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The Coase Theorem: Some Experimental Tests

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I. INTRODUCTION

IN *The Problem of Social Cost,*[1] Ronald Coase investigated the economic effects of liability rules for externalities when the affected parties can bargain with each other. More specifically, 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 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,[2] (*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. This result—commonly called the "Coase Theorem"—has generated a great deal of economic and legal discussion, much of it aimed at exploring the effects of weakening one or another of the model's assumptions.[3] Some of the most common theoretical discussions focus on the

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[1] R. H. Coase, The Problem of Social Cost, 3 J. Law & Econ. 1 (1960).

[2] This assumption includes the existence of enough basic contract and tort law and enforcement that the parties can deal with one another. On the philosophy of such an assumption, see David W. Carroll, Two Games That Illustrate Some Problems Concerning Economic Analysis of Legal Problems, 53 S. Cal. L. Rev. 1371 (1980).

[3] Literature on the Coase Theorem has explored, among other things, the following topics. (*A*) The long-run wealth effects of a change in liability rules: see, for example, Harold Demsetz, Wealth Distribution and the Ownership of Rights, 1 J. Legal Stud. 223 (1972); H. E. Frech, III, Pricing of Pollution: The Coase Theorem in the Long Run, 4 Bell J. Econ. & Manag. Sci. 316 (1973); H. E. Frech, III, Extended Coase Theorem and Long-Run Equilib-

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effects of transaction costs, especially those costs generated either by imperfect knowledge of one another's production and profit functions[4] or by the need to include many agents in a bargain.[5] Many observers have theoretically assumed (or deduced) that imperfect information or multiple agents in a bargain will tend to preclude contracting by the affected parties.[6] A great deal of legal and economic work rests directly on these two theoretical assumptions.[7]

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rium: The Nonequivalence of Liability Rules and Property Rights, 17 Econ. Inquiry 254 (1979); T. T. Maloney, The Coase Theorem and Long-Run Industry Equilibrium, 17 Q. Rev. Econ. & Bus. 113 (1977); G. Warren Nutter, The Coase Theorem on Social Cost: A Footnote, 11 J. Law & Econ. 503 (1968); Donald H. Regan, The Problem of Social Cost Revisited, 15 J. Law & Econ. 427 (1972); William Schulze & Ralph C. d'Arge, The Coase Proposition, Information Constraints, and Long-Run Equilibrium, 64 Am. Econ. Rev. 763 (1974). (*B*) The property rule/liability rule distinction: see, for example, Guido Calabresi & A. Douglas Melamed, Property Rules, Liability Rules and Inalienability: One View of the Cathedral, 85 Harv. L. Rev. 1089 (1972); Harold Demsetz, When Does the Rule of Liability Matter? 1 J. Legal Stud. 13 (1972); Harold Demsetz, The Exchange and Enforcement of Property Rights, 7 J. Law & Econ. 11 (1964); Roger Feldman, Liability Rules and the Transfer of Economic Rents, 3 J. Legal Stud. 499 (1974): Frech, "Extended Coase Theorem and Long-Run Equilibrium," *supra* note 3*A*; Ken-Ichi Inada & Kiyoshi Kuga, Limitations of the "Coase Theorem" on Liability Rules, 6 J. Econ. Theory 606 (1973). (*C*) A definition of transaction costs and their effect on the efficient assignment of legal rules: see, e.g., Guido Calabresi, Transaction Costs, Resource Allocation, and Liability—a Comment, 11 J. Law & Econ. 67 (1968); Thomas D. Crocker, Externalities, Property Rights, and Transaction Costs: An Empirical Study, 14 J. Law & Econ. 451 (1971); George Daly, The Coase Theorem: Assumptions, Applications, and Ambiguities, 12 Econ. Inquiry 203 (1974); A. Mitchell Polinsky, Economic Analysis as a Potentially Defective Product: A Buyers Guide to Posner's Economic Analysis of Law, 87 Harv. L. Rev. 1655, 1671–74 (1974); Richard A. Posner, Economic Analysis of Law, 34 (2d ed. 1977). (*D*) The consequences of imperfect information and the need for a well defined theory of "rational" behavior: see, for example, Otto A. Davis & Andrew B. Whinston, Externalities, Welfare and the Theory of Games, 70 J. Pol. Econ. 241 (1962); Regan, *supra* note 3A; Schulze & d'Arge, *supra* note 3*A*; George J. Stigler, The Theory of Price, 113 (3d ed. 1966); Cento G. Veljanovski, The Coase Theorem—the Says Law of Welfare Economics, 53 Econ. Record 535 (1977). (*E*) The inclusion of large numbers of agents in the contracting situation: see, for example, William J. Baumol, On Taxation and the Control of Externalities, 62 Am. Econ. Rev. 307 (1972); Calabresi & Melamed, *supra* note 3*B*; Daly, *supra* note 3*C*; Posner, *supra* note 3*C*; Stanislaw Wellisz, On External Economies and the Government Assisted Invisible Hand, 31 Economica 345 (n.s. 1964).

[4] See *supra* note 3, those publications dealing with the consequences of imperfect information and the need for a well-defined theory of "rational" economic behavior.

[5] See *supra* note 3, those publications dealing with the inclusion of large numbers of agents in the contracting situation.

[6] See, for example, Davis & Whinston, *supra* note 3*D*; Regan, *supra* note 3*A*; Schulze & d'Arge, *supra* note 3*A*; Stigler, *supra* note 3*D*; Veljanovski, *supra* note 3*D*; Baumol, *supra* note 3*E*; Calabresi & Melamed, *supra* note 3*B*.

[7] See, for example, Stanley M. Besen, William G. Manning, & Bridger M. Mitchell, Copyright Liability for Cable Television: Compulsory Licensing and the Coase Theorem, 21 J. Law & Econ. 67 (1978); Guido Calabresi, The Decision for Accidents: An Approach to

In 1972, Donald Regan pointed out that assumption *h* is quite unlike assumptions about agents' behavior in most economic models.[8] For example, a proof of the existence of the competitive equilibrium might presume that an individual maximizes utility subject to a budget constraint in the face of fixed prices by purchasing commodities in a market. In contrast, *h* posits that two specific individuals who find themselves in a position to strike a mutually advantageous bargain *will do so*. This assumption is, in essence, a statement that parties in non–zero-sum games

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Nonfault Allocation and Costs, 78 Harv. L. Rev. 730 (1965); Reuben A. Kessel, Transfused Blood Serum Hepatitis and the Coase Theorem, 17 J. Law & Econ. 265 (1974); Frederic L. Kirgis, Effective Pollution Control in Industrialized Countries: International Economic Disincentives, Policy Responses, and the GATT, 70 Mich. L. Rev. 859 (1972).

[8] Regan, *supra* note 3*A*. Assumption *h* is clearly needed to prove the theorem; none of the other assumptions guarantees that two agents who are in a position to strike a mutually advantageous deal will do so. The assumption of profit-maximizing producers (or expected utility-maximizing consumers) guarantees only *individual* rationality. Most economic models take such assumptions about individual rationality and impose some sort of mechanism or institution, such as a market, which combines the individually rational choices into a group outcome. The Coase Theorem proffers only the existence of basic contract law, which will be perfectly and costlessly enforced by the court system. The Coase Theorem also needs an assumption which provides for combining individually rational behavior into a group outcome. Instead of providing some specific mechanism, such as allowing one of the two parties to propose a deal and let the other accept if and only if accepting the deal would increase the acceptor's individual utility (or profits), assumption *h* makes the most general proposition that eventually some sort of deal will be struck. Hence, assumption *h* is the analog, in the Coase Theorem, of the assumption in a market model that consumers *will actually purchase* the goods and services, subject to a budget constraint, which maximize their utilities. Furthermore, assumption *h* is not captured by the assumption of zero transaction costs. It may be that even though the parties can negotiate and transact costlessly, one or both of the parties may behave strategically so as to capture more profits for himself. As Regan, *supra* note 3*A*, p. 430, notes, the essence of making credible threats is to carry them out, sometimes. But once a threat is carried out the Coase Theorem has failed. Even if such threats are not carried out, each party may continually threaten to refuse to agree to a deal unless that party receives quite favorable treatment. Parties can refuse to agree to the deal indefinitely. The only way to handle this dilemma for the Coase Theorem is to assume that the parties *will* strike a deal. Consider, in this vein, the argument found in William M. Landes & Richard A. Posner, Salvors, Finders, Good Samaritans, and Other Rescuers: An Economic Study of Law and Altruism, 7 J. Legal Stud. 83, 91 (1978): "Even where there is both mental capacity and adequate time for negotiating, the process of voluntary exchange may not work efficiently. Suppose the sinking ship is far out at sea—though in no immediate danger of sinking—and a potential rescuer comes upon it by chance or by responding to its distress signal. There is time for negotiation but little likelihood of another ship's chancing on the scene. The potential rescuer therefore has a monopoly position which he can use to try to extract the victim's promise, prior to initiation of any rescue efforts, to pay him all or most of the value of the ship and cargo. At the same time, because the rescuer has no alternative customer for his rescue services at the place where he has found the ship in distress, the "rescuee" has a monopoly position, making the situation one of bilateral monopoly. Transaction costs under bilateral monopoly are high because there is a range of possible prices which invites haggling. The haggling may be protracted, costly, and sometimes unsuccessful in producing agreement on terms." Assumption *h* also rules out both

will choose a Pareto optimal allocation.[9] As such, assumption *h* represents a departure from the conventional wisdom, which is that outcomes of non–zero-sum games are quite uncertain. Hence, Coase's Theorem is much more a proposition than a typical economic theorem. Once the analyst fully accepts this point, the Coase Theorem's appeal depends on the reasonableness of assumption *h* in a typical Coase Theorem setting. In other words, one must know whether two people who are in a situation satisfying assumptions *a* through *g* will tend to act in accordance with assumption *h*.

In addition, as is noted above, a great deal of important legal and economic work stands on the supposition that either including many parties to a bargaining situation (assumption *a*) or including imperfect information (assumption *b*) tends to preclude the formation of mutually advantageous contracts.[10] For example, Calabresi and Melamed use these suppositions to analyze the differences between property rules and liability rules.[11] To test these suppositions, one must know of the effects of relaxing assumption *a* (multiple parties) in the presence of assumptions *b* through *h*, of relaxing assumption *b* (imperfect information) in the pres-

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personal or social pressures which militate against contracting. If one of the parties to an externality were to believe that contracting is inherently evil, or that the behavior involved in the externality is terrible, the individual might refuse to ever sign a contract which pertained to the externality, and the Coase Theorem might fail. Social pressures could affect willingness to contract in an asymmetric fashion. For example, in Coase's original example of a rancher and a farmer, there were no social pressures on the two parties to resist economic forces. However, if cows were considered sacred to the extent that one who signed a contract to limit the number of cows kept on a ranch would be shunned by his friends, but no such attitude would exist toward a contract which increased the number of cows to be kept, then the following results might be obtained. First, if the farmer had a property right to exclude cows, so that the rancher had to obtain the farmer's permission to have a herd, then the farmer and rancher would strike a deal allowing the rancher to keep some cows. Second, if the rancher had a property right to have as many cows as he wished, so that the rancher and farmer could joint-profit maximize only by striking a deal to limit the number of cows the rancher would keep, then no deal would be struck. Such a pair of results would violate the Coase Theorem, and assumption *h* rules out all such problems. Of course, to the extent that the reader remains unconvinced that assumption *h* does not flow naturally from the other assumptions, he will not be particularly interested in (or surprised by) the strong appeal of the Pareto optimal outcome in the two-person, full-information experiments. Such a reader, however, should still be quite interested in the three-person and partial information variations on the Coase scenario which we test.

[9] A Pareto optimal allocation has the property that it is not possible to make one person better off without making another person worse off. In a non–zero-sum game a Pareto optimal allocation maximizes the joint profits from the game.

[10] See Crocker, *supra* note 3*C*; Mark Kelman, Consumption Theory, Production Theory and Ideology in the Coase Theorem, 52 S. Cal. L. Rev 669 (1979); Matthew Spitzer & Elizabeth Hoffman, A Reply to Kelman's Consumption Theory, Production Theory, and Ideology in the Coase Theorem, 53 S. Cal. L. Rev. 1187 (1980).

[11] Calabresi & Melamed, *supra* note 3*B*.

ence of assumptions *a* and *c* through *h*, and of relaxing assumptions *a* and *b* (multiple parties and imperfect information) in the presence of assumptions *c* through *h*.

II. Review of the Literature

There is a large and growing experimental literature on two- and three-person bargaining games. Many of the experiments illuminate one or more of the axioms discussed above, but almost no work has specifically tested the Coase bargaining problem in the specific ways discussed above.[12] However, we can make some important generalizations, which have significant implications for the design of an experiment. The main issue is whether parties to a bargain will choose a Pareto optimal allocation. Although subjects playing non–zero-sum games have not universally chosen Pareto optimal outcomes, in general they have tended to choose Pareto optimal outcomes more often when the experimental conditions have looked more like the Coase axioms. In particular, Pareto optimal choices seem to be more frequent under the following conditions: (1) When subjects play for significant amounts of real money,[13] (2) when all parties can engage in free face-to-face communications,[14] (3) when parties can make

[12] Jerome Chertkoff & James K. Esser, A Review of Experiments in Explicit Bargaining, 12 J. Experimental Soc. Psych. 464 (1976); Melvin J. Guyer & Barbara Perkel, Experimental Games: A Bibliography (1945–1971), 293 U. Mich. Mental Health Research Inst. Com. (1972); J. Keith Murningham, Models of Coalition Behavior: Game Theoretic, Social Psychological and Political Perspectives, 85 Psych. Bull. 1130 (1978). The only paper specifically on the Coase Theorem of which we are aware is Yves Coffi Prudencio, The Voluntary Approach to Externality Problems: An Experimental Test (Discussion Paper, 81-4, U. Ariz., Dep't Econ., 1981). The design of the experiments reported in that paper are quite different from the design of the experiments reported here.

[13] Victor Daniels, Communication, Incentive, and Structural Variables in Interpersonal Exchange and Negotiation, 3 J. Experimental Soc. Psych. 47 (1976); Philip S. Gallo, Jr., & Charles G. McClintock, Cooperative and Competitive Behavior in Mixed-Motive Games, 9 J. Conflict Resolution 68 (1965); H. H. Kelly *et al.*, A Comparative Experimental Study of Negotiation Behavior, 16 J. Personality & Soc. Psych. 411 (1970); Charles G. McClintock & Steven P. McNeel, Reward Level and Game Playing Behavior, 10 J. Conflict Resolution 98 (1966); Charles G. McClintock & Steven P. McNeel, Prior Dyadic Experience and Monetary Reward as Determinants of Cooperative and Competitive Game Behavior, 5 J. Personality & Soc. Psych. 282 (1967); Steven M. Medlin, Effects of Grand Coalition Payoffs on Coalition Formation in Three-person Games, 21 Behavioral Sci. 48 (1976).

[14] Chertkoff & Esser, *supra* note 12; Daniel Druckman, The Influence of the Situation in Inter-party Conflict 15 J. Conflict Resolution 523 (1971); Rudy V. Nydegger and Guillermo Owen, Two-person Bargaining: An Experimental Test of the Nash Axioms, 1 Int'l J. Game Theory 239 (1975); Alvin Roth & Michael Malouf, Game-theoretic Models and the Role of Information in Bargaining, 588 (Working Paper, U. Ill. at Urbana-Champaign, C. Com. and Bus. Ad. Faculty 1979); Richard G. Swennsson, Cooperation in the Prisoner's Dilemma Game I: The Effects of Asymmetric Payoff Information and Explicit Communication, 12 Behavioral Sci. 314 (1967); Harvey Wickman, Effects of Isolation and Communication on Cooperation in a Two-person Game, 16 J. Personality & Soc. Psych. 114 (1970).

enforceable contracts with one another,[15] (4) when there is an equal-split allocation among the Pareto optimal allocations,[16] (5) when all parties have full information about one another's payoffs,[17] and (6) when prizes are paid in public.[18] The first five conditions are all clearly contained in the Coase axioms. The last condition seems to be a natural extrapolation from Coase's perfect information and zero transaction costs assumptions.

A second issue, which Coase himself does not raise but which has troubled some commentators,[19] is how parties to a bargain typically divide the profits from a joint decision. The experimental literature differs on this issue. On the one hand, many articles conclude that subjects divide profits either equally or in proportion to the effort each party expends.[20] On the

[15] Peter Murdoch, Development of Contractual Norms in a Dyad, 6 J. Personality & Soc. Psych. 206 (1967); Harold H. Kelley, Linda Linden Beckman, & Claude S. Fisher, Negotiating the Division of a Reward under Incomplete Information, 3 J. Experimental Soc. Psych. 361 (1967); Robert Radlow & M. F. Weidner, Unenforced Commitments in Cooperative and Non-cooperative None-constant Sum Games, 10 J. Conflict Resolution 497 (1966); John Thibaut, The Development of Contractual Norms in Bargaining: Replications and Variation, 12 J. Conflict Resolution 102 (1968); John Thibaut & Claude Faucheaux, The Development of Contractual Norms in Bargaining Situations under Two Types of Stress, 1 J. Experimental Soc. Psych. 89 (1965); John Thibaut & Charles L. Gruder, Formulation of Contractual Agreements between Parties of Unequal Power, 11 J. Personality and Soc. Psych. 59 (1969).

[16] Lawrence E. Fouraker & Sidney Siegel, Bargaining Behavior (1963); H. Andrew Michener, Irving J. Ginsberg, & Kenneth Yuen, Effects of Core Properties in Four-person Games with Side Payments, 24 Behavioral Sci. 263 (1979); Sidney Siegel & Lawrence E. Fouraker, Bargaining and Group Decision Making: Experiments in Bilateral Monopoly (1960).

[17] William P. Smith, Reward Structure and Information in the Development of Cooperation, 4 J. Experimental Soc. Psych. 199 (1968).

[18] Druckman, *supra* note 14.

[19] See Demsetz, *supra* note 3*B*; Bruce A. Ackerman, Economic Foundations of Property Law (Questions 2–5) (1975).

[20] See, for example, Irving M. Lane & Lawrence A. Messe, Equity and the Distribution of Rewards, 20 J. Personality & Soc. Psych. 1 (1971); Gerald S. Leventhal, James W. Michaels, & Clifford Sanford, Inequity and Interpersonal Conflict: Reward Allocation and Secrecy about Reward as Methods of Preventing Conflict, 23 J. Personality & Soc. Psych. 88 (1972); Bernhardt Lieberman, Not an Artifact, 15 J. Conflict Resolution 113 (1971); Lawrence A. Messe, Robin R. Vallacher, & James L. Phillips, Equity and the Formation of Revolutionary and Conservative Coalitions in Triads, 31 J. Personality & Soc. Psych. 1141 (1975); William R. Morgan & Jack Sawyer, Bargaining Expectations and the Preference for Equality over Equity, 6 J. Personality & Soc. Psych. 139 (1967); Rudy V. Nydegger & Guillermo Owen, The Norm of Equity in a Three-person Majority Game, 22 Behavioral Sci. 32 (1977); Nydegger & Owen, *supra* note 14; Anatol Rapoport, Oded Frenkel, & Josef Perner, Experiments with Cooperative 2 × 2 Games, 1 Theory & Decision 67 (1967); Anatol Rapoport, Melvin J. Guyer, & David G. Gordon, The 2 × 2 Game (1976); Anatol Rapoport & Carol Orwant, Experimental Games: A Review, 7 Behavioral Sci. 1 (1962); Harry T. Reis & Joan Grunzen, On Mediating Equity, Equality and Self-Interest: The Role of Self-Preservation in Social Exchange, 12 J. Experimental Soc. Psych. 478 (1976); Roth & Malouf, *supra* note 14; E. Gary Shapiro, Effect of Expectations of Future Interaction on Reward

other hand, an almost equally large literature concludes that subjects try to maximize their own profits and refuse to settle for less than they could command by operating alone.[21]

The difference in results seems to be generated at least in part by different instructions and different information about payoffs given to the subjects. Subjects who divide the profits equally either tend to know all monetary payoffs[22] or tend to be told that their "task" is to divide up a sum of money. Conversely, subjects who bargain to unequal payoffs generally either tend to be ignorant of one another's payoffs[23] or tend to be instructed by the experimenter to try to make as much money as possible.[24] Where the instructions are less pointed about subject motivation, the results seem more mixed.[25] In general, the following experimental conditions seem to be associated with more equal splitting of profits: (1) repeated, face-to face negotiations;[26] (2) the ability to choose a Pareto optimal allocation which is also an equal split;[27] (3) public payoffs;[28] and (4) full information about one another's profits.[29]

Allocations in Dyads: Equity or Equality, 31 J. Personality & Soc. Psych. 873 (1975); Elaine Walster, Ellen Berscheid, & G. William Walster, New Directions in Equity Research, 25 J. Personality & Soc. Psych. 151 (1973).

[21] See, for example, Jerome M. Chertkoff, Coalition Formation as a Function of Differences in Resources, 15 J. Conflict Resolution 371 (1971); Sandra G. Funk, Amnon Rapoport, & James P. Kahan, Quota versus Positional Power in Four-person Apex Games, 16 J. Experimental Soc. Psych. 77 (1980); Kelley, Beckman, & Fischer, *supra* note 15; Michener, Ginsberg, & Yuen, *supra* note 16; H. Andrew Michener, Kenneth Yuen, & Irving J. Ginsberg, A Competitive Test of the M_1 (im) Bargaining Set, Kernel, and Equal Share Models, 22 Behavioral Sci. 341 (1977); Charles E. Miller, Coalition Formation in Characteristic Function Games: Competitive Tests of Three Theories, 16 J. Experimental Soc. Psych. 61 (1980); J. Keith Murnigham, Strength and Weakness in Four Coalition Theories, 23 Behavioral Sci. 195 (1978); Amnon Rapoport & James P. Kahan, When Three Is Not Always Two against One: Coalitions in Experimental Three-person Cooperative Games, 12 J. Experimental Soc. Psych. 253 (1976); Thibaut and Gruder, *supra* note 15.

[22] See Roth & Malouf, *supra* note 14, and Rudy V. Nydegger, Independent Utility Scaling and the Nash Bargaining Model, 22 Behavioral Sci. 283 (1977), for discussions of the effect of knowledge of payoffs on payoff splits. Melvin J. Guyer & Anatol Rapoport, Information Effects in Two Mixed-Motive Games, 15 Behavioral Sci. 467 (1969), also find this result.

[23] See note 22 *supra*.

[24] Particularly Kelley, Beckman, & Fisher *supra* note 15; Michener, Ginsberg, & Yuen *supra* note 16; Michener, Yuen, & Ginsberg, *supra* note 21; and Murnigham, *supra* note 21.

[25] See, for example, Funk, Rapoport, & Kahan, *supra* note 21; Morgan & Sawyer, *supra* note 20; and Lane & Messe, *supra* note 20.

[26] Josi Greenberg, Group vs. Individual Equity Judgments—Is There a Polarization Effect? 15 J. Experimental Psych. 504 (1979); Rapoport, Guyer, & Gordon, *supra* note 20; E. Gary Shapiro, *supra* note 20.

[27] Note 16 *supra*.

[28] Leventhal, Michaels, & Clifford Sanford *supra* note 20; Reis & Gruzen, *supra* note 20.

[29] Note 22 *supra*.

While the experimental literature summarized above has improved our understanding of how individuals bargain under a variety of different conditions, the general bargaining problem described by Coase has received little attention prior to the work reported here. There have been very few experiments which have both required subjects to bargain over a variety of different discrete choices and allowed them to make side payments to one another at the same time.[30] In Coase's view, the person owning the liability right gets compensated. For example, in bilateral monopoly experiments subjects bargain over discrete choices as individuals might bargain over levels of pollution, but side payments are generally forbidden.[31] On the other hand, most of the games which implicitly allow side payments involve only two or three alternatives from which to choose and are described in coalitional rather than discrete alternative form.[32] Typically, in such a game, subjects are given the following infor-

[30] Two such experiments are reported in Michener, Ginsberg, & Yuen *supra* note 16; Michener, Yuen, & Ginsberg, *supra* note 21.

[31] Edward H. Chamberlin, An Experimental Imperfect Market, 56 J. Pol. Econ. 95 (1948); Daniel Druckman & Thomas V. Bonoma, Determinants of Bargaining Behavior in a Bilateral Monopoly Situation II: Opponent's Concession Rate and Similarity, 21 Behavioral Sci. 252 (1976); Dan S. Felsenthal, Bargaining Behavior When Profits Are Unequal and Losses Are Equal, 22 Behavioral Sci. 334 (1977); Fouraker & Siegel, *supra* note 16; Melvin J. Guyer, An Analysis of Duopoly Bargaining, 11 General Systems 215 (1966); Donald L. Harnett & Larry L. Cummings, Bilateral Monopoly Bargaining: An International Study, in 3 Contributions to Experimental Economics 100 (Heinz Sauermann ed. 1971); Harold L. Johnson & Arthur M. Cohen, Experiments in Behavioral Economics: Siegel and Fouraker Revisited, 12 Behavioral Sci. 353 (1967); S. S. Komorita & Arline R. Brenner, Bargaining and Concession Making under Bilateral Monopoly, 9 J. Personality & Soc. Psych. 15 (1968); Heinz Sauermann & Reinhard Selton, An Experiment in Oligopoly, 5 Society for General Systems Research (1960).

[32] Murningham, *supra* note 12, reviews much of this literature; other examples include Theodore Caplow, A Theory of Coalitions in the Triad, 21 Am. Soc. Rev. 489 (1956) and Two Against One (1968); Chertkoff, *supra* note 21; Jerome Chertkoff & James K. Esser, A Test of Three Theories of Coalition Formation When Agreements Can Be Short-Term or Long-Term, 35 J. Personality & Soc. Psych. 237 (1977); Steven G. Cole, An Examination of the Power-Inversion Effect in Three-person Mixed-Motive Games, 11 J. Personality & Soc. Psych. 50 (1969); Funk, Rapoport, & Kahn, *supra* note 21; William A. Gamson, Experimental Studies of Coalition Formation, in 1 Advances in Experimental Social Psychology (Leonard Berkowitz ed. 1964); The Study of Coalition Behavior (Sven Groennings, E. W. Kelley, and Michael Leiserson eds. 1970); Abraham D. Horowitz & Amnon Rapoport, Test of the Kernel, and Two Bargaining Set Models in Four and Five-person Games in Game Theory as a Theory of Conflict Resolution (Anatol Rapoport ed. 1974); James P. Kahn & Amnon Rapoport, Test of the Bargaining Set and Kernel Models in Three-person Games in *id*; Harold H. Kelley & A. John Arrowood, Coalitions in the Triad: Critique and Experiment, 23 Sociometry 231 (1960); Medlin, *supra* note 13; H. Andrew Michener, John A. Fleishman, & Jerry J. Vaske, A Test of the Bargaining Theory of Coalition Formation in Four-person Groups, 34 J. Personality & Soc. Psych. 1114 (1976); Michener, Ginsberg, & Yuen, *supra* note 16; Michener, Yuen, & Ginsberg, *supra* note 21; H. Andrew Michener & Richard A. Zeller, The Effects of Coalition Strength on the Formation of Contractual Norms, 35 Sociometry 290 (1972); Miller, *supra* note 21; Murningham, *supra* note 21; J.

mation. Alone you make $\$x$. If you form a coalition with a second person, the two of you can split $\$2x + \$y$ and the odd person gets $\$x$. If all three players form a coalition, they split $\$3x + \$y + \$z$.

A set of experiments conducted by Michener, Yuen, and Ginsberg comes very close to a Coase bargaining situation.[33] Three subjects per experiment bargained over outcomes (instead of coalition divisions), and they could make side payments. Subjects were told to maximize their own payoffs. More than half, but by no means all, of the choices were Pareto optimal, and the mean payoff splits were far from equal. The authors concluded that the payoff splits generally fit the Shapley value,[34] which predicts that the payoffs will be in proportion to one's power in the game. However, the experimental situation above differs crucially from a Coase bargaining situation in that no one player could unilaterally choose the allocation as can the owner of a property right.

Experiments which have granted some unilateral power to one of the parties in a bargaining game have generally involved somewhat different decision tasks from that described by the Coase Theorem. For example, in one study, two players were given individual values and a joint value they could divide. One player was given the right to divide the joint reward if the other player did not depart from a joint cooperative strategy, and the subjects could write enforceable contracts specifying what each player would do. If the subjects wrote no contract, they were given their indi-

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Keith Murningham & Alvin E. Roth, The Effects of Communication and Information Availability in an Experimental Study of a Three-person Game, 23 Manag. Sci. 1336 (1977) and Large Group Bargaining in a Characteristic Function Game, 22 J. Conflict Resolution 299 (1978); Rapoport & Kahan, *supra* note 21; William H. Riker, Bargaining in a Three-person Game, 61 Am. Pol. Sci. Rev. 642 (1967); Loyda M. Shears, Patterns of Coalition Formation in Two Games Played by Male Tetrads, 12 Behavioral Sci. 130 (1967); W. Edgar Vinacke & Abe Arkoff, An Experimental Study of Coalitions in the Triad, 22 Am. Rev. 406 (1957); Karl E. Weick & Donald D. Penner, Triads: A Laboratory Analogue, Organization Behavior & Human Performance 191 (1966); Richard H. Willis, Coalitions in the Tetrad, 25 Sociometry 358 (1962).

[33] Note 21 *supra*.

[34] Lloyd S. Shapley, A Value for N-Person Games, in Contributions to the Theory of Games (H. W. Kuhn & A. W. Tucker eds. 1953). The Shapley value of each player in a game is that player's expected payoff, computed as follows:

$$EP_i = \sum_{S \subseteq N} \{[(s - 1)!\,(n - s)!\,]/n!\}\,[v(S) - v(S - i)],$$

where N = number of coalitions player i could join, S = a particular coalition, s = number of players in S, n = number of players in the game, $V(S)$ = payoff coalition S can command, and $V(S - i)$ = payoff coalition S could command if i did not join. The interpretation of the Shapley value focuses on the power player i can command as the pivotal player in a number of coalitions. The more coalitions i can join and the more i contributes to the payoffs commanded by those coalitions, the more intrinsic power i has and the more total payoff i can expect from playing the game.

vidual values.[35] In another experiment the subjects could divide the rewards, and both could write a contract specifying the division.[36] The authors of these two studies concluded that the ability to write enforceable contracts fosters the attainment of Pareto optimal outcomes.

Another important question raised by Coase's critics is whether a proposition describing two-person bargaining can be extended to larger groups. Experiments with three- and four-person games suggest that Pareto optimal outcomes can be achieved,[37] but experiments with larger groups have generally concluded that free-rider problems take over unless special allocation mechanisms are imposed.[38] However, these larger group experiments have not allowed open communication, side payments, and enforceable contracts.

This paper reports the results of a set of controlled experiments designed specifically to test the Coase proposition in two- and three-person bargains. The results strongly favor the Coase proposition and also strongly suggest that parties engaging in repeated negotiations with one another may split profits equally even though in single-shot negotiations they are more likely to choose individually rational divisions. Of the 114 experimental decisions, 89.5 percent were Pareto optimal. Sixty-two of those dictated that payoffs be divided nearly equally.

III. Experimental Design

A. *Two-person Experiments*

1. Perfect Information: Instructions

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

[35] Murdoch, *supra* note 15.

[36] Thibaut & Gruder, *supra* note 15.

[37] For example, Michener, Ginsberg, & Yuen, *supra* note 16; Michener, Yuen, & Ginsberg, *supra* note 21; Miller, *supra* note 21; Rapoport & Kahan, *supra* note 21; Medlin, *supra* note 13; Rapoport et al., Three Person Non-Zero-Sum Negotiable Games, 7 Behavioral Sci. 38 (1962).

[38] John R. Chamberlin, The Logic of Collective Action; Some Experimental Results, 23 Behavioral Sci. 441 (1978) and Provision of Public Goods as a Function of Group Size, 68 Am. Pol. Sci. Rev. 707 (1974); R. Mark Isaac & Charles R. Plott, The Opportunity for Conspiracy in Restraint of Trade: An Experimental Study (Working Paper No. 255, Cal. Inst. Tech. Soc. Sci. 1979); Charles R. Plott, Externalities and Corrective Policies in Ex-

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 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 $5 were next to number 2 on your payoff sheet and if number 2 were chosen, then you would be paid $5. In the example shown below, for instance, you might be person B. Your payoff sheets[39] list not only the value of each number to you, but also the value of each number to the other participant.

Two of you will participate together on each decision. One of you will be designated the "controller." 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

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

perimental Markets (1977) 180 (Working Paper No. 180, Cal. Inst. Tech. Soc. Sci. 1977); Vernon L. Smith, Incentive Compatible Experimental Processes for the Provision of Public Goods in 1 Research in Experimental Economics (Vernon L. Smith ed. 1979). One exception to the conclusion that free-rider problems are insurmountable is a six-person Prisoner's Dilemma experiment in which subjects could discuss and decide on a strategy halfway through the iterated game; V. Edwin Bixenstine, Clifford A. Levitt, & Kellogg V. Wilson, Collaboration among Six Persons in A Prisoner's Dilemma Game, 10 J. Conflict Resolution 488 (1966). While they could not legally enforce their strategy, they could subtly punish defectors. The results were that groups that knew all the payoffs and could discuss a strategy cooperated almost 100 percent of the time after their discussions. Groups which did not discuss cooperated much less and did not change significantly at any time.

[39] Sample payoff functions are reproduced in Table 1 below.

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).

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.

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 your payoffs on p.———.)

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———.

AGREEMENT FORM

A and B agree to set the number at———.
A and B agree that, from the award \$——— should be paid ——————— to ———————.

Signed ———————
A

———————
B

In essence, these instructions 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 was chosen. In this formulation, the numbers are analogous to the productive decisions in the Coase Theorem. For example, subjects A and B might correspond to the adjacent rancher and farmer in Coase's original model. Similarly, the chosen numbers might correspond to the size of the rancher's herd, and the money that was paid to the subjects might represent the rancher's and farmer's profits. The subjects were also told that one of them had the power to choose the number unilaterally. This power is analogous to a property right in the Coase situation.[40] For example, the controller's abil-

[40] Although Coase contrasted a liability rule in favor of farmers with a property rule in favor of ranchers, we have chosen to contrast opposite property rules because they are so much easier to model.

ity to choose the number might correspond to the farmer's right to obtain an injunction preventing the rancher from allowing his cows to wander onto the farmer's land. Finally, the instructions allowed subjects to transfer, by contract, payoffs from one party to another. This feature of the experiment directly mimics the contract mechanism which is central to the Coase Theorem.

Each of the instructions included some information telling the participant how much cash he would be paid (depending on which number was chosen).[41] Table 1 shows representative payoffs for two-party bargaining situations.[42] Notice that each schedule has a clear joint-profit maximizing number, which pays at least $1.00 more than the next highest number. After reading the instructions and examining their payoffs, subjects were tested on their understanding of the rules and the consequences of decisions they might make.[43] After both 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 experimenter flipped a coin, and the winner of the toss was designated the controller. The subjects were then instructed to proceed with the experiment (by choosing a number).

2. Experimental Institutions

In all of the two-person 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; contracts were in writing and strictly enforced. All payments were made in public. Subjects were given no motivational instructions; subjects were not told what their objectives should be in choosing a number or in forming contracts.

The instructions above for the first set of experiments modeled an environment as close as possible to one satisfying all the sufficient conditions for the Coase Theorem to hold: two parties who are fully informed about one another's payoffs and who have no transactions costs. Because we suspected that parties to a bargain might divide the profits differently if their relationship were to continue than if they were to make only one decision, there were two versions of this first set of experiments.

[41] See Vernon L. Smith, Experimental Economics: Induced Value Theory, 66 Am. Econ. Rev. 274 (1976), for a theoretical justification for inducing preference orderings with monetary payoffs.

[42] A variety of different payoff functions with the same structure was randomly used. The object of randomizing the payoff functions was to minimize possible experimenter effects.

[43] Tests are included with the instructions.

TABLE 1
SAMPLE PAYOFFS SCHEDULES ($)

A. TWO-PERSON EXPERIMENTS

DECISION 1			DECISION 2		
Number	A	B	Number	A	B
0	0.00	12.00	0	0.00	11.00
1	4.00	10.00	10	1.00	10.00
2	6.00	6.00	20	2.00	8.00
3	8.00	4.00	30	4.00	6.00
4	9.00	2.00	40	5.50	5.50
5	10.00	1.00	50	9.00	4.00
6	11.00	0.00	60	10.50	1.00
			70	9.00	0.00

B. THREE-PERSON EXPERIMENTS

DECISION 1				DECISION 2			
Number	A	B	C	Number	A	B	C
1	1.00	7.00	7.00	1	0.00	8.50	8.50
2	5.00	5.50	5.50	2	3.00	7.00	7.00
3	10.00	4.00	4.00	3	5.50	5.50	5.50
4	12.00	0.00	0.00	4	11.00	4.00	4.00
				5	13.00	0.00	0.00

a) *Sequential.* Six pairs of subjects made two decisions each, in sequence. The coin was flipped to decide who was the controller before deliberation began on each decision. The subjects thus knew they would make two decisions together, but during the first decision, they did not know who would be controller for the second. The object was to simulate a legal environment in which the assignment of rights was uncertain but the parties knew they would have to maintain a continuing relationship. This models, for example, a nuisance case in which the parties will interact over a period of time but in which the legal assignment of liability is not clear.

b) *Nonsequential.* Two groups of four subjects who did not know one another made six single, pairwise decisions each. The object was to model a legal environment in which one bargain would be struck between two parties who would never have to communicate again.

3. Two-person, Limited Information

The next set of experiments modeled an environment less favorable to Coase than the first. Subjects were only told their own payoffs. They were allowed to reveal their payoffs to the other subject in a bargain, but they

did not have to do so. The instructions for this pair of experimental institutions were identical to the instructions for the pair above, with one crucial exception. Where the instructions above stated, "Your payoff sheets list not only the value of each number to you, but also the value of each number to the other participant," the instructions for the limited information bargains stated, "Your payoff sheets list only the value of each number to you. The other participant is free to tell you anything he or she wishes to about the value of each number to him or her." Otherwise, these experiments were exactly the same as the first. These experiments were also divided into (*a*) *sequential*—four pairs made two decisions each, and (*b*) *nonsequential*—two groups of four each made six single pairwise decisions.

B. Three-person Experiments

1. Full-Information Instructions

As the subjects arrived at a designated room they were randomly assigned the letters A, B, or C. Each triad 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 the instructions silently and then listened to the monitor read them aloud.

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 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[44] 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 might be person B. 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 three people will participate together. Either one of you will be chosen as the "controller" or two of you will be chosen as "joint controllers."

[44] Sample payoff functions are reproduced in Table 1.

a) If *one* of you is chosen, 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 three participants. The other two participants may attempt to influence the controller to reach a mutually acceptable group decision; either or both of the other participants may offer to pay part or all of his or her earnings to the controller.

b) If *two* of you are chosen as joint controllers, then either 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 *lower* number will determine the number. If, for example, one joint controller chooses 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 (the one who is *not* a joint controller) may attempt to influence either or both of the remaining parties to reach an acceptable group decision; any party may offer to pay all or part of his or her earnings to one or both of the remaining parties.

In order to reach a group agreement, the following procedures must be followed:

a) If *one* person has been designated the controller, then either one or both 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 an 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 *two* participants have been chosen joint controllers, then *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 (that is, the joint controller choosing the lower number sets the number). The remaining participant 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 either party makes a physical threat, the threatened party will be paid his or her maximum payoff, and the threatening party 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 is the only controller.

Number	A's Payoff ($)	B's Payoff ($)	C's Payoff ($)
1	40	30	30
2	50	10	10

If B and C agree on number 1, but A chooses 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, and pay C $40 (representing a $30 payoff plus the $10 transfer from A).

2. Assume that B and C are joint controllers.

Number	A's Payoff ($)	B's Payoff ($)	C's Payoff ($)
1	40	30	30
2	50	10	10

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

If B 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 signs it.

If A, B, and C sign an agreement form choosing number 1 and directing that $10 of A's payoff be transferred to C and $5 of B's payoff be transferred to C, 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 C) and pay C $45 (representing a $30 payoff plus the $10 transfer from A and the $5 transfer from 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. Level ——— makes me the most money. Level ——— makes me the least money.
2. If C is the only controller and if C chooses number 4, I make ———.
3. If B and C are joint controllers and if B chooses 2 and C chooses 1, I make ———.
4. If A is the controller and he reaches an agreement with B and C which chooses number 2 and directs B to pay A $2 and C to pay A $3, I make ———.
5. If B 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 $0.50, I make ———.
6. If I am the only controller, I may set the number by myself, true or false? ———.

GROUP AGREEMENT FORM
(Three-person Experiments)

Number Chosen ———
$——— 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

These instructions are meant to model a pollution externality; A might correspond to a factory which wished to dump the by-products of its production process into a stream, and B and C might be downstream riparian owners who dislike increased levels of pollution. The choice of a number would correspond to the choice of a level of pollution. If A were the controller, his power to choose the number unilaterally would represent the factory's right to pollute as much as it wished, without having to pay anyone anything. If B and C were joint controllers, their shared power might represent each riparian owner's independent right to obtain an injunction preventing the factory from dumping any pollutants. Under such circumstances, B and C's right to attempt to set the number independently would correspond to each riparian owner independently telling the factory the maximum level of pollution the riparian owner will tolerate. The factory obviously may not pollute to any greater extent than the lowest level allowed from among the independent riparian owners. In just this way, if B and C attempt to set the number independently, the lower of their choices controls. For this very reason, all riparian owners would have to join in an agreement not to seek an injunction before the factory could rely on the agreement. Similarly, in the experiment, both B and C must join in a group agreement in order for A to be able to rely on it.

Each of the instructions included information telling each participant how much cash he and each of the other participants would be paid (depending on which number was chosen). Table 1 shows representative payoffs for three-party bargaining situations. Once again, notice that each schedule has a clear joint-profit maximizing number, which pays at least $1.00 more than the next highest number.

After reading the instructions and examining their payoffs, subjects were tested on their understanding of the rules and the consequences of the decisions they might make. After all three 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 experimenter flipped a coin, and the winner of the toss (either A alone or B and

C together) was designated the controller. The subjects were then instructed to proceed with the experiment (by choosing a number).

2. Experimental Institutions

The three-person, full-information experimental institutions were almost identical to the two-person, limited-information sequential institutions. Again, all bargaining was face-to-face and involved more money then 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.[45] All cash payments were made in public. Subjects were given no motivational instructions. Seventeen groups of three subjects made two decisions each, sequentially.

3. Three-person, Limited Information

This final set of experiments completes a square design of two and three subjects crossed with limited and full information making sequential decisions. The instructions are exactly the same as the three-person instructions given above, except for the crucial insert about knowledge of one another's payoffs. Where the instructions above 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 bargains state, "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." Eighteen groups of three subjects made two decisions each, sequentially.

IV. Experimental Results

Table 2 summarizes the results of all 114 experimental decisions. Overall, 89.5 percent of the decisions are Pareto optimal. In fact, the only deviation from nearly 100 percent joint-profit maximization is with three persons to a bargain, joint controllers, and limited information. These results clearly demonstrate that the Coase Theorem is supported under the following conditions: (1) two parties to a bargain, with and without full information; (2) three parties to a bargain and a single controller, with and without full information; and (3) three parties to a bargain, joint controllers, and full information.

Controllers' behavior regarding splitting the profits fell neatly into two groups. With only fifteen exceptions controllers either agreed to split the

[45] Contract forms are included with the instructions.

TABLE 2
EXPERIMENTAL RESULTS

EXPERIMENT	N	N_1: JOINT PROFIT MAXIMUM	PAYOFF DIVISION				
			N_2: Equal Splits	N_3: Within $1 Different from Equal Split	N_4: Controller Received Exactly the Individual Maximum	N_5: Controller Received More than the Individual Maximum	Other
Two person:							
Full information:							
Sequential	12	12	12	0	0	0	0
Nonsequential	12	11	5	0	4	3	0
Limited information:							
Sequential	8	8	6	0	2	0	0
Nonsequential	12	11	3	3	3	1	2
Three person, sequential:							
Limited information:							
Single controller	21	19	3	4	2	5	7
Joint controller	15	9	2	3	5	4	1
Full information:							
Single controller	13	12	3	2	1	2	5
Joint controller	16	15	9	2	1	3	1
Coin flip barred by subjects on second decision	5	5	4	1	0	0	0
Total	114	102	47	15	18	18	16

payoffs nearly evenly or demanded at least their individual maxima. The second strategy is individually rational for each play of the game and is generally predicted by game-theoretic solutions to the bargaining problem. The first strategy is more in keeping with the results of the social psychological experiments which did not instruct subjects to be individually rational.[46] If we define sharing as an allocation within $1.00 of an equal split, sixty-seven controllers shared and thirty-six bargained to a core allocation.[47]

Sharing occurred most frequently in two-person sequential decisions, and the presence or absence of full information seems to have made no difference. Eighteen of twenty controllers in two-person sequential decisons shared, compared with only eleven of twenty-four in two-person, nonsequential decisions. This suggests that controllers are more likely to share when the parties to a two-person agreement have a continuing relationship than when they do not. Joint controllers also frequently shared in three-person, sequential, full-information decisions. In addition, a number of three-person, sequential, full-information subject groups insisted on signing a sharing agreement covering both decisions. They would sign two agreement forms during discussion of the first decision.

It is possible that we would have observed fewer equal splits if we had not used college students as subjects. College students may not be as rationally self-interested as those who are older. This possible lack of self-interest might also derive from a feeling of "kinship" with fellow students.

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

[46] Note 20 *supra*.

[47] 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.

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. Nevertheless, the pattern of sharing vis-à-vis individual maximizing behavior may not be inconsistent with rational behavior in the fact of uncertainty. Sharing buys "good will" in a continuing relationship, especially one in which the other person might be controller the next time. While the expected value of demanding at least the individual maximum may be higher, the expected utility may be lower.[48]

Moreover, the pattern in the three-person, sequential, full-information experiments is consistent with a downward-sloping demand curve for risk avoidance. Once the coin has been flipped for the first decision and the outcome is known, adopting a sharing strategy for *both* decisions requires that single controllers on the first decision give up more than joint controllers relative to the *minimum* expected payoffs they can command. On the first decision a single controller commands at least $12.00, while a

[48] Richard Posner has recently suggested an economic rationale for the prevalence of sharing behavior in primitive (preliterate) societies. Posner hypothesizes that in a culture that produces food that cannot be stored from one period to another, voluntary "gifts" of surplus food production to needy individuals will form the basis of a primitive form of insurance against hunger and starvation. Those who produce surplus in one period may be needy the next. As long as the fortunate give to the needy in each period, everyone's chance of starving is greatly reduced. Posner explores the ramifications of these insights in A Theory of Primitive Society with Special Reference to Primitive Law, 23 J. Law & Econ. 1 (1980). Unfortunately, however, our results cannot be explained through Posner's analysis. Each subject's production was perfectly storable from one experiment to the next. Hence, the controller on the first of two sequential decisions could *self-insure* against the possibility of losing control on the second decision by refusing to share his surplus. Furthermore, Posner's thesis cannot explain any of the sharing behavior that we observed in nonsequential decisions or in the *second* of two sequential decisions, since there is no longer any insurance to be bought. Of course, the sharing behavior might be the "natural" outcome of this bargaining game if the subjects were to view *all* of the money to be paid to them as "profits" rather than just regard the additional money which can be earned by cooperating as profits. The Nash bargaining solution is to split evenly all profits where neither party has greater power within the game. This solution would suggest that the controller would take his individual maximum plus one-half of the surplus from cooperation. If, for some reason, the controller failed to fully appreciate his complete control over the amount he could command by himself (although each subject answered questions indicating that he *did* have such an appreciation), then the observed equal splits would correspond, in some sense, to the Nash bargaining solution. To test this possibility, we wish to run additional two- and three-person experiments, identical in all respects to the previous experiments, with one important change. When the coin is flipped and the controller is chosen, we will take an amount of cash equal to the maximum the controller can command by himself and give it to the controller immediately. The controller will be told that the cash is his and that it is up to him whether the experiment proceeds. If the experiment proceeds, the procedures will be unchanged. However, to effect an equal split, the controller will have to give up some of the cash in hand to the other party or parties. We suspect that such a change in procedure will reduce the number of equal splits.

TABLE 3
THREE-PERSON, SEQUENTIAL, FULL-INFORMATION RESULTS

	Number	Number Which Shared
First decision:		
Single controller	8	4
Joint controllers	9	7
Second decision:		
Binding contract:	5	5
Single controller on first decision	2	2
Joint controllers on first decision	3	3
Single controller:	5	1
Single controller shared on first decision	1	1
Joint controllers shared on first decision	1	0
Joint controller:	7	4
Single controller shared on first decision	1	1
Joint controllers shared on first decision	3	3

joint controller commands a minimum of only \$7.00. The second decision (before the coin flip) has an expected value of at least \$6.50 to the single controller and an expected value of at least \$4.25 to each joint controller. A sharing strategy yields \$12.33 to each participant. Hence, the decision to share requires a single controller on the first decision to trade away an expected return of at least \$6.50 on the second decision in exchange for \$0.33 with certainty. Joint controllers, however, may gain \$5.33 with certainty by trading away their expected value of at least \$4.25. Therefore, we would expect joint controllers to share more often than single controllers.

As Table 3 shows, in three-person, sequential, full-information experiments joint controllers were more likely to share than single controllers on both decisions. Moreover, all second-decision sharing was linked to a binding or implicit contract among the participants. Thus, either the participants had actually signed such a contract, or they had shared on the first decision, creating an implicit contract to share all proceeds.

V. CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

The experimental results presented in this paper provide strong support for Coase's proposition that agents will bargain to a joint-profit-maximizing outcome when it exists in two- and three-party bargaining situations under full information and when one party has the right to make the decision unilaterally under limited information. It is too early to tell

whether the experimental departures from Pareto optimality jointly controlled, three-person, partial-information games are significant. Four of the six departures occurred in the first of two decisions and were followed by a Pareto optimal decision. Thus, it may be that the game is more difficult to learn with joint controllers. In that case we might simply be observing an experience effect which was not evident in the easier games. This hypothesis requires further testing.

However, if these indications of failure to achieve Pareto optimal results in jointly controlled, three-person, partial-information games are confirmed by future testing, we may be able to derive substantial policy implications for the law. 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, interferes with other land uses, for example, homeowning, so as possibly to constitute a "nuisance" under the law.[50] 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) Homeowners' 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: (1*a*) 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. (2*a*) Homeowner's right—the factory may pollute at any level it chooses, but it must pay homeowners for any damage caused by the pollution.

There are problems[52] associated with both damages and injunctive rem-

[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 Co., 26 N.Y.2d 219, 257 N.E.2d 870, 309 N.Y.S.2d 312 (1970).

[51] We realize that there are other possibilities, but restricting the discussion to these two alternatives simplifies the textual discussion. For a good discussion of a hybrid remedy, see Robert C. Ellickson, Alternatives to Zoning: Covenants, Nuisance Rules, and Fines as Land Use Controls, 40 U. Chi. L. Rev. 681, 738 (1973).

[52] We assume that 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.

edies.[53] 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. Our experiments provide some confirmation of this intuition. The almost complete dominance of Pareto optimal outcomes in our two-person experiment suggests that, if there is only one homeowner, a court may choose from between rules 1 and 2 (depending on whether the factory is or is not a nuisance) with confidence that the parties will bargain to an efficient outcome. Hence, injunctive entitlements have appeal in two-party situations.

However, when there are "many" homeowners, it has commonly been feared that strategic behaviors (often termed "free-rider problems") and problems of coordination may preclude the parties' rearrangement of judicial decisions into Pareto optimal patterns. Our results provide some crucial insights. First, although such fears may be realistic in some circumstances, one cannot know whether to be worried about injunctive remedies merely by counting all of the parties to a lawsuit and asking if there are "many" parties. The dominance of Pareto optimal outcomes in single controller, three-person games suggests that, if there are two homeowners, a court may choose rule 1 with good confidence that the parties will bargain efficiently. However, with exactly the same parties, our results to date imply that a court may not choose rule 2 with the same high level of confidence about optimal bargaining.[54] Furthermore, a court may have to begin worrying about such concerns when there are only two homeowners.[55] All together, these insights suggest that, in contexts like

[53] These problems are discussed in much greater detail in Calabresi & Melamed, *supra* note 3*B*.

[54] Moreover, if our hypothesis that inexperience is responsible for some departures from Pareto optimality is confirmed, then the courts should behave differently when they suspect parties will make only one bargain than when the courts suspect they will bargain repeatedly. If agents are to bargain repeatedly, they may converge quickly to the efficient outcome under either rule 1 or rule 2, but if one single bargain is to stand for many years the court may have to worry about rule 2.

[55] Discussions in the law and economics literature tend to avoid addressing the question of how many is "many"; instead the literature discusses only situations in which there are hundreds of homeowners, thereby sidestepping the problem. For example, in discussing the sources of high transactions costs, Judge Richard Posner (then Professor Posner) stated in his treatise: "The costs of transacting are highest where elements of bilateral monopoly coincide with a large number of parties to the transaction—a quite possible conjunction. For example, if homeowners have a right to be free from pollution, the factory that wishes to acquire the right to pollute must acquire it from every homeowner. If only one out of a thousand refuses to come to terms, the rights that the factory has purchased from the other 999 are worth nothing (why?) Because the holdout can extract an exorbitant price, as in our

our example, a judge must begin worrying about problems with rule 2 when he does not yet have to worry about rule 1.[56] We can derive similar (tentative) policy conclusions about the law of easements and equitable servitudes on land with such an analysis. Of course, further experimental work with joint controllers and larger bargaining parties is needed before we can say that the Coase Proposition is confirmed experimentally as a more general behavioral prediction.[57]

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right-of-way example in the previous section, each homeowner has an incentive to delay coming to terms with the factory; the process of negotiation may therefore be endlessly protracted." Richard Posner, *supra* note 3*C*, at 45. Posner also discusses the possibility of bargaining breakdown in two-party discussions. *Id.* Also see the discussion in Calabresi & Melamed, *supra* note 3*B* (100,000 citizens).

[56] Obviously, further experimental research is needed to ascertain the point at which, if a court finds no nuisance, "many" homeowners prevent efficient contracting. We are currently engaged in such tests.

[57] The results also provide some support for predictions about how agents in such bargaining situations will divide the profits. Controllers in two-person sequential bargains and, more generally, those with a previous experience sharing profits or a monetary incentive to share are more likely to share. Others are somewhat more likely to demand their individual maxima. We feel that it is premature, at this stage, to draw normative conclusions from the sharing behavior between subjects in these experiments. However, before one may draw such normative implications for the Coase Theorem one would need a theory of how subjects (or people in general) ought to behave with respect to exploiting economic rights. Such a theory might stem from a notion of just deserts. For example, one might feel that full exploitation of an economic right was justified only where the owner of the right had acquired it through labor. Under such a theory the subjects in our experiment, who acquired the right to be controller through a flip of the coin rather than through labor, should share the profits. Alternatively, one might feel that one may morally exploit a property right if and only if the other party with whom one is dealing is wealthier, of a higher caste, etc. Under this theory, we would have to know the relative status of controllers and noncontrollers in our experiments before being able to make any normative pronouncements on the sharing behavior. The development of a general, normative theory lies well beyond the scope of this paper. Even if we had a well-developed normative theory of exploitation of economic rights, our data are far too sketchy to allow any meaningful application. We intend to return to these questions upon completing the full set of Coase Theorem experiments.