that suggests bargaining breakdown follows from large numbers (up to 20, at least) of parties to a bargain, alone.

regarding manner in naturally occuring environments. Hence, perhaps subjects were behaving differently merely because of the laboratory setting. Two considerations suggest that this possibility should not present problems for the applicability of our results. First, the degree of self-regarding behavior increased markedly when we switched the experimental treatment from coin flip to game trigger, suggesting that the laboratory setting was not producing that behavior. Second the results of the experiments with self-regarding controllers supported the Coase Theorem just as strongly as did the experiments with non-self-regarding controllers. Thus, even if people are, on average, less self-regarding in the laboratory than in naturally occuring environments, it does not seem to pose a threat to the test of the Coase Theorem. The Theorem is quite robust to subject differences in willingness to be self-regarding in a laboratory environment.

Depite the Theorem's robustness in the laboratory, however, one might still be concerned that observer effects and differences between the subject pool and the population at large render our results inapplicable in naturally occuring environments. One might worry, for example, that subjects bargained to efficient outcomes merely because they believed that they were expected to do so. Such beliefs might have come from a desire to appear to be "nice" because they were being watched by the experimenter. To the extent

that merely being observed produces a drive to bargain to efficient outcomes, however, our results remain applicable to many non-laboratory settings. Little of the bargaining to which our results would be applied takes place in absolute secrecy. The results, and often the bargaining process itself, of virtually all important business deals are scrutinized, either by management, boards of directors, stockholders, or governmental organizations. Hence, a similar drive toward efficiency could easily be produced in those settings.

The subject pool in our experiments is also quite similar to the group of people who make the kind of business deals and get involved in the kind of lawsuits the Coase Theorem models. These subjects, who tended to be juniors, seniors, and graduate students between 20 and 25 years of age will be the businesspeople and propertied individuals of the next generation. Despite this similarity, however, some might argue that they were too young and inexperienced in bargaining to provide a model for bargaining behavior. While we recognize this possibility, we think in it is probably relatively unimportant. Most of the subjects were management students and law students and both groups get instruction and practice in bargaining. They all seemed to take the experiments very seriously, and the results suggest that they did. Only if one believes that these people will grow less likely to contract to efficient outcomes as the grow

older and gain more experience would one question the usefulness of our subjects for a test of the Coase Theorem. Yet, that seems unlikely, since the efficient outcome gives each party to the bargain at least as much, and perhaps more, than he or she could get by forcing a bargaining breakdown. An experienced negotiator learns over time to get as much as possible from the bargain, not how to insure the bargain's failure.

2. Experimental Treatment Effects

A policy analyst might still hesitate to apply our results, however, because he feels that our experiments failed to incorporate enough of the naturally occuring phenomena which the analyst confronts. These concerns are quite serious. To fully understand where one may (and may not) validly apply such experimental results, we must investigate the most crucial sources of bargaining breakdown not modeled in our experiments. First, certain important bargaining and coordination costs were absent in our experiments. We only went up to 20 parties to a bargain and we brought them together face-to-face for the purpose of bargaining with one another. We did not forbid them to make joint maximizing deals including side payments. We have no reason to believe they disliked the task of bargaining with one another. And, we included institutions such as standard form contracts and an hourly wage for bargainers, which

undoubtedly reduced the costs of bargaining and facilitated the achievement of efficient outcomes. Naturally occuring bargains might not be efficient if large groups do not get orgainized to sit down together or if government regulations forbid them to do so. If they do sit down together they might not reach an efficient outcome if they cannot enforce their agreements or if the bargaining takes a great deal of time and the bargainers are not being paid. In addition, if the parties hate each other so much that they either won't talk or they prefer to hurt one another instead of maximizing jointly, no efficient bargaining is likely to take place. For such reasons, our results should not be applied to a pollution dispute involving hundreds of unorganized homeowners, a price fixing deal between large corporations, or a divorce settlement.

Second, informational deficiencies or asymmetries might also produce inefficient outcomes. Our experiment did not model situations in which parties did not know their own profit functions or could not learn the functional nature of the interference between their profit functions. In such a situation individuals might <u>try</u> to joint maximize, given their information, but still be unable to do so. In some sense, however, one could argue that such behavior does not violate the spirit of the Coase Theorem. We simply need to reformulate the Theorem with informational constraints, just as standard economic welfare theory is being reformulated

subject to those constraints.[16] The Theorem's predictions would undoubtedly be different, however, and we would want to test the new predictions with a limited information set.

Third, we modeled no significant wealth effects in our experiments. Large wealth effects on consumer demand functions preclude the application of the Coase Theorem since the invariance result no longer holds theoretically.

Despite all these precautionary statements, however, we still believe that in a substantial number of instances a policy analyst might apply our results with some confidence. Such instances would include situations where bargaining and enforcement costs are low, where there are few informational problems, and where no more than 20 people are involved. We turn now to a consideration of how our results might be applied.

B. Implications of Our Results for Legal Policy

Our results may provide implications for the law of remedies in property, tort and contract, suggesting support for the use of injunctive remedies, as opposed to damages. An example from our previous paper[17] will help illustrate this point:

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16 see, e.g., Milton Harris and Robert M. Townshend, Resource Allocation Under Asymmetric Information, 49(1) Econometrica 33 (1981).

The choice of remedies for the area of nuisance law[49] provides a good example. Assume that a particular new land use, for example, a cement factory, interfers with other land uses, for example, homeowning, so as pos-[50] sibly to constitute a "nuisance" under the law. Regardless of whether the court finds the new factory to be a nuisance, the court must confront the thorny issue of whether to grant the winning side the right to an injunction or to limit that side to a damages remedy.[51] These are the two injunctive remedies, which were modeled in our experiment, from which the court must choose: (1) Factory's right -- the factory may pollute at any level it chooses. (2) Homeowner's right -- any homeowner is entitled to an order of the court directing the factory to emit no pollutants. The court may also choose from these two damages remedies: (1a) Factory's right -- the homeowners may obtain an order of the court directing the factory to emit no pollutants if and only if the homeowners pay the factory all damages it suffers from reducing its level of pollution. (2a) Homeowner's right -- the factory may pollute at any level it chooses, but it must pay homeowners for any damage caused by the pollution.

These are problems[52] associated with both damages and injunctive remedies. Injunctive relief may be inefficient because bargaining may fail to achieve Pareto optimality. Damages remedies are plagued by the difficulty of accurately appraising damages and the increased administrative costs associated with such a valuation. Where there is only one cement factory and one homeowner, the risk associated with injunctive entitlements -- the failure of contracting -- has been thought to be low.

[49] See Maurice T. Van Hecke, Robert N. Leavell, & Grant S. Nelson, Cases and Materials on Equitable Remedies and Restitution, 425-59 (1973) for general background on this subject.

[50] For example, Boomer v. Atlantic Cement C., 26 N.Y.2d 219, 257 N.E.2d 870, 309 N.Y.S.2d 312 (1970).

[51] We realize that there are other possibilites, but restricting discussion to these two alternatives simplifies the textual discussion. For a good discussion of a hybrid remedy, see Robert C. Ellickson,

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[17] Hoffman and Spitzer, Supra, note 1.

Alternatives to Zoning: Covenents, Nuisance Rules, and Fines as Land Use Controls, 40 U. Chi. L. Rev. 681, 738 (1973).

52 We assume the law is, or should be, concerned at least in part with economic efficiency. This topic has been much discussed in the literature of law and economics. See Symposium on Efficiency as a Legal Concern, 8 Hofstra L Rev. 485-771 (1980), and A Response to the Efficiency Symposium, 8 Hofstra L. Rev. 811-973 (1980). We recognize that the proper jurisprudential role of economics is controversial, but resolution of this controversy lies well beyond the scope of this paper.

(pp. 96-97)

The results of our experiments provide support for this surmise. The two-person experiments produced almost 100% efficient outcomes. Hence, a court could choose between rule 1 and rule 2 (deciding whether or not a factory is a nuisance), knowing that the parties will bargain to whatever outcome is the most efficient. Where there are <u>many</u> parties to a bargain, conventional wisdom suggests that the risk of bargaining breakdown, due to strategic behaviors and coordination problems, increases to the point where one should incur the inaccuracies and costs inherent in a damages entitlement. In such circumstances, the court should choose between rule 1a and rule 2a, which might allow the parties to more closely approximate the efficient outcome.

The law and economics literature in this area generally avoids discussing the question of how many is "many." Instead, a typical discussion will assume at least 1000 parties to a bargain when discussing coordination

problems.[18] In contrast to these discussions, our experimental results provide good evidence that 20 is not "many". Therefore, a court may choose between rule 1 and rule 2 (injunctive entitlements) if there are few bargaining or enforcement costs, few information problems, and no more than 20 parties, and be reasonably sure the parties will bargain to the efficient outcome. In such circumstances, the costs and inaccuracies of damages entitlements may be avoided.[19] The same style of analysis can be used to produce policy implications for remedies throughout tort, contract,

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[18] See, e.g., Posner, Supra, note 3 (1000 parties); and Guido Calabresi and A. Douglas Melamed, Property Rules, Liability Rules and Inalienability: One View of the Cathedral, 85 Har, L. Rev. 1089 (1972) (100,000 citizens).

[19] At this point the moderate departures from optimality in the 3 and 4 person, joint controller, limited information, coin flip experiments are best viewed as statistical outliers, especially in view of the overwhelmingly high percentage of efficient outcomes in the 3, 4, 10 and 20 person, joint controller experiments. Hence, our tentative conclusions in Hoffman and Spitzer, supra, note 1, at 96-98, that joint controllers pose a problem for the Coase Theorem, should be discarded.

Our results may also provide some implications for the current jurisprudential debate over the appropriate role of economic efficiency as a norm in the law. As used in the literature, which has burgeoned around Richard Posner's various defenses of his "wealth maximization" norm, [insert cites] economic efficiency has been equated with the Hicks-Kaldor compensation criterion. We will neither defend nor attack this criterion as a norm in this paper. Instead, we will show how the Coase Theorem, and our results, might affect the nature of the debate.

One of the central difficulties with the Hicks-Kaldor version of economic efficiency is that the

and other areas of property law.

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criterion directs some to be made worse off, while some are made better off, merely because everyone could (but will not be) made better off. Where a judge must choose one of two allocations of a property right, and bargaining is too expensive, the rights will remain where they are judicially placed. The criterion of economic efficiency leads the judge to imagine a world in which bargaining, coordination, and enforcement costs are zero, predict which of the claimants would purchase the right at auction, and then actually award the right to that claimant. Richard A. Posner, Symposium on Efficiency as a Legal Concern, 8 Hofstra L. Rev. 485-771 (1980), defends such an approach by arguing that economic efficiency can be equated with Pareto superiority in the long run. Needless to say, this position has been attacked on an a number of grounds. See, e.g, all of the other articles in id. and also A Response to the Efficiency Symposium, 8 Hofstra L. Review. 811-973 (1980).

Regardless of the ultimate success of the arguments for and against Posner's version of the economic efficiency criterion, however, our experimental results should affect the tenor of the arguments. One who is arguing for the use of the efficiency norm may now claim the norm describes what parties to a bargain will decide to do for themselves. The judge, then is simply facilitating an inevitable process and is justifiably concerned about promoting economic efficiency. By simply choosing the efficient outcome the judge merely saves society the legal costs which would be incurred during a long bargaining process.

Those who argue against economic efficiency as a norm may also find support in our results. After all, if the parties can be trusted to contract an efficient solution by themselves, a judge may ignore efficiency concerns and concentrate instead upon effecting a "fair" distribution of income or on setting a precedent for an appealing theory of rights. Only in circumstances in which the Coase Theorem cannot be applied with confidence should economic efficiency have any claim on judicial attention.

In general, therfore, the form of the debate alters when one is fairly certain that the Coase Theroem is applicable. Our experimental results can be seen as a preliminary map of the domain in which the Coase Theorem's applicability shifts the tone of the debate. That domain turns out to be quite substantial.

V. Conclusions

Our experimental results provide very strong support for the Coase Theorem as tool for anaylzing decisions of groups of twenty persons or less, when bargaining, coordination and enforcement costs are low and there are few information problems. Although a policy analyst should be quite careful about applying these results to a non-laboratory setting, where he may do so with some confidence he can produce substantial implications for the law of remedies in tort, contract and property.

Table 2

KEY:

N = total number of decisions

N_1 = number of joint profit maximums

N_2 = number of equal splits ± $1.00

N_3 = number individually rational divisions

N_4 = other payoff divisions

Experiment	N	N_1	N_2	N_3	N_4
I. Coin Flip,					
A. Two-Person					
1. Sequential					
a. Full Information	12	12	12	0	0
b. Limited Information	8	8	6	2	0
2. Non-sequential					
a. Full Info	12	11	5	7	0
b. Limited Info	12	11	6	4	2
B. Four Person Sequential					
1. 3 x 1 Controllers					
a. Full Info	75	75	49	15	11
single controller	41	41	25	6	10
joint cont	31	31	21	9	1
no flip	3	3	3	0	0

Table 2 (con.)

Experiment	N	N_1	N_2	N_3	N_4
b. Limited Info	54	42	28	20	6
single	23	18	8	10	5
joint	28	21	17	10	1
no flip	3	3	3	0	0
2. 2 x 2 Controllers					
a. Full Info	9	6	1	6	2
b. Limited Info	45	42	16	20	9
Coin Flip Totals	227	207	123	74	30
percentages		91%	54%	33%	13%
II. Game Trigger					
A. Two-person					
1. Sequential					
a. Full Info	22	21	7	15	0
b. Limited Info	20	18	7	11	2
2. Non-sequential					
a. Full Info	24	20	2	21	1
b. Limited Info	18	18	0	10	8

Table 2 (con.)

Experiment	N	N_1	N_2	N_3	N_4
B. Three-person Non-sequential					
1. Full Info	24	23	1	23	0
single	8	8	0	8	0
joint	15	14	0	15	0
no game	1	1	1	0	0
2. Limited Info	24	23	3	18	3
single	5	5	1	3	1
joint	19	18	2	15	2
C. Four Person Non-sequential					
1. 3 x 1 Controllers					
a. Full Info	12	12	1	11	0
single	6	6	1	5	0
joint	6	6	0	6	0
b. Limited Info	12	10	1	10	1
single	2	2	0	1	1
joint	10	8	1	9	0
2. 2 x 2 Controllers Limited Info	12	12	0	12	0

Table 2 (con.)

Experiment	N	N_1	N_2	N_3	N_4
D. Ten Person Sequential					
1. 5 x 5 Controllers					
a. Full Info	12	11	0	12	0
b. Limited Info	12	12	0	11	1
2. 9 x 1 Controllers					
a. Full Info	8	8	0	7	1
b. Limited Info	10	10	1	8	1
E. Twenty Person, Sequential, Limited Info	8	8	0	7	1
Game Trigger Totals	218	206	23	176	19
percentages		94%	11%	81%	8%
Grand Totals	445	413	146	250	49
percentages		93%	33%	56%	11%
Full Information	210	199	78	117	15
percentages		95%	37%	56%	7%
Limited Information	235	214	68	133	34
percentages		91%	29%	57%	14%