EXPERIMENTAL EVALUATION OF THE COASE THEOREM*

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I. INTRODUCTION

THE Coase Theorem is a theoretical proposition describing the outcomes of mutually advantageous bargains in the face of the generation of an externality. The traditional Coasian framework is summarized in the set of assumptions adopted by Hoffman and Spitzer in their behavioral evaluation of the Theorem: "(*a*) two agents to each externality (and 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."[1]

The Coase Theorem is generally stated in terms of the neutrality of the resulting level of the externality to the initial assignment of property rights between the two parties. That is, irrespective of which party has the unilateral property right (UPR) to impose the externality on the other party, we should find the Pareto-optimal level of externality generation. The compelling feature of this Coasian result is that it is brought about by the self-interest of each party and does not rely on their altruism with respect to one another or the visible hand of the state.

In an important study, Hoffman and Spitzer provide an experimental evaluation of the behavioral relevance of the Coase Theorem.[2] They claim

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[1] Elizabeth Hoffman & Matthew L. Spitzer, The Coase Theorem: Some Experimental Tests, 25 J. Law & Econ. 73 (1982). Footnote omitted, emphasis added.

[2] For related experimental studies see Yves C. Prudencio, The Voluntary Approach to Externality Problems: An Experimental Test, 9 J. Envtl. Econ. & Mgmt. 213 (1982); Elizabeth Hoffman & Matthew L. Spitzer, Experimental Tests of the Coase Theorem with

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that their results provide strong support for the Coase Theorem. Indeed their results have been employed in at least one standard textbook exposition.[3] Following Regan,[4] Hoffman and Spitzer focus on the behavioral implications of assumption *h* above. This assumption implies *two* distinct behavioral outcomes: (i) that the two parties will agree on a Pareto-optimal level for the externality; and (ii) that any such agreement will be attained by means of a mutually advantageous bargain between the two parties. Hoffman and Spitzer present experimental results that overwhelmingly support the first outcome but reject the second outcome. Pooling over all their experiments, 89.5 percent of all bargains resulted in a Pareto optimal solution. However, in 60.8 percent of those solutions the two parties essentially[5] agreed to split the total payoff equally, even though this represented a disadvantageous bargain for one of the parties (the "controller," or holder of the UPR) relative to the payoff attainable without any bargaining.

Hoffman and Spitzer explicitly recognize the problem with their results:

> A core allocation is individually rational, Pareto optimal, and rational for every possible winning coalition of players. Some might argue that our results do not support Coase's hypothesis because so many subjects split equally instead of bargaining to a core allocation. It seems to us, however, that Coase's efficiency prediction has been the crucial part of his hypothesis in shaping legal and economic policy. It is on that basis that we claim our results support the Coase Theorem. We recognize that Coase *expected* the income distribution would favor the controller. That expectation is, of course, not confirmed in general by our results.[6]

Ignoring the exegetical issue of what Coase "really meant,"[7] we can argue that the policy significance of the Coase Theorem derives primarily from the view that the delimitation of UPR serves to facilitate the inter-

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Large Bargaining Groups, 15 J. Legal Stud. (1986), forthcoming; and Elizabeth Hoffman & Matthew L. Spitzer, Entitlements, Rights and Fairness: An Experimental Examination of Subjects' Concepts of Distributive Justice, 14 J. Legal Stud. 259 (1985).

[3] Jack Hirshleifer, Price Theory and Applications 490 (3d ed. 1984).

[4] Donald H. Regan, The Problem of Social Cost Revisited, 15 J. Law & Econ. 427 (1972).

[5] The word "essentially" allows for divisions of the total payoff that are within $1.00 of an equal split.

[6] Hoffman & Spitzer, *supra* note 1, at 93 n.47.

[7] For an exchange on the question of the relevance of the core concept for the Coase Theorem see Varouj A. Aivazian & Jeffrey L. Callen, The Coase Theorem and the Empty Core, 24 J. Law & Econ. 175 (1981); and R. H. Coase, The Coase Theorem and the Empty Core: A Comment, 24 J. Law & Econ. 183 (1981). In the original paper Coase actually refers to "mutually satisfactory bargains": see R. H. Coase, The Problem of Social Cost, 3 J. Law & Econ. 1, 4 (1960), for example.

nalization of externalities through individually rational bargaining. Hirshleifer notes that from a "policy point of view, Coase's Theorem strongly suggests that the *unambiguous assignment of exchangeable property rights,* whatever the specific nature of the assignment may be, might be an important step in promoting the achievement of efficiency."[8] Similarly, Cooter observes that the Coase Theorem "is taken to suggest a definite approach to policy legislation—use the law to lubricate private bargaining."[9] The critical behavioral presumption, then, is that the affected parties act in a self-interested fashion in the bargaining context defined by the initial property rights assignment. This presumption is not supported by the results of Hoffman and Spitzer's experiments.

An alternative line of defense of their results is offered by Hoffman and Spitzer, based on the interpretation of their results as reflecting the altruism of their subjects:

> Indeed, to the extent that the sharing behavior indicates that either the subjects were failing to profit maximize or were maximizing interdependent utility functions which might violate one of the axioms of the Coase Theorem, our results cannot be taken to verify the theorem. Since the initial conditions were not all satisfied, assumption *h* might not have received a good test. However, if our assumption regarding individual motivations were incorrect, then these results may take on even more significance, for they seem to indicate that the Coase Theorem's prediction about production still has great power; the Pareto optimum was chosen almost 90 percent of the time. These experiments would seem to say that in two- and three-person situations a scholar might be able to assert with some confidence that groups will behave *as if* all of the Coase Theorem's assumptions were satisfied.[10]

In short, the Coase Theorem is behaviorally "right for the wrong reasons." Moreover, if we can rely on economic agents to be altruistic with respect to the generation of externalities, why do we need UPR (or Pigouvian taxes, for that matter) to internalize the problem? In this light, the Coase Theorem is rendered behaviorally vacuous for policy purposes.

In the next section we develop an experimental design that allows a careful evaluation of the Coase Theorem in the simplest possible context: two parties, full information concerning each other's payoffs, and nonsequential bargaining (that is, no subject has any continuing experimental relationship with any other subject).[11] Our experimental results are pre-

[8] Hirshleifer, *supra* note 3, at 491.

[9] Robert Cooter, The Cost of Coase, 11 J. Legal Stud. 1, 14 (1982).

[10] Hoffman & Spitzer, *supra* note 1, at 93–94.

[11] Note that this is just one of the many experimental designs considered by Hoffman and Spitzer (HS). It is, however, the one that HS present as most directly relevant for the evaluation of the Coase Theorem (that is, the other designs involve relaxing one or more of the assumptions of the theorem).

TABLE 1
ALTERNATIVE PAYOFF SCHEDULES

Schedule	Number	Payoff to A	Payoff to B	Joint Payoff
I	1	.00	4.00	4.00
	2	.50	3.50	4.00
	3	2.00	3.00	5.00
	4	2.50	1.00	3.50
	5	3.00	.50	3.50
	6	4.00	.00	4.00
II	1	.00	4.00	4.00
	2	.50	3.50	4.00
	3	2.50	3.50	6.00
	4	2.50	1.00	3.50
	5	3.00	.50	3.50
	6	4.00	.00	4.00
III	1	.00	4.75	4.75
	2	.50	4.50	5.00
	3	1.75	4.25	6.00
	4	2.50	2.50	5.00
	5	4.50	.50	5.00
	6	4.75	.00	4.75

NOTE.—The joint payoff values were not provided to subjects.

sented in Section III. We find that the comparable Hoffman-Spitzer results that are inconsistent with individual rationality are attributable to a lack of understanding by certain subjects of the meaning of UPR. We are also able to demonstrate that the Coase Theorem is *not* behaviorally vacuous for policy purposes, by illustrating the necessity of an initial assignment of property rights for mutually advantageous bargaining to produce an efficient outcome.

II. EXPERIMENTAL DESIGN AND HYPOTHESES

As far as possible our design and instructions followed Hoffman & Spitzer. All subjects were recruited from the economics undergraduate program at the University of Western Ontario. None had received any formal exposure to the Coase Theorem or game theory. The subjects were told in effect that they would be bargaining in three successive sessions, each time with a different opponent. The complete experimental instructions, reproduced in Appendix A, carefully avoid (as far as possible) the use of any "loaded" word such as "bargaining" or "opponent." Each participant was to be paid according to a publicly posted payoff schedule. This schedule showed the monetary value to each subject of six numbers (see Table 1). The exact monetary amount paid depended on whether the subject was designated "person A" or "person B" (decided by a coin flip)

and on the number eventually chosen (by way of agreement or disagreement). Subjects were told that they would be paid by check at the end of a series of experiments.[12] Physical threats were not allowed: all bargaining negotiations were monitored to reinforce this requirement.

Subjects were told that there could be either an "agreement outcome" or a "disagreement outcome" in each session. The former was simply an agreement between the two parties as to which number to choose *and* how much of the total payoff would go to each participant. In response to a public question from one subject in the initial experiments, it was explained to all subjects that the agreement form could be used solely to agree upon a number without any sidepayments being made. In subsequent experiments this point was made orally during the initial public reading of the instructions. In one series of experiments, designated "No Property Rights," we prohibited explicit contractual sidepayments; Appendix B presents the modified instructions used in these experiments.

Subjects were informed that one of three alternative disagreement outcomes would apply—random, zero, and controller—and that they would be told at the beginning of each session which one applied to them. The instructions defining each of these outcomes are reproduced in Appendix A. In the *random* outcome, a number is drawn at random and applied to both participants. Each number is equally likely to be drawn at random. In the *zero* outcome both participants receive zero payoff for the session. The *controller* outcome follows when one player is designated the "controller" at the outset of each session, based on a coin flip. The controller may choose the number by himself or herself and inform the monitor, who will stop the experiment and pay both participants. The other participant may attempt to influence the controller to reach a mutually acceptable joint decision; the other participant may offer to pay part or all of his or her earnings to the controller.

Subjects were given a demonstration of our "random number generator" (a die) and a simple example of a *hypothetical* controller outcome. They were then asked to answer privately a brief series of *hypothetical* questions designed, among other things, to see if they understood what a controller's "property rights" were (specifically, that the controller can unilaterally choose any number, with or without the "opponent's" agreement). All subjects answered each question correctly. Each bargaining

[12] Subjects also knew that none of the subsequent experiments would involve bilateral bargaining with any of their opponents in the current experiments. Payment of earning with a lag probably served to reinforce the importance of the explicit agreement form in our experiments (as the only effective or credible way to transfer any of the joint payoffs from a decision).

session could last for ten minutes, with several warnings provided about the time remaining.[13] Very few of the observed outcomes were decided "at the wire," and this time limit did not appear to be a binding constraint on negotiating behavior. Table 1 lists the payoff schedules adopted in each experiment, and Table 2 presents our experimental design.

The first series of experiments involves a "replication" of Hoffman and Spitzer's design with our subject pool and our (relatively trivial) modifications to their instructions.[14] These experiments adopt unilateral property rights (UPR) in each of the three sessions, with the social surplus equal to $1.00 or $2.00. In addition to providing a behavioral benchmark for subsequent treatments, these experiments allow us to examine two hypotheses concerning Hoffman and Spitzer's results:

H1. The altruistic divisions of the joint payoff are due to learning behavior (that is, they occur primarily in sessions 1 or 2, and not in session 3).

H2. The altruistic divisions of the joint payoff are an artifact of a small social surplus (that is, increasing the surplus from $1.00 to $2.00 will reduce the number of observed altruistic divisions).

The first hypothesis is suggested by a comparison of the sequential and nonsequential two-person, full-information results of Hoffman and Spitzer. In the former experiments, which were conducted in just one session, 100 percent of the divisions were exactly altruistic; in the latter experiments, which were conducted (like ours) in three successive sessions, "only" 45.5 percent of the Pareto-optimal decisions were altruistically divided. Given the importance of learning behavior and sequential replication in other areas of experimental behavior, it is important to check if

[13] HS apparently allowed an indeterminate amount of time for bargaining. Don Coursey, Bilateral Bargaining, Pareto Optimality, and the Empirical Frequency of Impasse, 3 J. Econ. Behav. & Organization 243 (1982) provides a systematic study of the effect of time constraints on the observed frequency of impasse in bilateral bargaining experiments. We regard the introduction of a time constraint as a potentially important modification of the HS design for two reasons: (i) it avoids the problem of extraneous pressures on the time allowed for bargaining (for example, one subject may have a pressing appointment at a certain time), which may lead to different subjective costs of continuing to bargain (or, in Coasian jargon, "transactions costs"); and (ii) it allows us to ensure that our financial incentives are salient for any particular subject pool (that is, we can ensure that the potential payoffs are commensurate with the opportunity cost of the time involved in the experiment).

[14] Examples of these modifications are the time limit constraint and the payment of subjects with a lag. Although we have a strong prior expectation that these are behaviorially innocuous modifications for present purposes, it is important to confirm this before studying less trivial modifications. If this prior is not accepted, then our experiments do not constitute a literal replication of HS, but they do stand as an independent series of experiments. Moreover we may then examine the effect of the important modifications in an orthogonal fashion, irrespective of the extent to which we "replicate" HS.

TABLE 2
EXPERIMENTAL DESIGN

Institution	Experiment	Session	Disagreement Outcome	Training Session	Social Surplus ($)	Payoff Schedule (See Table 1)
Unilateral property rights	UPR(1)	1	Controller	...	1	I
		2	Controller	UPR(1)	1	I
		3	Controller	UPR(1)	1	I
	UPR(2)	1	Controller	...	2	II
		2	Controller	UPR(2)	2	II
		3	Controller	UPR(2)	2	II
No property rights	NPR(Z)	1	Zero	...	1	III
		2	Zero	NPR(Z)	1	III
		3	Zero	NPR(Z)	1	III
	NPR(R)	1	Random	...	1	III
		2	Random	NPR(R)	1	III
		3	Random	NPR(R)	1	III
Joint property rights	JPR(Z)	1	Zero	...	1	I
		2	Zero	JPR(Z)	1	I
	JPR(R)	1	Random	...	1	I
		2	Random	JPR(R)	1	I
Unilateral property rights	UPR(Z)	3	Controller	JPR(Z)	1	I
	UPR(R)	3	Controller	JPR(R)	1	I

this simple explanation accounts for the observed altruism (Hoffman and Spitzer do not report the results for their nonsequential experiments by session). The second hypothesis addresses the issue of the opportunity cost, in terms of forgone monetary payoff, of altruism in these experiments.[15] Alternatively, hypothesis H2 is also suggested by vague notions of the opportunity cost of "understanding the property rights of a controller" (presuming such comprehension requires some mental exertion that is valued by the subject).

The second series of experiments establishes a no property rights (NPR) bargaining environment with alternative disagreement outcomes. Here the subjects could agree on a particular number, but could not *contractually* transfer any of the resulting joint payoff from one party to the other. The payoff schedule used in these experiments (schedule III in Table 1) yields a Pareto-optimal outcome (3) that maximized the joint payoff and a *different* Pareto-optimal outcome (4) that divided the joint payoff (which was $1.00 less than the maximum joint payoff) equally between the two parties. We have the following hypothesis in these experiments:

H3. In the absence of transferable property rights the parties will not choose the joint payoff maximum.

Clearly, if this hypothesis is rejected, we do not have an "externality problem" to solve (by Coasian or other means). The importance of establishing that there is indeed a behavioral problem to solve, before examining the ability of certain institutions to solve it behaviorally, is long established in the experimental literature.[16]

[15] HS randomized over payoff schedules, noting that "each schedule has a clear joint-profit maximizing number, which pays at least $1.00 more than the next highest number." Hoffman & Spitzer, *supra* note 1, at 85. In a personal communication, Elizabeth Hoffman notes that for the two-person full-information HS experiments the social surplus was always $2.00 or more. HS do not report the results obtained for different levels of the social surplus.

[16] See, for example, Vernon L. Smith, Incentive Compatible Experimental Processes for the Provision of Public Goods, 1 Research in Experimental Econ. 59 (1979), sec. 4, on the "free-rider problem" for public goods; on the "monopoly problem," see Vernon L. Smith, An Empirical Study of Decentralized Institutions of Monopoly Restraint, in Essays in Contemporary Fields of Economics (G. Horwich & J. Quirk eds. 1981); Don Coursey, R. Mark Isaac & Vernon L. Smith, Natural Monopoly and Contested Markets: Some Experimental Results, 27 J. Law & Econ. 91 (1984); and Glenn W. Harrison & Michael McKee, Monopoly Behavior, Decentralized Regulation, and Contestable Markets: An Experimental Evaluation, 16 Rand J. Econ. 51 (1985); on the "externality problem," see Charles R. Plott, Externalities and Corrective Policies in Experimental Markets, 93 Econ. J. 106 (1983); and on the "predatory pricing problem," see Glenn W. Harrison, Predatory Pricing in Experiments (May 1985) (unpublished manuscript, Univ. Arizona, Dep't Econ.); and R. Mark Isaac & Vernon L. Smith, In Search of Predatory Pricing, 93 J. Pol. Econ. 320 (1985).

The third series of experiments establishes joint property rights (JPR), in the sense that no party has the right *unilaterally* to choose any number that can guarantee a positive payoff, but that the two parties have the right to choose any number *jointly* and divide the total payoff as they wish. The alternative to coming to a joint agreement is that neither party can be certain of receiving a positive payoff (the random disagreement outcome) *or* they are certain to receive nothing (the zero disagreement outcome). The following hypotheses are proposed:

H4. The establishment of joint property rights increases the number of joint maximum payoff outcomes.

H5. The total payoff received under joint property rights will be equally split between the two parties.

Hypothesis H4, if accepted, may be taken as consistent with a weak behavioral form of the Coase Theorem: that it is only necessary *for efficiency* that JPR be established. Hypothesis H5 is consistent with the Nash solution for bargaining games of this form.[17]

The final series of experiments establishes unilateral property rights (UPR) for one party. An essential feature of our design is that these UPR experiments follow "training sessions" consisting of JPR experiments (with zero or random disagreement outcomes). This sequential feature reinforces the delimitation of *unilateral* property rights that is at the heart of the Coasian individual rationality question. We therefore hypothesize:

H6. The establishment of unilateral property rights increases the number of joint maximum payoff outcomes.

H7. The establishment of unilateral property rights increases the number of individually rational bargains by the property right holder.

It is interesting to note the rather close approximation of this final design to the stylized facts describing the manner in which naturally occurring legal decisions are made. One can view the trial process—wherein property rights are assigned—as a final stage of a bargaining *series* in which the initial periods involve incompletely specified property rights.[18] The behavioral implication of our design is that the pre-property-rights negotiation will impress the value of the property right on the person ultimately designated as controller. Hypothesis H7 expresses the impact of the "pretrial" bargaining process on the posttrial allocation of re-

[17] John F. Nash, The Bargaining Problem, 18 Econometrica 155 (1950); and John F. Nash, Two Person Cooperative Games, 21 Econometrica 128 (1953).

[18] See Robert Cooter & Stephen Marks, with Robert Mnookin, Bargaining in the Shadow of the Law: A Testable Model of Strategic Behavior, 11 J. Legal Stud. 225 (1982).

sources. If not rejected, H7 may be considered as consistent with a strong behavioral form of the Coase Theorem.

III. Experimental Results

Table 3 presents the detailed results of our experiments, along with those reported by Hoffman and Spitzer for their nonsequential two-person full-information design. In Table 4 we present the results of several χ^2 tests to determine if the behavioral outcomes discussed below differ significantly between experiments.[19] Note that the test adopted is two sided, and that the direction of any difference in outcome is not predicted. The "critical level" shown in Table 4 is the *smallest* significance level at which the null hypothesis could be rejected (that is, a critical level of .490 indicates that one would have to have at least 49 percent confidence in the alternative hypothesis in order to reject the null). We report on rejection of the null hypothesis in Table 4 at a stringent 2 percent critical level.

Hypothesis H1 is rejected on the basis of the UPR(1) results for each session: there is no apparent learning behavior across the three sessions. This result is confirmed in Table 4 by a χ^2 test on the UPR(1) results reported in Table 3, indicating that the probability of altruistic outcomes is not significantly different in session 3.

Comparing Hoffman and Spitzer's pooled results with the UPR(1) series of our experiments we find that 45.5 percent (five of eleven) of their Pareto-optimal decisions were accompanied by equal-split (altruistic) outcomes, while 60.0 percent (nine of fifteen) of our bargains yielded this result. We cannot reject the hypothesis that these results are identical (the appropriate χ^2 statistic is .540 with a critical level of .4627). Our results therefore replicate those of Hoffman and Spitzer, indicating that the *minor* changes we made to their procedures are indeed behaviorally unimportant. This confirms our use of the UPR(1) experiments as a base from which to evaluate the remaining experimental institutions.

Hypothesis H2 is supported by a comparison of the UPR(1) and UPR(2) results: increasing the social surplus significantly reduced the number of altruistic divisions from 60.0 percent (nine out of fifteen) to a mere 11.1 percent (one out of nine). Although the strength of this treatment is remarkable, it indicates that the individual irrationality of Hoffman and Spitzer's results may be due in part to the adoption of payoff schedules involving a "small" social surplus.[20]

[19] W. J. Conover, Practical Nonparametric Statistics 144–51 (2d ed. 1980) provides a formal explanation of the χ^2 test used.

[20] Note that we varied the size of the social surplus in an absolute sense (from $1.00 to

TABLE 3
EXPERIMENTAL RESULTS

EXPERIMENT	SESSION	NUMBER OF DECISIONS (N)	NUMBER OF JOINT PROFIT MAXIMUM DECISIONS (N_1)	PAYOFF DIVISION					
				Equal Splits (N_2)	Within $1.00 of Equal Splits ($N_3$)	Controller Receives Exactly the Individual Maximum (N_4)	Controller Receives More than Individual Maximum (N_5)	Other (N_6)	Disagreement Outcome (N_7)
HS	All	12	11	5	0	4	3	0	n.a.
UPR(1)	1	5	5	3	1	0	1	0	0
	2	5	5	2	0	1	2	0	0
	3	5	5	3	0	2	0	0	0
	All	15	15	8	1	3	3	0	0
UPR(2)	1	3	3	1	0	0	2	0	0
	2	3	3	0	0	1	2	0	0
	3	3	3	0	0	0	3	0	0
	All	9	9	1	0	1	7	0	0
NPR(Z)	1	2	0	2	0	n.a.	n.a.	0	0
	2	2	0	2	0	n.a.	n.a.	0	0
	3	2	0	2	0	n.a.	n.a.	0	0
	All	6	0	6	0	n.a.	n.a.	0	0
NPR(R)	1	2	0	1	0	n.a.	n.a.	0	1
	2	2	0	0	0	n.a.	n.a.	0	2
	3	2	0	0	0	n.a.	n.a.	0	2
	All	6	0	1	0	n.a.	n.a.	0	5
NPR (Z and R)	All	12	0	7	0	n.a.	n.a.	0	5
JPR(Z)	1	7	7	6	1	n.a.	n.a.	0	0
	2	7	7	7	0	n.a.	n.a.	0	0
	All	14	14	13	1	n.a.	n.a.	0	0
JPR(R)	1	10	10	9	1	n.a.	n.a.	0	0
	2	10	9	8	0	n.a.	n.a.	0	2
	All	20	19	17	1	n.a.	n.a.	0	2
JPR (Z and R)	All	34	33	30	2	n.a.	n.a.	0	2
UPR(Z)	3	7	6	2	0	2	3	0	0
UPR(R)	3	10	9	0	1	5	3	1*	0
UPR (Z and R)	3	17	15	2	1	7	6	1	0

NOTE.—Refer to Table 2 for a description of the experimental design; n.a. means outcome not applicable.

* Controller chose his individual maximum and transferred $1.00 to the other player. This outcome was implemented by the agreement form, with both subjects signing.

TABLE 4
STATISTICAL TESTS

	Population 1		Population 2		Class 1		
Hypothesis	Experiment	Sessions	Experiment	Sessions	Definition	Population 1 Value	Population 2 Value
H1	UPR(1)	1	UPR(1)	3	$N_2 + N_3$	4	3
	UPR(1)	2	UPR(1)	3	$N_2 + N_3$	2	3
	UPR(1)	1 & 2	UPR(1)	3	$N_2 + N_3$	6	3
H2	UPR(1)	All	UPR(2)	All	$N_2 + N_3$	9	1
H3	NPR	All	UPR and JPR	All	N_1	0	72
H4	NPR	All	JPR	All	N_1	0	33
H6	UPR(Z and R)	All	NPR	All	N_1	15	0
	UPR(Z and R)	All	JPR	All	N_1	15	33
	UPR(Z and R)	All	NPR and JPR	All	N_1	15	33
H7	UPR(Z and R)	All	UPR(1)	All	$N_4 + N_5$	13	6

Hypothesis H3 is overwhelmingly supported: none of the twelve decisions in the NPR experiments involved choosing the joint profit maximum. In the NPR(Z) series all of the agreements involved the equal-split outcome, whereas in the NPR(R) series 83.3 percent (five out of six) of the negotiations ended with the disagreement outcome.[21] We therefore conclude that there is indeed a behavioral "externality problem" to solve.

Hypothesis H4, implying a weak behavioral form of the Coase Theorem, is convincingly supported. Fully 97.1 percent (thirty-three out of thirty-four) of the decisions with JPR were agreements to choose the joint-profit-maximizing number. This contrasts significantly with the results just discussed for the NPR experiments (with none of the decisions being the joint-profit maximum). Hypothesis H5 is also strongly supported: 97.0 percent (thirty-two out of thirty-three) of the Pareto-optimal payoffs in the JPR experiments were divided virtually equally between the two parties. This result is, of course, perfectly consistent with Nash *and* Coasian solutions, given that UPR are not assigned to one party.

Hypothesis H6 is firmly supported, with 88.2 percent (fifteen out of seventeen) of the decisions in the experiments that establish UPR in session 3 being Pareto optimal. This again contrasts sharply with the

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$2.00) *and* relative to the disagreement outcome payoff to the controller. An interesting area for subsequent research would be to determine which of these two interpretations of "increased social surplus" is the more important. Neither interpretation has any behavioral significance from the perspective of formal game theory, which predicts individually rational bargains in either case.

[21] Note that the *expected* monetary payoff to player B from the random disagreement outcome in the NPR(R) experiments exceeded the equal-split payoff by $0.25. This expected payoff was $1.75 less than the payoff this party received at the joint maximum payoff decision.

TABLE 4 (*Continued*)

Definition	Class 2 Population 1 Value	Class 2 Population 2 Value	Null Hypothesis	Alternative Hypothesis	χ^2 Test Statistic	Critical Level	Reject Null Hypothesis?
$N - N_2 - N_3$	1	2	$P_1 = P_2$	$P_1 \neq P_2$	.476	.490	No
$N - N_2 - N_3$	3	2	$P_1 = P_2$	$P_1 \neq P_2$	.400	.527	No
$N - N_2 - N_3$	4	2	$P_1 = P_2$	$P_1 \neq P_2$	.0	1.0	No
$N - N_2 - N_3$	6	8	$P_1 = P_2$	$P_1 \neq P_2$	5.531	.0187	Yes
$N - N_1$	12	3	$P_1 = P_2$	$P_1 \neq P_2$	66.816	.0	Yes
$N - N_1$	12	1	$P_1 = P_2$	$P_1 \neq P_2$	41.213	.0	Yes
$N - N_1$	2	12	$P_1 = P_2$	$P_1 \neq P_2$	21.933	.0	Yes
$N - N_1$	2	1	$P_1 = P_2$	$P_1 \neq P_2$	1.594	.207	No
$N - N_1$	2	13	$P_1 = P_2$	$P_1 \neq P_2$	1.862	.172	No
$N - N_4 - N_5$	4	9	$P_1 = P_2$	$P_1 \neq P_2$	4.394	.0361	Yes

NOTE.—See W. J. Conover, Practical Nonparametric Statistics 144–51 (2d ed. 1980) for an explanation of all statistical terminology, Table 2 for a description of each experiment, and Table 3 for the definition and values for each class. The null hypothesis states that the probability of the class 1 outcome in population 1 is equal to the probability of the class 1 outcome in population 2.

previously discussed result for the NPR experiments. However, it is not possible to discern any significant difference in the *efficiency* properties of the JPR and UPR experiments (this result follows from the strong acceptance of hypothesis H4).

Finally, we find that we cannot reject hypothesis H7 on the basis of the results reported in Table 3. Under UPR, with "trained" subjects that had bargained initially under the JPR property rights specification, 76.5 percent (thirteen out of seventeen) of the decisions involved individually rational outcomes while the initial UPRT(1) experiments (our replication of Hoffman and Spitzer) generated only 40.0 percent (six out of sixteen) individually rational outcomes for the controller.[22] Table 4 indicates that this difference in behavior is statistically significant. This is dramatic support for the strong behavioral form of the Coase Theorem.

IV. Conclusion

The experimental results reported here strongly support the Coase Theorem. This is in contrast to Hoffman and Spitzer's results, which

[22] Our UPR results are not significantly different from the results in Hoffman & Spitzer, *supra* note 2, in which 87.5 percent (twenty-one out of twenty-four) of all decisions in their comparable "game-trigger" experiments were individually rational. These experiments utilized a prebargaining "trigger game" (such as tic-tac-toe) in which the winner "earned the right" to be the controller in the bargaining game. Issues of moral authority aside, this trigger clearly served to reinforce the significance of being a controller. Our experimental design does the same thing in a less artificial way. Moreover, our results demonstrate that the "moral authority" of such a game trigger is not necessary (although it may be sufficient) to encourage individually rational outcomes.

violate the individual rationality requirement of the Coase Theorem (as well as game theory). It would be interesting to undertake the boundary experiments[23] identified by Hoffman and Spitzer (limited information concerning opponent payoffs and/or larger bargaining groups) with our experimental design, given that the Coase Theorem has now been established for the bargaining environment in which it was originally presented (full-information, two-person bargaining).

APPENDIX A

Experimental Instructions

General

You are about to participate in an experiment in decision making. 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 will be paid by a check at the end of the experimental series.

Specific Instructions

You will be asked to make several choices over three sessions. Each choice will involve choosing a number. The cash value to you of the number is given in the payoff schedule written on the blackboard. For example, if $5 were next to number 2 on the payoff sheet (for the column pertaining to you), then you would be paid $5 if number 2 were chosen. In the example shown below, for instance, you might be person B. The payoff schedule lists the value of each number to you as well as the value of each number to the other participant.

Two of you will participate together on each decision. Although we will have three sessions, you will make only one decision with any particular person. That is, you will not participate with the same person in more than one session (and, hence, one decision). Each session will last ten minutes.

Agreement Outcomes

You may arrive at an agreement with the other participant as to which number to choose and how to allocate the resulting monetary payoff. If a joint agreement is reached, *both* parties must sign the attached agreement form, stating both what the chosen number will be *and* how much money will be transferred from one participant's earnings to the other's. *No physical threats are allowed.* If a joint agreement is made and the form is signed, the monitor will terminate the experiment and pay each participant according to the terms set forth in the agreement.

[23] See Vernon L. Smith & Arlington W. Williams, The Boundaries of Competitive Price Theory: Convergence, Expectations and Transactions Costs (June 1982) (unpublished manuscript, Indiana Univ., Dep't Econ.) for an example of boundary experiments; and Vernon L. Smith, Microeconomic Systems as an Experimental Science, 72 Am. Econ. Rev. 923, 942 (1982) for a general discussion of their methodological role.

Disagreement Outcomes

If you cannot come to an agreement before the end of each session, one of three alternative disagreement outcomes will be imposed on both of you. You will be informed by the monitor at the beginning of each session which of the three alternatives applies. The possible disagreement outcomes are:

1. Random: one of the numbers will be drawn at random, and will apply to both participants. Each number is equally likely to be drawn at random.
2. Zero: both participants receive zero payoff in that session.
3. Controller: one of you will be designated the "controller" at the outset of each session. This will be decided by a coin flip. 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 both participants. The other participant may attempt to influence the controller to reach a mutually acceptable joint decision; the other participant may offer to pay part or all of his or her earnings to the controller.

Example

The following example illustrates a decision in which one participant is a controller.

Assume that A is the controller and that participants A and B have the following payoffs associated with numbers 0, 1, and 2:

Number	A's Payoff ($)	B's Payoff ($)
0	4	1
1	5	2
2	3	5

If A and B were to agree to set the number at 0, and further agree that B should get $1 from A's payoff, then the monitor would terminate the experiment, pay A $3 (representing the $4 payoff less the $1 transfer to B) and pay B $2 (representing the $1 payoff plus the $1 transfer from A).

An illustrative agreement form is shown below.

AGREEMENT FORM (Example)

A and B agree to set the number at ____.
A and B agree that $_____ from the monetary payoff should be paid from _____ to _____.

Signed: A: _____
B: _____

Do you have any questions? Please answer the following questions to make sure that you understand the instructions.

QUESTIONS

(Refer to the payoffs marked EXAMPLE on the blackboard)

1. Number ____ makes me the most money.
   Number ____ makes me the least money.
2. If the other participant is the controller and he picks number 4, I make $_____.
3. If I agree to pay $2 to the other participant and we agree on number 1, I make $_____.

APPENDIX B

OUR EXPERIMENTAL INSTRUCTIONS

General

You are about to participate in an experiment in decision making. 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 will be paid by a check at the end of the experimental series.

Specific Instructions

You will be asked to make several choices over three sessions. Each choice will involve choosing a number. The cash value to you of the number is given in the payoff schedule written on the blackboard. For example, if $5 were next to number 2 on the payoff sheet (for the column pertaining to you), then you would be paid $5 if number 2 were chosen. In the example shown below, for instance, you might be person B. The payoff schedule lists the value of each number to you as well as the value of each number to the other participant.

Two of you will participate together on each decision. Although we will have three sessions, you will only make one decision with any particular person. That is, you will not participate with the same person in more than one session (and, hence, one decision). Each session will last ten minutes.

Agreement Outcomes

You may arrive at an agreement with the other participant as to which number to choose. If a joint agreement is reached, *both* parties must sign the attached agreement form, stating the chosen number. *No physical threats are allowed.* If a joint agreement is made and the form is signed, the monitor will terminate the experiment and pay each participant according to the terms set forth in the agreement.

Disagreement Outcomes

If you cannot come to an agreement before the end of each session, one of two alternative disagreement outcomes will be imposed on both of you. You will be informed by the monitor at the beginning of each session which of the alternatives applies. The possible disagreement outcomes are:

1. Random: one of the numbers will be drawn at random, and will apply to both participants. Each number is equally likely to be drawn at random.
2. Zero: both participants receive zero payoff in that session.

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