Efficiency of Alternative Bargaining Procedures

AN EXPERIMENTAL STUDY

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This article reviews experimental work on two party bargaining where a bargainer has information unavailable to the other party. The situation is one where the bargaining is on a single issue only and is distributive, (i.e., the negotiations are on the sharing or distribution of the common gains from trade). Two experimental situations are reviewed and several observations are drawn, including the following: (1) in a single-stage game, a simultaneous offer does more poorly than either a buyer first or a seller first offer; (2) neither buyer first nor seller first offer seems superior; (3) no procedure with symmetric information offers an advantage to the buyer or the seller; (4) seller first offer is most efficient in the case where the seller has more information; and (5) more information leads to an advantage to the bargainer with the additional information. The implications of these and other observations for theoretical and additional experimental work in this area are discussed.

THE PROBLEM CONTEXT: BARGAINING ON A SINGLE ISSUE

This article is concerned with two-party bargaining in situations where a bargainer has private information unavailable to the other party. We deal with single-issue bargains only, such as the price per unit at which raw material is purchased from a supplier or the price at which one firm is acquired by another.

The problem of price bargaining is a long standing one in economics where it goes under the name of bilateral monopoly. It is also important in the area of industrial marketing, where buying firms negotiate price

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contracts with single suppliers. According to Hill, Alexander, and Cross (1975: 83) "most major purchases by businesses, private institutions and numerous government agencies and departments are probably negotiated." They go on to note, "The buyer must be cognizant of the cost situation of his own firm as well as that of suppliers . . . [he] must seek every advantage . . . to which his company is entitled" (1975: 84).

Sometimes, of course, price is only one among several issues to be settled. We shall assume here, however, that all other issues have been settled or are not up for bargaining.

Bargaining on a single issue is sometimes described in the labor negotiations literature as "distributive" bargaining (Walton and McKersie, 1965). This is because the negotiations are on the sharing or distribution of the common gains from trade. For example, the buyer in a contract negotiation will try to obtain as low a price as possible while the seller will try to get as high a price as possible. However, the interests of the parties are not strictly opposed since they both want to arrive at an agreement, if such an agreement results in mutual gains, and they both want to conclude the bargaining as soon as possible, as time is valuable.

If the total gains from trade were known to both bargainers, it might be surmised that they would quickly settle on some symmetric agreement, such as splitting the gains equally. Seldom, in practice, is the size of the total gain from an agreement known to either party. The buyer knows the maximum amount he or she is willing to pay, while the seller knows the minimum he or she will accept. Each has some idea about the other's restrictions and costs but does not know them exactly. The maximum a buyer will pay and the minimum a seller will accept are sometimes called their respective "reservation prices." If the buyer's reservation price is lower than the seller's, no gains from trade exist, but the parties could still bargain for a time before they determine this. Even when potential gains from trade exist they could fail to be realized, since each player could try to seek a particular advantage, jeopardizing a final agreement.

This lack of perfect or shared information translates into a practical art for negotiators:

> An essential of negotiating skill, therefore, is the ability to assess the strengths and weaknesses of the opposing party and to understand fully what he has at stake. At the same time, it becomes important that the buyer not disclose what he has at stake in either a corporate or a personal sense. The negotiator must sometimes be willing to take calculated risks—to let this opponent believe that he (the buyer) is negotiating from a position of strength, a position that he may not in fact enjoy to the extent that he might imply. In this respect, negotiating is acting or role playing. There is room in the role for emotion, for being arbitrary, and for disregarding the

> apparent logic of the situation—up to a point. That point comes when the opponent himself may be forced to emotional responses and irrational behavior [Corey, 1976: 17].

Henderson (1967: 57) concurs: "It is worth emphasizing that your competitor is under the maximum handicap if he acts in a completely rational, objective and logical manner." And Karass (1970: 37) describes an ideal negotiator as one who has "a high tolerance for ambiguity and uncertainty as well as the openmindedness to test his own assumption and the opponent's intentions."

THEORETICAL BACKGROUND

The problem described above is one of *incomplete information*; that is, a bargainer does not possess complete information about the opponent's characteristics (for example, the opponent's reservation price). Most classical bargaining theory, however, deals with situations of *complete information*; both bargaining parties know the payoffs to both associated with every conceivable agreement. The question discussed in the work of Nash (1950, 1953), Raiffa (1953), and Roth (1979) is then which agreement among all the ones available will be selected by the players if (prior to the bargaining) they agree to observe certain rules of bargaining.

One principle that is common to all the classical work (although Roth, 1979, discusses the consequences of dropping it) is that of Pareto-optimality. In our context, this means that whenever a mutually beneficial agreement exists it will be attained. The classical model thus does not deal with the strategic issues involved in the transmission of information in the bargaining process.

The articles by Harsanyi (1968) set the stage for modeling games of incomplete information. The method proposed by Harsanyi was conceptually simple and elegant; players were uncertain about each other's characteristics and would therefore assess probability distributions on the uncertain quantities involved. If these probability distributions were publicly known and were consistent (in a sense made precise by Harsanyi), the incomplete information problem (with one or more players being unable to calculate all the payoffs because, for example, one of the other players has private information about preferences) would become an imperfect information problem where the introduction of a chance move with commonly known probabilities would enable expectations of payoffs to be calculated.

Recently, researchers have addressed the bargaining problem as a noncooperative game of incomplete information (as opposed to the classical literature, concerned mainly with a cooperative, complete information model). The literature in this area can be divided broadly into two categories. In the first category (Chatterjee and Samuelson, 1983; Crawford, 1982, for example) the emphasis is on accurately representing certain important features of the real-life bargaining process. In the second category fall the normative papers (Myerson, 1979; Myerson and Satterthwaite, 1981; and Samuelson, 1981) that seek to determine the conditions under which a bargaining process is "optimal" in a sense to be discussed shortly.

Crawford (1982) explains disagreements in bargaining by the use, by both players, of pre-play commitments that are costly, although not impossible, to reverse. Mutually incompatible commitments lead to disagreement. This article does not follow up on this interesting line of research, but is based on the model in Chatterjee and Samuelson (1983).

This model is as follows. Each bargainer knows only his or her own reservation price. The bargaining is a one-stage process. Each player makes a sealed offer; if the buyer's offer is higher than the seller's, an agreement takes place at a price that is a convex combination of the two offers, but if the seller's demand is higher than the buyer's offer the bargaining terminates with no agreement. The model includes the cases where the agreement, if it takes place, is at the buyer's offer, at the seller's demand, or midway between the two. This model is similar to the noncooperative version of Nash's scheme, where each player makes a demand and receives the conflict payoffs if the demands are incompatible. Here, as contrasted with Nash, the players are uncertain which, if any, trades are mutually beneficial.

The solution concept used in the Chatterjee-Samuelson article is that of Bayesian Nash equilibrium: Each player selects a decision rule relating this player's information to his or her offer and the decisions are selected to be best against each other. Using this approach to predict a solution, the authors show that in equilibrium none of the three procedures—settling at the buyer's offer, settling at the seller's demand, and settling midway between the two—is efficient in the sense of guaranteeing an agreement whenever one is mutually beneficial. (This concept of efficiency is often called "full-information" efficiency.)

This inefficiency result was extended by Chatterjee (1982) and proved in general in Myerson and Satterthwaite (1981). Myerson and Satterthwaite showed that any bargaining mechanism, whether one-stage or not, would fail to be both efficient and individually rational, where the latter condition ensures that the players are no worse off by participating in the bargaining no matter what the values of their respective reservation prices. Myerson and Satterthwaite also show that if the reservation prices are independently drawn from uniform (0,1) probability distributions, the one-stage bargaining procedure where each player makes a sealed offer and an agreement "splits the difference" between the two if the buyer's offer is higher than the seller's demand, is the procedure with an equilibrium that maximizes the expected total gains from trade. The procedure has an equilibrium that is often called "ex ante efficient," indicating efficiency in expectations *prior* to players learning their reservation prices.

The tool used by Myerson and Satterthwaite to prove their results is what they call "the revelation principle." This principle specifies a correspondence between the equilibrium of any bargaining game, and the truthful revelation equilibrium of a suitably structured one-stage direct revelation game. In such a game, players announce their reservation prices and an outcome is determined based on these announcements. The correspondence holds because a player's equilibrium strategy in any complex bargaining procedures is a function of his or her reservation price and of the underlying probability distributions, assumed not to change. The final outcome depends on the players' strategies and is therefore some "outcome function," g(. . .) say of their reservation prices.

If we now define a one-stage procedure whereby each player announces his or her reservation price and the referee transforms these announcements into a result by using the outcome function of the original game, then neither player has an incentive to deviate from truth telling, unless that player has an incentive to practice self-deception. We can then constrain the available outcome functions to require that each player be at least as well off under bargaining as he or she would have been without bargaining and try to determine requirements for an outcome function that maximizes the expected sum of payoffs. The outcome function includes both the probability of agreement and the amount exchanged between buyer and seller as a function of their respective reservation prices.

Once these optimality conditions have been derived, however, it is not trivial to recover the optimal bargaining procedure to satisfy these conditions. Thus, although the revelation principle yields interesting and strong normative results, it neither specifies a stategic bargaining process, nor offers advice to individual bargainers on what to do.

In a paper extending the basic bargaining model, Samuelson (1981) considers a model with "asymmetric" information, where one bargainer (the seller) has strictly better information on the value of the item than the other. Moreover, the reservation prices are dependent, with the buyer's being some function of the seller's—for example, the buyer's reservation price is 1.25 the seller's. The dependence causes problems of "adverse selection" discussed by Akerlof (1970).

Samuelson shows that the bargaining procedure that maximizes the buyer's payoff is the "buyer-first-offer" procedure, where the buyer makes an offer that the seller can either accept or reject. (This is equivalent to the game where both buyer and seller make offers but the agreement, if one takes place, is at the buyer's offer.) The results for the best procedure from the point of view of the seller are somewhat less than conclusive and show only that a seller-first-offer procedure is optimal whenever the optimal procedure is implementable by a simple scheme. The objective function the seller maximizes in Samuelson's article is the expected payoff *prior* to knowing his or her reservation price. Once the seller knows his or her reservation price, choice of a procedure reveals some private information and the issue becomes more complicated. (See Myerson, 1981, for an attempt to analyze this situation.) The total ex ante expected payoff is also maximized by seller-first-offer whenever the optimal procedure is simply implementable.

Thus some progress has been made on both the normative and positive models of bargaining under incomplete information. Another line of inquiry has focused on whether multistage bargaining games are more or less efficient (i.e., do they Pareto-dominate or are they Pareto-dominated by) than one-stage games of the sort analyzed in Chatterjee and Samuelson (1983). In an example in Chatterjee and Ulvila (1982) it is shown that a two-stage extension of the simple one-stage game leads to lower expected payoffs in equilibrium for both players if there is some positive probability of the game not continuing into the second round. This is counter-intuitive because the first-stage offers reveal some information and one might expect (although it is not, in general, true) that the opportunity for obtaining additional information should lead to better expected payoffs. It is shown that this learning effect could be offset by inflexible stands adopted during the first stage.

The only complete analysis of a multistage game is under complete information (Rubinstein, 1982). There is no general theoretical extension of the example mentioned in the previous paragraph. Recent work following Sobel and Takahashi's 1983 article (see Fudenberg and Tirole, 1983; and Cramton, 1983) has, however, analyzed a multistage procedure where one player (whose reservation price is common knowledge except in Cramton, 1983, and part of Fudenberg and Tirole, 1983) makes the offers and the other responds by accepting or rejecting the current offer. Much of the analysis in these papers depends crucially on this specification, since it enables the updating to be performed by truncations of the prior probability distribution. Neither simultaneous offers nor sequential, alternating offers have been formally analyzed.

A NEED FOR EMPIRICAL RESEARCH

D'Abro (1951: 3) lists the stages of the scientific method as (1) observational, (2) experimental, and (3) theoretical. He goes on to state that this order is the order in which they arise in any scientific inquiry. This view, while overly restrictive, points out the importance of observation in the research process. Bunge (1967) describes the research process as a cycle of theory (or model), observation, evaluation, and new theory/model.

In light of the above, it is interesting to note that model development in this area is seldom put to empirical tests. This is despite the fact that the impetus for a few of the model developments was provided by classroom simulations (Raiffa, 1982). An exception is the experimental work carried on by Roth and his colleagues in parallel with their theoretical analysis:

> Although it has not yet become standard practice to test economic theories with experimental data, bargaining seems to be a subject well-suited to the endeavor, both because there is a well-developed body of deductive theory on the subject and because, being an activity which can take place between as few as two agents, it readily lends itself to reliable experimental investigation [Roth and Murnighan, 1982: 2].

In line with this view, we conducted some experiments to provide insight into the choice of bargaining procedure in both symmetric and asymmetric information conditions. We restricted ourselves to comparisons among four types of procedures, namely:

(1) buyer first offer (BFO);
(2) seller first offer (SFO);
(3) simultaneous offers; and
(4) multistage bargaining.

We expected the desirability of these procedures to depend upon the informational conditions under which the players bargained. We considered two variations of incomplete information, labelled "symmetric" and "asymmetric," respectively. In what we call the "symmetric" case (Chatterjee and Samuelson, 1983), each of the two bargainers had private information (i.e., his or her reservation price) and there were commonly known probability distributions from which the quantities constituting this information were independently drawn. The "symmetry" lies in each person having private information.

In the "asymmetric information" case (Akerlof, 1970; Samuelson, 1981), the seller knew his or her reservation price, and both the buyer and the seller knew that the buyer's reservation price was 1.25 times the seller's. Thus the seller had an informational advantage.

The BFO and SFO procedures (both single-stage) do not differ in their strategic features in the symmetric case, but have different implications for the asymmetric case. This is because (in the symmetric case) the player moving second has no opportunity to use the information contained in the other player's offer. His only role is to consider the relation of the offer to his reservation price and then decide to accept or reject the offer. Under asymmetric information, an offer made by the seller conveys information about the buyer's reservation price as well, and this additional information has to be taken into account in the buyer's acceptance or rejection decision. However, the fact that the buyer is expected to do this influences the seller's offer as well, and issues of strategic information transmission arise (Crawford and Sobel, 1982).

The same issue of strategic manipulation of information by the players arises in the multistage game, even though the buyer's reservation price is independent of the seller's reservation price. This happens because each player tries to gauge how much the other will be willing to give up, and since the other player's offers convey information about his or her flexibility and should be used in preparing counteroffers. However, a player may try to convey misleading information, leading to a worse result than a one-stage game (as in the example in Chatterjee and Ulvila, 1982).

In the particular multistage bargaining procedure we designed, buyers and sellers were given reservation prices drawn from known probability distributions and were asked not to reveal these prices directly to each other. The game proceeded with each participant writing down an offer and exchanging it with his or her opponent. If these offers were incompatible, both players paid the stage costs and went on to make another offer. We felt that the difference between simultaneous and sequential offer procedures within each stage would be slight, since information transfer takes place in both cases from one stage to the next. In general, the particular extensive form chosen may have a considerable impact on the analysis, especially if one assumes that only one side makes offers. We felt, however (without proof), that there was sufficient symmetry in both specifications (since we had two-sided incomplete information and both sides making offers in both versions) to provide plausibility for this assumption.

We also expected that strategic manipulation would not be important in determining the efficiency of the bargaining procedures, since people in the real world frequently do not bargain as skillfully as might be predicted by game theorists. Our prior belief was that naive players manipulate less, and therefore reveal more to each other in repeated-offer situations and can therefore be expected to obtain better results on average than in the one-stage game. (That is, they may use randomized strategies that have a higher probability associated with revealing one's type than the equilibrium mixed strategies.)

Along with exploring the strategic use of information, we were also interested in whether there was a systematic relation among the first three procedures.

EXPERIMENTAL SETTING

We performed two sets of experiments with subjects drawn primarily from undergraduate students at the Pennsylvania State University. (There were a few graduate student volunteers as well.) Prior to running the experiments, the instructions were tested on participants in a Ph.D. seminar.

The first experiment, the "scarab" experiment, was conducted with volunteers from diverse undergraduate majors. The participants were paid a flat rate (of \$5.00) and an incentive payment (of at most \$5.00) proportional to their average payoff in the bargaining experiment. The buyers and sellers in this experiment were asked to negotiate a price for an ancient Egyptian scarab, an object chosen so that neither the subjects nor the experimenters would have any strong prior notions on its value. The sellers' reservation prices were randomly drawn from a uniform probability distribution between \$25(000) and \$125(000), and the buyers' reservation prices were similarly drawn from a uniform distribution between \$75(000) and \$175(000). The expected size of the zone of agreement was approximately \$54(000) units. The stage cost in the multistage version was \$5(000) per stage.

This experiment dealt only with the symmetric information condition. The arrangement for the experiment was as follows. Each volunteer was randomly assigned a partner and a role as either buyer or seller. The instruction sheet contained the player's reservation price and a direction not to show his or her opponent this reservation price. The first procedure (BFO) was then explained with examples, and each pair then proceeded to play. After one round, the volunteers switched roles from buyer to seller and vice-versa, and the game was repeated with a different set of reservation prices. The bargainers were then reassigned partners, and the next procedure was carried through in the same manner. Throughout the experiment, care was taken to ensure that the bargainers were exchanging offers without other communications and that they were doing so after understanding the rules of the game.

The second experiment was based on an industrial marketing case called "Lion vs. Unicorn," a price negotiation associated with a purchasing agreement, and was administered in an undergraduate industrial marketing course. No fixed fee was given in this case but a prize was given to the student with the highest average payoff. Most of the participants in this exercise were marketing majors. The probability distributions for the seller and buyer reservation prices were uniformly between \$200 and \$300 (for the seller) and \$250 and \$350 (for the buyer), respectively, again with an expected zone of agreement of \$54. The penalty for bargaining beyond one stage in the multistage game was reduced to \$1 per stage.

This experiment was also carried out under the asymmetric information condition with the seller's reservation price being between \$200 and \$300 and the buyer's reservation price being 1.25 times the seller's.

These experiments were carried out in different contexts and with different groups of subjects, but the arrangements for playing the various games were identical with those in the previous experiment. Further, the stage cost for the multistage game was high in one case and low in the other. By varying the conditions, we hoped to see consistency of results that could not be ascribed to the specifics of the bargaining situation or the specific bargainers themselves.

RESULTS

The results of these experiments are included in Tables 1 to 6 and are summarized in a series of observations, detailed below. These observations suggest anomalies and directions for future research, but are not meant to prove (or disprove) existing theories.

(text continues on page 284)

TABLE 1

Lion/Unicorn Experiment Results Summary: Symmetric Information

		BFO	*SFO*	*Game SIM*	*Multi*	*Overall*
A. Seller value	Mean:	244.1	255.7	250.4	244.7	248.8
	Standard Deviation:	26.3	35.1	30.8	28.9	30.5
	N:	32	34	32	34	132
B. Buyer value	Mean:	289.6	288.4	293.5	304.5	294.0
	Standard Deviation:	24.6	29.1	27.6	26.0	27.4
	N:	32	34	32	34	132
C. Zone of agreement	Mean:	47.6	38.2	45.8	59.8	47.9
	Standard Deviation:	30.8	37.4	31.6	38.3	35.3
	N:	32	34	32	34	132
D. Seller offer	Mean:	–	288.7	284.7	–	286.8
	Standard Deviation:	–	28.1	27.2	–	27.5
	N:	0	34	32	0	66
E. Buyer offer	Mean:	259.6	–	265.8	–	262.7
	Standard Deviation:	19.6	–	24.5	–	22.2
	N:	32	0	32	0	64
F. Price, given agreement	Mean:	265.0	272.5	279.5	278.2	273.5
	Standard Deviation:	16.3	23.1	20.2	18.3	19.8
	N:	21	19	10	29	79

G. Frequency of agreement	Mean:	0.65	0.55	0.31	0.85	0.59
	N:	32	34	32	34	132
H. Seller payoff	Mean:	22.4	20.6	12.7	29.4	21.4
	Standard Deviation:	21.4	23.0	21.2	28.4	24.3
	N:	32	34	32	34	132
I. Buyer payoff	Mean:	19.2	15.3	10.8	26.3	18.0
	Standard Deviation:	20.2	22.4	19.8	26.4	22.9
	N:	32	34	32	34	132
J. Total payoff (H + I)	Mean:	41.7	36	23.6	55.8	39.5
	Standard Deviation:	35.8	36.8	38.0	41.2	39.8
	N:	32	34	32	34	132
K. Efficiency (J/C)		.87	.94	.51	.93	

TABLE 2
Scarab Experiment Results Summary

		BFO	*SFO*	*Game SIM*	*Multi*	*Overall*
A. Seller value	Mean:	73052	77683	76006	69275	73752
	Standard Deviation:	21181	31516	28636	26758	26984
	N:	35	30	34	38	137
B. Buyer value	Mean:	130586	127124	125938	128685	128147
	Standard Deviation:	32552	29314	28389	28788	29534
	N:	35	30	34	38	137
C. Zone of agreement	Mean:	59442	50811	51655	60802	55997
	Standard Deviation:	35063	32270	36165	31901	33820
	N:	35	30	34	38	137
D. Seller offer	Mean:	–	107924	102591	–	105091
	Standard Deviation:	–	29363	22166	–	25718
	N:	0	30	34	0	64
E. Buyer offer	Mean:	95149	–	92910	–	94046
	Standard Deviation:	22937	–	19173	–	21041
	N:	35	0	34	0	69
F. Price, given agreement	Mean:	102794	97144	95624	98190	99024
	Standard Deviation:	17761	27415	12683	22565	21006
	N:	28	18	13	33	92

G. Frequency of agreement	Mean:	0.8	0.6	0.38	0.87	0.67
	N:	35	30	34	38	137
H. Seller payoff	Mean:	27939	12624	13467	25272	20254
	Standard Deviation:	23043	14991	21316	26830	23094
	N:	35	30	34	38	137
I. Buyer payoff	Mean:	27915	25160	14711	27249	23850
	Standard Deviation:	25000	32105	23292	23914	26306
	N:	35	30	34	38	137
J. Total payoff (H + I)	Mean:	55855	37784	28179	52521	44104
	Standard Deviation:	38557	39434	39723	35852	39539
	N:	35	30	34	38	137
K. Efficiency (J/C)		.93	.74	.54	.86	

TABLE 3
Lion/Unicorn Results Summary: Asymmetric Information

		Game BFO	SFO	SIM	*Overall*
A. Seller value	Mean:	259.2	245	247.6	250.8
	Standard Deviation:	27.9	27	31.4	29.4
	N:	35	33	33	101
B. Buyer value	Mean:	324.0	306.2	309.5	313.5
	Standard Deviation:	34.9	34.6	39.3	36.8
	N:	35	33	33	101
C. Zone of agreement	Mean:	64.8	61.2	61.9	62.7
	Standard Deviation:	6.9	6.9	7.8	7.3
	N:	35	33	33	101
D. Seller offer	Mean:	–	293.0	288.1	290.6
	Standard Deviation:	–	20.0	24.5	22.3
	N:	0	33	33	66
E. Buyer offer	Mean:	273.1	–	299.1	285.7
	Standard Deviation:	21.9	–	27.5	27.8
	N:	35	0	33	68
F. Price	Mean:	284.2	289.7	292.1	288.9
	Standard Deviation:	21.8	17.5	19.0	19.2
	N:	19	28	21	68
G. Frequency of agreement	Mean:	0.54	0.85	0.64	0.67
	N:	35	33	33	101
H Seller payoff	Mean:	23.4	41.4	32.9	32.4
	Standard Deviation:	29.2	26.1	30.8	29.4
	N:	35	33	33	101
I. Buyer payoff	Mean:	9.3	9.6	5.2	8.1
	Standard Deviation:	24.2	24.6	22.8	23.7
	N:	35	33	33	101
J. Total payoff (H + I)	Mean:	32.7	51.0	38.2	40.5
	Standard Deviation:	30.7	22.7	29.9	28.9
	N:	35	33	33	101
K. Efficiency (J/C)		.50	.83	.61	

Observation 1: The sum of payoffs under simultaneous offers with symmetric information is worse than that with BFO or SFO. Table 1 (Lion/Unicorn) shows a mean simultaneous offer total payoff of 23.6 vs. 41.7 for BFO and 36 for SFO. Table 2 (Scarab) gives 28719 vs. 55855

TABLE 4
Lion/Unicorn Experiment: Symmetric Information Hypothesis Tests

	Null Hypothesis	*Wilcoxon Test**		*T-Test***	
		Test	*Significance*	*Test*	*Significance*
Buyer payoff	SFO >BFO	1.17	0.12	0.87	0.19
	SIM >BFO	2.01	0.02	1.61	0.05
	BFO >MLT	0.60	0.27	1.03	0.15
	SIM >SFO	1.03	0.14	0.67	0.25
	SFO >MLT	1.37	0.08	1.79	0.03
	SIM >MLT	1.78	0.03	2.43	0.01
Seller payoff	SFO >BFO	0.72	0.23	0.54	0.29
	SIM >BFO	2.04	0.02	1.81	0.03
	BFO >MLT	0.12	0.45	0.86	0.19
	SIM >SFO	1.37	0.08	1.24	0.10
	SFO >MLT	0.51	0.30	1.36	0.08
	SIM >MLT	1.49	0.06	2.43	0.01
Total payoff	SFO >BFO	0.97	0.16	0.84	0.19
	SIM >BFO	1.96	0.02	1.95	0.02
	BFO >MLT	0.75	0.22	0.22	0.41
	SIM >SFO	1.26	0.10	1.11	0.13
	SFO >MLT	1.45	0.07	1.95	0.02
	SIM >MLT	2.18	0.01	2.96	0.01

*Test for stochastic dominance of one frequency distribution of payoff versus the other, as noted in the null hypothesis.
**T-test, test for difference in mean total payoff.

and 37784 for BFO and SFO, respectively. The significance of these differences is computed (Table 4) as .02 (BFO vs. SIM) and .10 (SFO vs. SIM) for Lion; the comparable statistics are .002 and .15 for Scarab (Table 5). (We used the Wilcoxon test statistic here.)

Observation 2: Neither BFO nor SFO is superior to the other. No statistics consistently favor one procedure over the other.

Observation 3: The multistage game leads to a higher frequency of agreement. For Lion the frequency of agreement was 85% vs. 51% on the average for the other three (Table 1). The comparable numbers for Scarab are 87% vs. 59% (Table 2).

Note that while the total payoff for the Lion game reflected this higher rate of agreement, for the Scarab game the high stage penalty resulted in an average payoff lower than BFO. The average number of stages was a little over two for the Lion games vs. 1.6 for Scarab, so this heavy stage penalty reduced the number of stages in the bargaining process.

TABLE 5
Scarab Experiment Hypothesis Tests

	Null Hypothesis	Wilcoxon Test* Test	Wilcoxon Test* Significance	T-Test** Test	T-Test** Significance
Buyer payoff	SFO >BFO	1.11	0.13	0.40	0.33
	SIM >BFO	2.70	0.01	2.23	0.01
	MLT>BFO	0.01	0.49	0.08	0.46
	SIM >SFO	1.40	0.07	1.46	0.07
	SFO >MLT	1.02	0.15	0.35	0.36
	SIM >MLT	2.62	0.01	2.21	0.01
Seller payoff	SFO >BFO	2.76	0.00	3.24	0.00
	SIM >BFO	2.91	0.00	2.70	0.00
	MLT>BFO	0.50	0.30	0.45	0.32
	SFO >SIM	0.69	0.24	0.27	0.39
	SFO >MLT	1.68	0.04	2.41	0.01
	SIM >MLT	2.01	0.02	2.05	0.02
Total payoff	SFO >BFO	1.95	0.02	2.00	0.02
	SIM >BFO	2.80	0.00	2.93	0.00
	MLT>BFO	0.44	0.32	0.38	0.35
	SIM >SFO	1.01	0.15	0.85	1.19
	SFO >MLT	1.84	0.03	1.75	0.04
	SIM >MLT	2.47	0.01	2.73	0.00

*Test for stochastic dominance of one frequency distribution of payoff versus the other, as noted in the null hypothesis.
**T-test, test for difference in mean total payoff.

Also note that by a quirk of the random number generator, the multistage game had a higher average zone of agreement than the overall average and the higher payoffs in the multistage game are partially attributable to this. Therefore, there seems no clear-cut evidence on the efficiency of the multistage procedure relative to the single-stage procedures. However, it is clearly not worse, and the "efficiency ratio" (K, Tables 1-3) is high for both the experiments.

Observation 4: No procedure confers an advantage to either the buyer or the seller. For Scarab, the average buyer payoff is nearly twice the average seller payoff under SFO, while the sharing is about equal for the other procedures. The Lion/Unicorn experiment does not show this feature, so the Scarab anomaly appears related to the peculiarities of the Scarab subjects.

Note that theoretical results exist for some of the questions addressed above. Chatterjee and Samuelson (1983), suggest that the efficiency

TABLE 6
Lion/Unicorn Experiment Asymmetric Data: Hypothesis Tests

	Null Hypothesis	*Wilcoxon Test**		*T-Test***	
		Test	*Significance*	*Test*	*Significance*
Buyer payoff	BFO> SFO	0.15	0.43	0.05	0.47
	SIM > BFO	0.68	0.24	0.70	0.24
	SIM > SFO	0.78	0.21	0.74	0.22
Seller payoff	BFO> SFO	2.66	0.00	2.67	0.00
	BFO> SIM	1.20	0.11	1.31	0.09
	SIM > SFO	1.23	0.10	1.20	0.11
Total payoff	BFO> SFO	1.98	0.02	2.78	0.00
	BFO> SIM	0.58	0.27	0.74	0.22
	SIM > SFO	1.51	0.06	1.96	0.02

*Test for stochastic dominance of one frequency distribution of payoff versus the other, as noted in the null hypothesis.
**T-test, test for difference in mean total payoff.

question must be resolved on a case-by-case basis. We found no evidence to contradict this, except for the apparent inferiority of the simultaneous offers procedures. Chatterjee and Samuelson also claim that the expected profit of the seller decreases as the procedure moves toward BFO from SFO, at least where the reservation prices have identical uniform distributions. This conclusion is not borne out by the Scarab experiment.

Observation 5: SFO is the most efficient procedure for the asymmetric game. SFO has an 85% frequency of agreement compared with 54% and 64% for BFO and simultaneous offers respectively (Table 3). The hypotheses that BFO and simultaneous offers yield higher payoffs than SFO are rejected at the .024 and the .065 levels, respectively (Table 6).

Observation 6: SFO is the best procedure for the *buyer* as well as the seller, although the difference between buyer and seller expected payoffs is not significant (Table 6).

Observation 7: The seller's information gives a clear advantage to the seller resulting in two-thirds or more of the total payoff in every case. The asymmetric case clearly favors the player with the information (Table 3).

Observations 5-7 provide partial support, at best, for Samuelson's (1981) proposition on the optimality of these procedures.

CONCLUSIONS/IMPLICATIONS

The results presented here have several implications. By far the most compelling is the need to test, experimentally, theoretical results in bargaining. These experiments are not overly difficult to arrange and provide a way to evaluate the results of theoretical investigations, both normative and positive. The normative theory of bargaining must subsume human behavior under bargaining situations in its development of optimal strategies; positive theories have the ability to be tested empirically.

More specifically, the observations made here suggest several further investigations:

(1) The conditions for inferiority of simultaneous offers to BFO and SFO should be established theoretically.

(2) Theoretical positive work should relate frequency of agreement to the bargaining scenario. Such work should predict agreement frequencies for multistage procedures and relate such predictions to stage costs.

(3) The superiority of SFO in the asymmetric case suggests that a monetary value could be placed on the higher level of information. The computation of such a value, perhaps akin to the familiar "expected value of sample (perfect) information" in decision analysis, could be a welcome piece of research.

(4) These experiments did not relate structured bargaining models to free-format bargaining. Future work should examine the relationship between bargainers' reservation prices and final outcomes. Such a relationship would make it possible to test, for example, Myerson's results on the informed principal and on two-person cooperative games with incomplete information, especially relevant for the asymmetric game described here (Myerson, 1982).

(5) Most of the theoretical results assume risk-neutral bargainers. This may not be the case, and the role of risk aversion (risk proneness) in bargaining situations could be investigated both empirically and theoretically. This would extend the partial analysis in Chatterjee and Samuelson (1983) that suggests that the less risk-averse player would be at an advantage, and that risk averters would tend to make offers closer to their reservation prices. (Similar results have been obtained on risk aversion in the axiomatic bargaining literature (see Kihlstrom et al., 1981).

(6) An experimental study of this nature is always subject to the question of participant seriousness and rule comprehension. Further experiments could replicate these results, perhaps with nonstudent groups (purchasing agents, e.g., who are professional bargainers) to test the issue of negotiation-experience. Participants might be asked to risk all or part of their participation fee in future experiments to encourage seriousness as well as to clarify the role of risk aversion noted in (5) above.

(7) Finally, this experiment, and most of existing theory, deals with bargaining on a single issue. Both theoretical and empirical work would be welcome in the more realistic situations where the item under negotiation has a bundle of terms (price, delivery, time, minimum purchase amounts, length of contract, etc.).

In conclusion, the results presented here are exploratory, not definitive. They raise questions with some existing theory in the area of distributive bargaining and suggest directions for both theoretical and empirical future research. We hope that this investigation helps, in some small way, to provide direction for future research in this area, leading to a better understanding of bargaining procedures and efficient strategies for the bargainers among us, professionals and amateurs alike.

APPENDIX

PARTIAL INSTRUCTIONS FOR THE LION DOMESTIC PRODUCTS EXPERIMENT

You will be participating in sixteen negotiating sessions; in eight as a Lion director and in eight as a Unicorn director. Your negotiating counterpart will be randomly assigned from the other members of the class.

In each negotiating session you will be given confidential information that you are not to show to your counterpart. (You may reveal it through an offer if you like.) As a Lion director, this private information will be an estimate of how much it will cost you to produce one unit of polyultralene if you were to make it yourself. We call this number b. As a Unicorn director, you will be told the cost of producing one unit of PUL, denoted by s. These cost figures cover all direct costs and appropriate allowances for fixed costs and (in Unicorn's case) for future investment programs.

Recently published estimates by industry security analysts have suggested that Unicorn's unit cost (s) is equally likely to be any value between $200 and $300, and that Lion, which has not engaged in prior manufacture of this good, can make it at a cost (b) equally likely to be anywhere between $250 and $350. For example, the probability that Unicorn's cost lies between $200 and $225 is the same as the probability that it lies between $250 and $275. Lion's cost b lies with equal probability in the intervals $300 to $315 and $320 to $335. Note that the actual value of b or s in any given game is *not* publicly known.

Note also that except in a few sessions we shall assume that the cost estimates b and s are independent. That is, knowledge of the actual value of s would *not* change b and vice-versa.

Payoffs. Suppose that the price you negotiate is p. Then, if you are a Lion director, your payoff will be $(b-p). If you are a Unicorn director, your payoff will be $(p-s). If you fail to negotiate an agreement, your payoffs are zero (0) for both Lion and Unicorn directors.

Example. Suppose b = $340, s = $266, and p = $300.

Lion's payoff is———?

Unicorn's payoff is ———?

DESCRIPTION OF THE GAMES

Game 1

You will participate twice, once as a Lion Director and once as a Unicorn Director.

Lion writes down an offer that is conveyed to Unicorn. Unicorn chooses either to accept or to reject the offer. If the offer is accepted, the negotiated price p is equal to that offer. If it is rejected both players get payoffs of 0.

Samples

Lion:	(b = $329)	Offer = $275
Unicorn:	(s = $281)	Reject

Payoffs: 0 for Lion, 0 for Unicorn.

Note: Unicorn will never accept an offer less than 's' (which is $281 in this example).

Lion:	(b = $329)	Offer = $319
Unicorn:	(s = $281)	Accept

Payoffs: Lion ($329-$319) = $10
Unicorn ($319-$281) = $38

Note: that it is *never* to Unicorn's advantage to reject an offer above 's' ($281 in this example). In this game (as well as games 2 and 4) the outcome is predetermined once an offer is made, so you will not be playing against an actual (physical) opponent.

Game 2

Once again you will participate twice, once as Lion and once as Unicorn.

Unicorn writes down a demand that is conveyed to Lion, which then decides whether to accept or reject it.

Sample

Unicorn:	(s = $298)	Offer = $300
Lion:	(b = $302)	Accept

Payoffs: $2 for both

Note: Lion will never reject anything below b.

Game 3

You will participate once in each role.

In this game, Lion and Unicorn write down offers simultaneously. If Lion's offer is greater than Unicorn's, an agreement is reached at a price halfway between the two offers. If not, there is no agreement.

Samples

Lion:	(b = $345)	Offer = $247
Unicorn:	(s = $260)	Offer = $343

Payoffs: 0 to both

Lion:	(b = $345)	Offer = $340
Unicorn:	(s = $260)	Offer = $323

Payoffs: Lion, $\$\left[\$345 - \frac{\$340 + \$323}{2}\right] = \$14.50$

Unicorn, $\$\left[\frac{340 + 323}{2} - 260\right] = \$71.50$

Games 4, 5, and 6

Game 4 corresponds exactly to Game 1, Game 5 to Game 2, and Game 6 to Game 3, except for one important difference. In these games, Unicorn has the right information on the cost. Lion knows that its unit cost will be 1.25 times Unicorn's cost, but of course it does not know Unicorn's cost. In other words, b = 1.25s. Note: If you are a Lion director you will not discover your payoff immediately. Moreover, your payoff could be negative.

Sample (Game 4)

Lion: Offer = \$290
Unicorn: (s = \$220) Accept

Payoffs: Lion: (\$220) (1.25) – \$290 = – \$15
Unicorn: \$290 – \$200 = \$70

Sample (Game 5)

Unicorn: (s = \$220) Offer = \$230
Lion: Accept

Payoffs: Lion: (\$220) (1.25) – \$230 = \$45
Unicorn: \$230 – \$220 = \$10

Sample (Game 6)

Lion: Offer = \$312
Unicorn: (s = \$250) Offer = \$300

Payoffs: Lion: $(\$250)(1.25) - \frac{\$312 + 300}{2} = \$312.50 - 306 = \$6.50$

Unicorn: $\frac{(\$312 + \$300)}{2} - \$250 = \$56$

Note: In Games 4, 5, and 6 the value of s still lies between \$200 and \$300, although the value of b now lies between \$250 and \$375.

Game 7

Once again, you will play each role once.

Games 1-6 were all single-stage exercises. Game 7 allows you to make offers and counteroffers in a closer simulation of actual bargaining.

Lion and Unicorn write down offers simultaneously and exchange them. If Lion's offer is greater than Unicorn's, there is an agreement and the agreed price lies midway between the two offers (as before). If this is not the case in the first stage, either side can choose to break off completely. If neither decides to break off, another set of offers is exchanged. Note: In this game there is a cost associated with negotiating ($1 per negotiation stage).

Sample 1

Stage	Lion's Offer (b = $312)	Unicorn's Offer (s = $280)
1	$200	$350
2	$250	$300
3	$275	$295
4	$275	$290
5	$275	$290
6	$280	$287
7	$284	$284

Payoffs: Lion $312 – $284 – (number of stages) ($1) = $28 – 7 = $21

Unicorn $284 – $280 – (number of stages) ($1) = $4 – $7 = $3

Sample 2

Stage	Lion's Offer (b = $312)	Unicorn's Offer (s = $280)
1	$256	$305
2	$304	$290

Payoffs: Lion $\$312 - \frac{(\$304 + \$290)}{2}$ – (number of stages) ($1) = $312 – $297 – 2 = $13

Unicorn $\frac{\$304 + \$290}{2} - \$280 - 2 = \$15$

Sample 3

Stage	Lion's Offer (b = $312)	Unicorn's Offer (s = $280)
1	$206	$340
2	$208	$330

Stage	Lion's Offer	Unicorn's Offer
3	$208	$320
		decides to break off (by not submitting offer to experiment)

Payoffs: Lion 0 – (3) ($1) = – $3
Unicorn 0 – (3) ($1) = – $3

Note: You will have to pay the stage costs irrespective of whether there is agreement or not.

Game 8

This game is completely unstructured except for the values of b and s. You are to negotiate a price p with a counterpart, and your payoff will be $ (b – p) if you are a Lion director and $ (p – s) if you are a Unicorn director.

PLEASE READ THE INSTRUCTIONS THOROUGHLY AND IF HAVE ANY QUESTIONS ABOUT ANY OF THE PROCEDURES, PLEASE ASK THEM BEFORE THE NEGOTIATIONS START.

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