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TWO-PERSON SEQUENTIAL BARGAINING BEHAVIOR WITH EXOGENOUS BREAKDOWN

ABSTRACT. We examine bargaining behavior in a noncooperative game in which players alternate in making and responding to proposals over the division of a given surplus. Although the number of bargaining periods is unlimited and time is not discounted, the bargaining is subject to exogenous breakdown at each period with a fixed probability which is common knowledge. We manipulate three probabilities of breakdown in a between-subjects design that allows comparison with previous studies of two-person bargaining with time discounting. Assuming that subjects maximize expected utility, and this utility is measured by monetary payoffs, our results reject both the subgame perfect equilibrium and equal split solutions. Data analyses reveal that a substantial percentage of subjects behave adaptively in that they systematically search for the highest acceptable demands.

Keywords: Two-person sequential bargaining problem, complete information, exogenous risk of breakdown, experimental economics.

INTRODUCTION

Several factors have been recognized to drive the parties in a bargaining process to reach an agreement rather than insist indefinitely on incompatible demands. One such factor is the impatience of the parties to enjoy the fruits of agreement. This impatience can be interpreted as the 'cost' of bargaining. As Cross has observed,

> . . . the passage of time has a cost in terms of both dollars and the sacrifice of utility which stems from the postponement of consumption, . . . it is precisely this cost which motivates the whole bargaining process. If it did not matter when the parties agreed, it would not matter whether or not they agreed at all. (1969, p. 13).

A second factor is the parties' fear that by prolonging the negotiations they may lose the opportunity to reach any agreement because of exogenous breakdown. For example, members of a marketing channel may bargain over the gains from some opportunity that they cannot exploit individually, but their bargaining may break down if a third party exploits this opportunity. In other situations breakdown may be

Theory and Decision **32**: 241–268, 1992.

caused by natural catastrophes, institution of new laws or regulations, abrupt changes in the political structure, introduction of new technology, and so on.

Both factors can be modeled by adopting a strategic (noncooperative) approach to the bargaining problem. The approach we use owes much to the seminal paper by Rubinstein (1982), who modeled a special class of two-person bargaining as a game in extensive form with alternating offers, complete information, infinite horizon, and time discounting. He then showed that there exists a unique pair of bargaining strategies that constitute a subgame perfect equilibrium (SPE). Because our experimental paradigm is based on the Rubinstein's game, we consider it below in some detail.

A Strategic Model of Two-Person Bargaining

Two players (bargainers) I and II alternate making offers concerning how to divide some amount k (of money). Time is divided into periods. In even numbered periods t (starting at an initial period $t = 0$) I may propose to II any division $(x, k - x)$ of the money. If II accepts this proposed allocation the game ends with I receiving x and II receiving $k - x$. If II rejects I's offer, and if t is not the final period of the game, then the game proceeds to period $t + 1$, and the roles of the two players are reversed. If an offer made in the last period of the game is rejected, then the game ends with each player receiving zero payoff.

The preference relations of the players are defined on the set of ordered pairs of the type (y_i, t), where $0 \leq y_i \leq k$ $(i = 1, 2)$, and t is a non-negative integer. The pair (y_i, t) is interpreted as 'player i receives y_i at time t'. A novel feature of the two-person sequential bargaining game is that the preferences of the two players are (possibly different) functions of time. Rubinstein's imposed mild conditions on the players' preference, which include strict monotonicity, continuity, stationarity, and the larger his/her share the more 'compensation' a player requires in order for a delay of one period to be immaterial to him/her. The preference relations of both players are assumed to be common knowledge.

This characterization of the bargaining process gives rise to a game in extensive form with perfect information. Since any allocation of the amount ('pie') k can be supported as a Nash equilibrium, Rubinstein resorted to the SPE concept (Selten, 1975) as a decision rule.

The conditions imposed on the preference relations allow for several families of functions. Two families have received special attention by Rubinstein:

1. *Fixed bargaining cost*: Player i's preference is derived from the function $y_i - tc_i$, i.e., each player i bears a fixed cost c_i per period.

2. *Fixed discounting factor*: Player i's preference is derived from the function $y_i \delta_i^t$, i.e. each player i has a fixed discount factor δ_i $(0 < \delta_i < 1)$.

The (unique) SPE solution has the following structure:

Fixed bargaining cost. Agreement is reached on period $t = 0$. If $c_1 > c_2$, I receives c_2. If $c_1 < c_2$, I receives the entire amount k. If $c_1 = c_2$, any partition of the pie yielding I at least c_1 is supported by SPE.

Fixed discount factor. There is a unique SPE, which dictates that agreement should be reached immediately ($t = 0$) with I requiring and receiving the fraction

$$(1 - \delta_2)/(1 - \delta_2 \delta_1)$$

of the pie.

The two factors δ_1 and δ_2 have been interpreted as cost of delay. Alternatively, when I and II are expected utility maximizers, $1 - \delta_1$ and $1 - \delta_2$ may be interpreted as the subjective probabilities of I and II, respectively, that the negotiation on period t will be terminated by an exogenous force before period $t + 1$ commences. It is this alternative interpretation of the discount factors that drives the present study.

Major Goals

Previous experimental studies designed to assess the effects of the parameters incorporated in the two-person sequential bargaining procedure described above, have tested the predictive power of the SPE solution, and proposed alternative solutions to account for the regularities in the data (Güth *et al.* 1982; Binmore *et al.* 1985, 1989; Güth and Tietz, 1986a, 1986b; Neelin *et al.* 1988; Binmore *et al.* 1989; Harrison and McCabe, 1989; Ochs and Roth, 1989; Rapoport *et al.* 1990; Weg *et al.* 1990; Bolton, in press; and Weg and Zwick, in press). For partial reviews and critical surveys of this rapidly growing literature, see Roth (1988) and Ochs and Roth (1989). We do not intend to add to these reviews, only to mention and discuss several issues in order to highlight the distinctive features of the present study.

Except for the studies by Rapoport *et al.* (1990), Weg *et al.* (1990), and Weg and Zwick (in press), all previous studies have focused on two-person bargaining with a finite and rather small ($t \leq 5$) horizon (Ståhl, 1972). Additionally, in all previous studies that investigated the fixed discount factor case the parameters δ_1 and δ_2 were implemented as the cost of delay for I and II, respectively. Like the three previous studies by Rapoport *et al.*, Weg *et al.*, and Weg and Zwick, the present study simulates an infinite time horizon. However, the factor $1 - \delta_i$ is implemented as the probability of exogeneous breakdown, not the cost of delay.

Shrinkage of the pie or equal probability of breakdown in the negotiations may be attended to differently by real subjects. In the former case, on each round of bargaining the players have to split a pie of a different size. In contrast, when the probability of breakdown is fixed, the players have to consider only a single number, namely $1 - \delta$. If, for example, players are concerned with an *absolute* payoff rather than some *proportion* of the pie, the two alternative implementations of the discount factor may yield different patterns of behavior. Thus, our first purpose in this paper is to compare to each other these two implementations. For this purpose, we have chosen probabilities of breakdown which correspond to the values of the (common) discount factors used by Weg *et al.* (1990) and Binmore *et al.* (1989).

The implementation used in the present study overcomes a methodological shortcoming of three previous studies with infinite time horizon. Because infinite time horizon games cannot be directly implemented in a laboratory environment (Roth, 1989), Rapoport *et al.* (1990), Weg *et al.* (1990), and Weg and Zwick (in press), had to terminate the bargaining when it got 'too long'. Their subjects had to be instructed that the bargaining game would be terminated if it lasted 'for too many trials'. Although very few games were terminated prematurely, the possibility that the subjects' behavior was influenced by these instructions could not be ruled out. Technically, the subjects in the three aforementioned studies played a two-person bargaining game with a small but unknown probability of exogenous breakdown. Rubinstein's result does not apply to this case. Only when the discount factors are implemented as probabilities of exogenous breakdown does the conduct of a genuine infinite time horizon game become possible.

Previous research on sequential bargaining has raised the fairness vs. strategic behavior debate. Güth *et al.* (1982), Güth and Tietz (1986a, 1986b), Ochs and Roth (1989), and Weg *et al.* (1990) have all concluded that at least some players may incorporate distributional concerns in their utility functions, and that models invoking the notion of equity account for a high percentage of the agreements between the two players. In contrast, Binmore *et al.* (1985, 1989), Rapoport *et al.* (1990), and Weg and Zwick (in press), presented evidence that equity considerations are only constraints on profit seeking based on strategic account (see also Kahneman *et al.* 1986). The second purpose of the present paper is to contribute to this debate in another context where bargaining is subjected to the fixed probability of exogenous breakdown.

Finally, the present paper is also concerned with the effects of experience on performance. Binmore *et al.* (1985), Harrison and McCabe (1989), and Rapoport *et al.* (1990) have all concluded that experience with the task makes players realize their strategic advantage and learn how to exploit it. In contrast, Neelin *et al.* (1988) and Weg *et al.* (1990) found no learning effects. While there is a common economic argument that people will learn to act rationally, otherwise they will be wiped out of the market, this argument has been qualified by Einhorn and Hogarth (1981) and Thaler (1986), who pointed out that learning takes place only when the individual receives timely and organized feedback about his/her performance. The third purpose of the present study, then, is to investigate the effects of experience on bargaining behavior. This purpose, of course, requires individual level analyses. Harrison and McCabe (1989) claim that only when subjects receive experience in the subgame does their behavior converge to the predictions of the game theoretic model. When discounting is due to the exogenous risk of breakdown, every subgame is identical to the game that includes it. Therefore, Harrison and McCabe's condition for learning is satisfied in the present study.

METHOD

Subjects

Fifty-four male and female students from Penn State University, most of them undergraduates, participated in the study. Subjects were recruited through a classified advertisement placed in the campus newspaper promising monetary reward contingent on performance in a bargaining game.

Experimental Design

The subjects participated in groups of six in a single experimental session that lasted approximately 90 minutes. The mean payoff per subject was \$15.00. Each session consisted of 24 bargaining games to assess the role of experience. For each game, the six subjects were partitioned into three dyads whose members bargained with each other over how to divide a fixed sum ('pie') of \$30.

Three probabilities of random termination were used in a between-subjects design, thus defining three experimental conditions: 1/10, 1/3, and 5/6. We chose these probabilities to allow comparison with previous studies. A discount factor of 9/10 was used by Binmore *et al.* (1989) in a control group, and discount factors of 2/3 and 1/6 were used by Weg *et al.* (1990). These discount factors correspond to probability of termination of 1/10, 1/3, and 5/6, respectively.

Procedure

At the beginning of each game I proposed an allocation ($\$x$, $\$k - x$). II responded by accepting I's proposal, in which case both players were credited with the agreed amounts and the game ended, or by rejecting it and writing down (but not submitting) a counter-proposal. This procedure prevents subjects from rejecting a demand before considering what counterdemands are available to them. If II rejected I's proposal, a wheel of chance was spun to determine whether the game would continue. The numerical probability of termination was common knowledge, and remained constant during the entire session. If the wheel of chance terminated the game, no reward for the game was given. If it did not, II submitted his or her counter-proposal to I. I responded by either accepting II's proposal, in which case both players were credited with the agreed amounts, or rejecting it and writing down a counter-proposal. Rejection activated the wheel of fortune. This process continued until either an agreement was reached or the game was terminated by the wheel of chance.

Upon arrival at the laboratory, each of the six subjects was randomly assigned to either the left or right side of a large room. Subjects read the game instructions (see Appendix) and raised questions on the conduct of the game, if they had any.

The experimenter then read aloud instructions for a practice game that explained the structure of the game in detail. Subjects played this practice game and then adjourned to their respective cubicles in another room. The cubicles did not allow the subjects to identify the other players.

Dyad composition was varied systematically from game to game so that each of the three players in one side of the room played each of the three players on the other side of the room exactly eight times in random order and never played any other player in two consecutive games.

Each player assumed the role of I in 12 games and II in 12 other games presented in an alternating order. Players were asked to write down their share of the agreement (zero, if the game was exogenously terminated) at the end of each game. This helped them to keep a record of their previous earnings.

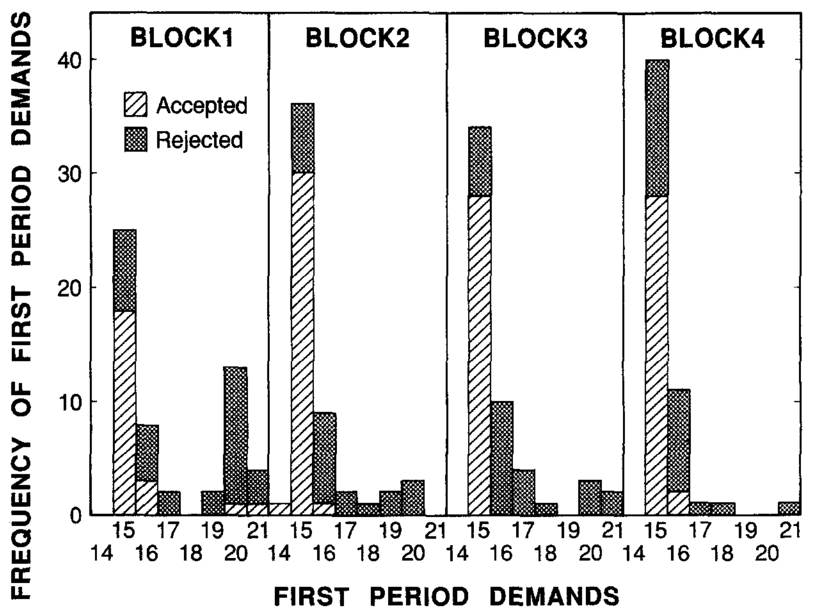
All the proposed allocations were submitted in writing on a 'message form' that required the subject to (1) accept or reject a previous proposal, (2) specify his/her share, and (3) specify the share of his/her partner. No other communication between dyad members was allowed.

To motivate subjects to bargain seriously, subjects were instructed that at the end of the session, 3 of the 24 games would be chosen randomly, and that their payoff would equal the mean of their individual payoffs on these 3 games.

RESULTS

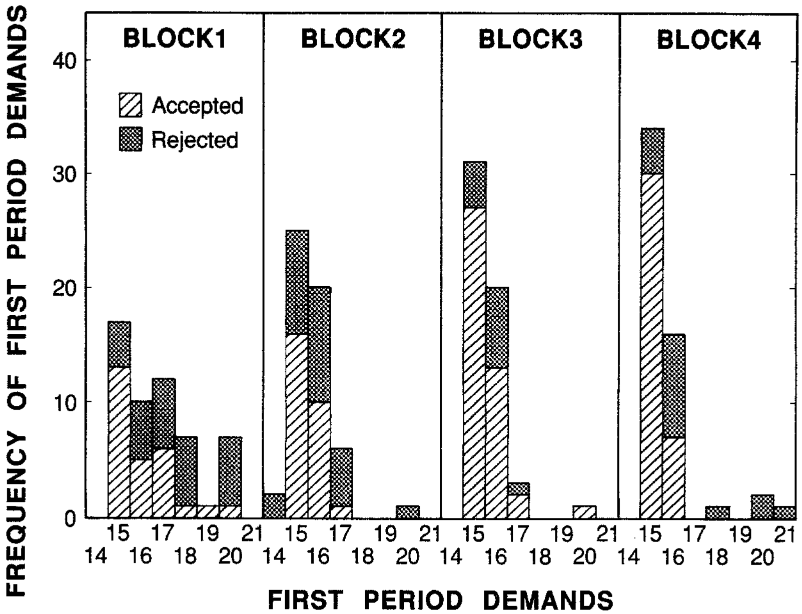
First Period Demands

The effect of experience on bargaining behavior was investigated by dividing the 24 games in each session into four blocks of six games each. Figures 1A through 1C display the frequency distributions of first-period demands for Conditions 1/10, 1/3, and 5/6, respectively. The three figures differentiate between first period demands that were immediately accepted by II and those that were rejected. The means of the demands that were either accepted (A) or rejected (R) on the first

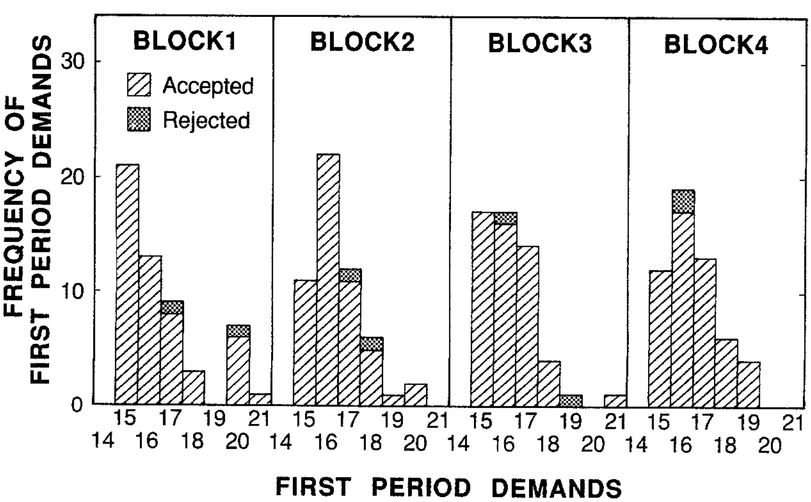


(A)

Fig. 1. (A) Frequency distribution of first period demands in condition 1/10. (B) Frequency distribution of first period demands in condition 1/3. (C) Frequency distribution of first period demands in condition 5/6.


FREQUENCY OF FIRST PERIOD DEMANDS
BLOCK1
BLOCK2
BLOCK3
BLOCK4
Accepted
Rejected
0
10
20
30
40
14 15 16 17 18 19 20 21
FIRST PERIOD DEMANDS

(B)


FREQUENCY OF FIRST PERIOD DEMANDS
BLOCK1
BLOCK2
BLOCK3
BLOCK4
Accepted
Rejected
0
10
20
30
14 15 16 17 18 19 20 21
FIRST PERIOD DEMANDS

(C)

TABLE I

Mean first period demands by condition and block.

Condition		Block 1		2		3		4		Overall	
		Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
	A	15.00	17	14.83	30	15.03	28	15.07	30	14.98	105
1/10	R	18.74	37	16.64	24	17.73	26	16.25	24	17.47	111
	A11	17.57	54	15.63	54	16.23	54	15.59	54	16.26	216
	A	15.32	14	15.40	24	15.20	31	15.20	32	15.27	101
1/3	R	17.26	40	15.97	30	16.12	23	16.88	22	16.22	115
	A11	16.76	54	15.71	54	15.59	54	15.89	54	15.99	216
	A	15.80	41	16.12	37	16.06	43	16.34	41	16.08	162
5/6	R	19.00	13	17.18	17	17.36	11	16.88	13	17.58	54
	A11	16.57	54	16.45	54	16.32	54	16.47	54	16.46	216

A = First period demand was accepted.
R = First period demand was rejected.

period are presented in Table I together with the associated frequencies. The results are presented by condition and block.

The SPE solution predicts that agreement will be reached on the first period with I demanding and getting 15.79, 18.00, and 25.71 in Conditions 1/10, 1/3, and 5/6, respectively. The equal split model predicts a 15–15 split. The overall means of the first period demands (Table I) are 16.26, 15.99, and 16.46 for Conditions 1/10, 1/3, and 5/6, respectively. These means differ significantly from the predicted share of the equal split model ($t(17) = 4.85$, $p < 0.001$, $t(17) = 6.52$, $p < 0.001$, and $t(17) = 6.94$, $p < 0.001$, for Conditions 1/10, 1/3, and 5/6, respectively; two-tailed test), and the SPE model ($t(17) = 1.80$, $p > 0.08$, $t(17) = -13.27$, $p < 0.001$, and $t(17) = 44.09$, $p < 0.001$; two-tailed test). The only exception is in the test of the SPE model in Condition 1/10.

All 648 first period demands (accepted and rejected) were subjected to a condition-by-block multivariate analysis of variance (MANOVA) with block as a repeated measure. The condition-by-block interaction was found to be significant ($F(6, 98) = 2.19$, $p < 0.05$) as was the main effect of block ($F(3, 49) = 5.41$, $p < 0.002$). The main effect due to condition (predicted by the SPE model) was not significant ($F(2, 51) = 1.23$, $p > 0.3$).

Table I shows that the block-by-condition interaction is due to different trends of learning in the three conditions. To further study these learning trends, we conducted three additional MANOVA tests on the mean first period demands in each condition separately. In Conditions 1/10 and 1/3, where the probability of termination is relatively low, blocks 1 and 4 were found to be significantly different from each other ($F(1, 17) = 12.05$, $p < 0.002$, and $F(1, 17) = 4.10$, $p < 0.05$, respectively). As shown in Table I, the mean first period demand in block 4 is smaller than the corresponding mean in block 1 in both of these conditions. In both conditions experience tends to lower the first period demands in the direction of equal split. Blocks 1 and 4 were not significantly different from each other in Condition 5/6 ($F(1, 17) < 1$).

Despite the failure of the equal split model to account for the mean first period demands, Figures 1A and 1B show that the almost equal split first period demands, and first period agreements ($14.5 \leqslant x \leqslant 15.5$) are the most frequent in Conditions 1/10 and 1/3. Furthermore, the frequency of almost equal split increases with experience from block 1 to block 4, due to reduction in the between-subject variability attributable to learning.

Table I shows that a major reason for the failure of the SPE solution is that subjects rejected offers that, according to the SPE model, should have been accepted had the utilities of the subjects been based solely on monetary payoffs. Indeed, even though I had a strategic advantage in the first period, exploitation of this advantage was in most cases unprofitable. Figure 2 portrays the relationship between I's cumulative earnings (vertical axis) and his/her mean first period demand (horizontal axis). The correlation between these two measures is -0.45, -0.57, and -0.14 for Conditions 1/10, 1/3, and 5/6, respectively (all correlations are significantly different from zero at the 0.05 level). Figure 2 shows that in Conditions 1/10 and 1/3, but not in Condition 5/6, the highest cumulative gain was achieved by a subject with a relatively low first period demand. In both of these conditions, the subjects who had the highest demands on the first round earned less than the mean earning for the condition. Ochs and Roth (1989) reported very similar results.

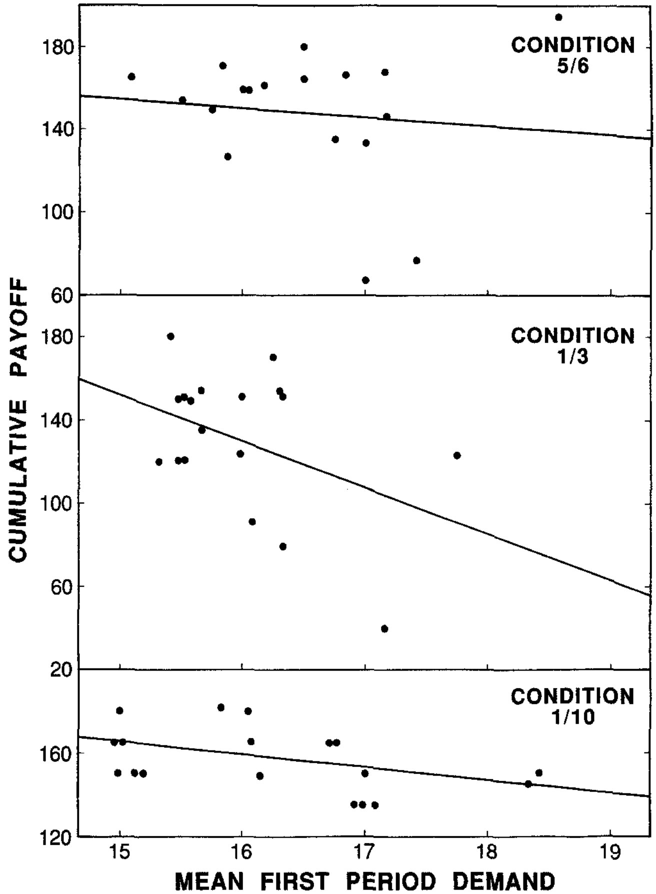


Fig. 2. Cumulative earnings versus mean first period demand.

Agreements

By scoring first periods that terminated in agreement as 1, and first periods that terminated in rejections by 0, and submitting the score frequencies to MANOVA, we tested the effects of block and condition, and found that both main effects were significant ($F(2, 52) = 24.16$, $p < 0.001$, and $F(3, 52) = 5.74$, $p < 0.01$, for condition and block, respectively). The condition-by-block interaction was not significant ($F(6, 50) = 1.87$, $p > 0.1$). Scheffe's test reveals that the condition main effect is due to a significant difference between Condition 5/6 and the other two conditions. Whereas the percentage of first period demands that were accepted was 75 in Condition 5/6, the corresponding percentages in Conditions 1/10 and 1/3 dropped to 48.61 and 46.76, respectively. Table I also shows that, when averaged across conditions, the percentage of first periods ending with an agreement increased monotonically over blocks.

Only 368 of the 648 demands made on the first period were accepted (Table I). In deriving the prediction that the first period demand will be accepted instantaneously, the SPE model assumes that rationality is common knowledge. In reality, a rational player may reasonably doubt the rationality of his or her opponent. Delaying agreement might then be worthwhile in that it provides an opportunity to learn whether the opponent is exploitable especially if the risk of breakdown is not too high (Binmore *et al.*, 1989). Note that even when an agreement is not immediate, the SPE solution provides a prediction for future play provided that no breakdown has occurred. Due to the structure of the game, where the probability of exogenous breakdown is constant, the predicted allocation on each period is the same.

In addition to the 368 demands that were accepted on the first period, 142 more demands were accepted on later periods. Table II presents mean accepted final demands and frequency distributions of agreements by condition and block. These means are very close to the

TABLE II

Mean accepted final demands and frequency distributions of agreements by condition and block.

	Condition					
	1/10		1/3		5/6	
BLOCK	Mean	*N*	Mean	*N*	Mean	*N*
1	15.07	43	15.33	29	15.79	43
2	14.94	48	15.27	42	16.09	38
3	15.04	46	15.20	39	16.15	44
4	15.08	51	15.19	45	16.31	42
ALL	15.03	188	15.24	155	16.08	167

means of the first period demands that were immediately accepted (Table I). Note that the identity of the subject making the demand that was eventually accepted is not under experimental control. As a result, not all subjects made at least one demand that was eventually accepted. In order to take advantage of the orthogonal properties of the experimental design in the analysis below, we planted the mean of the accepted demands for a given block-by-condition combination whenever no data existed for a specific subject (see Rapoport *et al.*, 1990). This happened only three times.

Statistical analyses yielded essentially the same results as in the case of first period demands. The mean final shares differed significantly from the SPE predictions in all three conditions ($t(17) = -23.3$, $p < 0.001$; $t(17) = -58.3$, $p < 0.001$; and $t(17) = -108.0$, $p < 0.001$, for Conditions 1/10, 1/3, and 5/6, respectively). They also differed significantly from the predictions of the equal split model in Conditions 1/3 ($t(17) = 5.0$, $p < 0.001$), and 5/6 ($t(17) = 12.2$, $p < 0.001$), but not in Condition 1/10 ($t(17) = 1$, $p > 0.05$). In all conditions, the actual means were closer to the equal split model than to the SPE model.

The accepted demands of all 510 games, which ended in agreement, were also subjected to a condition-by-block MANOVA (with block as a repeated measure). Neither the condition-by-block interaction effect nor the block main effect were significant ($F(6, 98) = 1.55$, $p > 0.1$; $F(3, 49) < 1$, respectively). However, the condition effect was significant ($F(2, 49) = 86.8$, $p < 0.001$). Scheffe's test shows that Condition 5/6 differed significantly from Conditions 1/10 and 1/3, but that the latter two conditions did not differ significantly from each other.

Comparison with Previous Studies

Table III presents the mean percentage of the pie demanded on the first period and the mean percentage of the pie eventually received by the player who had made the final accepted demand by experiment. Recall that Conditions 1/10 through 5/6 correspond to previous studies conducted by Binmore *et al.* (1989) and Weg *et al.* (1990). The similarity in the findings for Conditions 1/10 and 1/3 is remarkable. The only difference is in Condition 5/6. In the present study subjects in this condition demanded on the average less than the subjects in

TABLE III

Mean percentage of the pie demanded on the first period and mean percentage of the pie received by the player who had made the final accepted demand.

	Condition					
	1/10		1/3		5/6	
Period	Binmore *et al.* (Control Group)	Present Study	Weg *et al.* (Exp. 1)	Present Study	Weg *et al.* (Exp. 2)	Present Study
First	55.3	54.2	52.02	53.30	57.33	54.84
Final	50.2	50.1	51.22	50.82	54.77	53.61

Experiment 2 of Weg *et al.* and granted a smaller share of the pie in the final agreement.

Adaptive Behavior

In investigating individual differences we followed Ochs and Roth (1989), who divided their subjects into three groups in terms of their first period demands. The first group (21% of the sample) included players who never demanded more than 50% of the pie on the first period. The second group (36.8% of the sample) consisted of subjects for whom the first period demand on game 1 was not the maximum of all the first period demands ever made by the subject and the first period demand on game $g + 1$ was never smaller than the one made on game g, unless the latter was rejected. The third group (18.4% of the entire sample) included subjects who demanded more than 50% of the pie on the first period of game 1, and this demand was the maximum of all first period demands that the subjects made. Ochs and Roth remarked that the bargaining behavior in group one had no learning component to it, whereas the behavior of subjects in the second group indicated cautious search for the highest acceptable demand, and the behavior of subjects in the third group suggested exploitation of 'first mover' advantage. Because type-two and type-three behavior was exhibited in the same experimental condition, the aggregate data 'mask the volume of adaptive behavior which was exhibited by a substantial portion of the subjects in our experiment' (1989, p. 374).

Following Ochs and Roth, we examined the first period demand made by I on game g (denoted by $d(g)$) as a funtion of his/her first period demand on game $g-2$ (denoted by $d(g-2)$) and II's response (demand either accepted or rejected). The individual frequencies are presented in Table IV, one part for each condition. Note that each player assumed the role of I (and made the first period demand) on 12 alternating games. Note, too, that because $d(g)$ depends on $d(g-2)$, we had to delete Games 1 and 2 from the analysis and start it on Game 3.

Table IV shows that eight subjects (Subjects 1, 4, 11, and 18 in Condition 1/10; Subjects 6 and 12 in Condition 1/3; and Subjects 4 and 8 in Condition 5/6) ignored II's response to their first period demand in game $g-2$ and continued to demand the same amount on at least 9 out of a total of 11 games. In all eight cases (except Subject 12 in Condition 1/3) the first period demand was for 50% of the pie. Clearly, subjects in this group invoked rigidly the norm of equity regardless of II's response to their demand. Subject 12 in Condition 1/3 demanded \$16 on seven games and \$17 on three more games disregarding II's response on game $g-2$. None of these eight subjects showed any evidence of learning from experience.

Characterizing adaptive behavior on the part of I as a search for the highest acceptable demand, we define it by the conjunction of the following three conditions:

$$d(g) \geqslant d(g-2), \text{ if } d(g-2) \text{ was immediately accepted,}$$

$$d(g) \leqslant d(g-2), \text{ if } d(g-2) \text{ was immediately rejected,}$$

$$d(g) \neq d(g-2) \text{ in two games or more.}$$

We regard the highest acceptable demand as an individual index, not unlike level of aspiration, that may fluctuate during the session due to the experience gained by the subject when playing role II. Additionally, the knowledge that their opponents may change from one game to another may cause some subjects to violate one or more of the conditions above on some of the games.

We tested the 'adaptive behavior' hypothesis against an alternative 'random' hypothesis stipulating that $d(g) < d(g-2)$, $d(g) > d(g-2)$, or $d(g) = d(g-2)$ with equal probabilities. A violation of the adaptive

TABLE IV

Player I's first period demand on game g as a function of his/her first period demand on game $g-2$ and player II's response.

	Condition 1/10					
	$d(g) < d(g-2)$		$d(g) > d(g-2)$		$d(g) = d(g-2)$	
Player	Accept	Reject	Accept	Reject	Accept	Reject
1	0	0	0	0	11	0
2	0	3	1	1	6	0
3	0	3	0	1	7	0
4	0	0	0	0	9	2
5	0	2	2	0	7	0
6	0	2	1	1	5	2
7	0	5	2	1	0	3
8	0	3	3	2	1	2
9	1	3	3	1	3	0
10	0	3	1	0	5	2
11	0	0	0	0	9	2
12	0	4	3	0	3	1
13	0	6	2	1	0	2
14	1	5	2	3	0	0
15	1	4	0	2	0	4
16	0	4	1	5	0	1
17	0	4	0	3	1	3
18	0	1	0	1	4	5
Total	3	52	21	22	71	29

	Condition 1/3					
	$d(g) < d(g-2)$		$d(g) > d(g-2)$		$d(g) = d(g-2)$	
Player	Accept	Reject	Accept	Reject	Accept	Reject
1	0	2	1	0	6	2
2	1	2	0	2	5	1
3	0	2	0	2	2	5
4	0	6	1	3	0	1
5	0	3	1	0	7	0
6	0	0	1	0	9	1
7	1	4	3	2	0	1
8	0	4	0	1	0	6
9	1	3	3	0	2	2
10	1	1	2	0	3	4
11	1	3	1	1	3	2
12	0	1	0	0	4	6
13	0	3	3	0	4	1
14	1	4	3	1	1	1
15	1	3	0	2	2	3

TABLE IV (Continued)

16	2	2	5	0	0	2
17	4	3	2	1	0	1
18	1	4	3	2	1	0
Total	14	50	29	17	49	39
	Condition 5/6					
	$d(g) < d(g-2)$		$d(g) > d(g-2)$		$d(g) = d(g-2)$	
Player	Accept	Reject	Accept	Reject	Accept	Reject
1	2	3	5	0	1	0
2	0	5	1	0	3	2
3	0	4	5	0	2	0
4	0	0	1	0	10	0
5	0	4	2	2	1	2
6	0	1	2	0	5	3
7	0	1	3	0	6	1
8	0	1	1	0	9	0
9	3	1	4	0	2	1
10	0	0	3	0	8	0
11	0	2	4	0	5	0
12	2	3	5	0	1	0
13	0	2	1	1	7	0
14	0	2	1	0	8	0
15	4	1	5	0	0	1
16	2	1	3	0	4	1
17	1	1	3	0	5	1
18	1	2	3	0	5	0
Total	15	34	52	3	82	12

behavior hypothesis is any positive entry in columns 2 and 5 of Table IV provided the sum of entries for each subject in columns 2 through 5 is two or more. Table IV shows that the number of violations in Conditions 1/10, 1/3 and 5/6 is 25, 31, and 18, respectively. However, the frequencies of violations are not distributed evenly among the subjects. Under the 'random' hypothesis, the proability of zero or one violation in 11 games is 0.07. Therefore, we identified a subject as exhibiting adaptive behavior if he/she violated the adaptive behavior hypothesis no more than once.

Of the 54 subjects who participated in the experiment, 24 (44.4%) were identified as exhibiting adaptive behavior. These were (Table IV) Subjects 2, 3, 5, 6, 7, 10, 12, and 13 in Condition 1/10; Subjects 1, 5, 8, 9, 10, and 13 in Condition 1/3; and Subjects 2, 3, 6, 7, 10, 11, 13, 14, 17, and 18 in Condition 5/6.

In our search for different patterns of behavior on the part of the player making the first demand we have identified two groups of subjects. Included in the first group are eight subjects who did not change their first period demands over games. Seven of these eight subjects disregarded the 'first mover' advantage as well as the response of II on game $g-2$ and insisted on equal split. A second and larger group includes 24 subjects, who changed their first period demand in a systematic and meaningful manner presumably in an attempt to find the highest demand that would still be acceptable to their opponents. A third group includes the remaining 22 subjects, who are responsible for almost all the violations of the 'adaptive behavior' hypothesis recorded in Table IV. An examination of the demands made by these subjects shows the same distinction between Condition 5/6 and the other two conditions that we observed before. Most of the violations in Conditions 1/10 and 1/3 were of the variety where $d(g) > d(g-2)$, although $d(g-2)$ was rejected by II (22 out of 25, and 17 out of 31 violations in Conditions 1/10 and 1/3, respectively). Presumably, subjects committing these violations were not overly impressed by the rejection of their previous first period demand because rejection in these two conditions was in most cases not followed by an exogenous breakdown of the bargaining. In contast, most of the violations in Condition 5/6 (15 out of 18) were of the variety where $d(g) < d(g-2)$, although $d(g-2)$ was accepted by II. Realization of the high probability of exogenous breakdown might have caused subjects in this condition to lower their first period demands.

Counterdemands

Another implication of the SPE model – one whose reasonability is difficult to question – is that a player who has rejected an allocation on period t will demand a share on period $t+1$ which is equal to or larger than the share he/she has just rejected. In other words, a player would not make a counterdemand in terms of its expected value which is disadvantageous. Ochs and Roth (1989) noted the failure of this prediction in both finite and infinite two-person sequential games with time discounting. They reported that 81% of counterdemands in their study were disadvantageous. Similar rates were found in a reanalysis of the counterdemands in the study of Binmore *et al.* (1985) (75% in Game A) and Neelin *et al.* (1988) (65% in their two experiments).

Weg *et al.* (1990) noted that the percentage of disadvantageous counterdemands depended on the condition (symmetric vs. nonsymmetric players). In the symmetric case, they reported that 66.7% of counterdemands were disadvantageous in Experiment 1 (which corresponds to Condition 1/3 in our study) and 100% in Experiment 2 (which corresponds to Condition 5/6 in our study). In the present study we had a total of 389 counterdemands of which 249 (64.0%) were disadvantageous in expected value terms. A subsequent analysis shows that the percentage of disadvantageous counderdemands depends strongly on the probability of exogenous breakdowns: 52.6%, 82.1%, and 100% in Conditions 1/10, 1/3, and 5/6, respectively. Our results correspond to those reported in earlier studies.

DISCUSSION

Two-person sequential bargaining situations with exogenous breakdown are prevalent. Ours is probably the first attempt to implement the common discount factor as a fixed probability of exogenous breakdown, rather than as cost of delay, and study the resulting game experimentally. Perhaps the major limitation of this study, and the previous experiments on two-person sequential bargaining, is the assumption of complete information. Whether exogenous breakdown may occur or not, typically two-person bargaining involves two aspects: there is a succession of steps, and the bargainers do not know the value to others of reaching an agreement. Noncooperative models of bargaining capturing these two aspects have been recently developed (e.g. Fudenberg *et al.*, 1985). Some of them yield results which are not at all intuitive. For example, neither uniqueness of the equilibrium nor decreasing offers hold in the case of two-sided uncertainty. Experimental tests of these more realistic models of two-person bargaining with incomplete information are warranted.

While restricted to the case of complete information, the present study yields several conclusions which we present and discuss below.

1. First period demands differed significantly from the demands predicted by the equal split model as well as the SPE solution (except in Condition 1/10). Similar results were obtained for the final accepted demands. As in most previous studies of two-person sequential bargaining, in all cases mean demands were closer in value to the equal split than the SPE solution.

2. First period demands were accepted in 48.6% and 46.8% of the trials in Conditions 1/10 and 1/3, respectively. In contrast, the percentage of acceptance in Condition 5/6 was 75. According to the SPE solution, first period demands should have been accepted had the utilities of the subjects been based on monetary payoffs and maximization of expected utility was the sole motive. Moreover, in contrast to the SPE solution, rejections of demands were followed instantaneously by disadvantageous counterdemands in 52.6%, 82.1%, and 100% of the cases in Conditions 1/10, 1/3, and 5/6, respectively. These results, too, replicate previous results (see Ochs and Roth, 1989).

3. Conditions 1/10 and 1/3 bear a similarity to previous tests of sequential two-person bargaining with finite horizon (typically restricting the number of periods from 2 to 5). The expected number of bargaining periods in the former condition is 10 and in the latter 3. In contrast, Condition 5/6 is more like the ultimatum game of Güth *et al.* (1982) and Güth and Tietz (1986a, 1986b). The difference among these three conditions is reflected in the results. In Conditions 1/10 and 1/3 experience with the task shifted the first period demands in the direction of equal split and away from the predicted allocations by the SPE solution. In contrast, experience with the task had no discernable effect on the first period demand in Condition 5/6. The existence of feedback in Conditions 1/10 and 1/3, but not in Condition 5/6, might have accounted in part for the difference between the results. In the former two conditions rejection of the first period demand was more often than not followed by subsequent demands that typically did not result in more favorable outcomes to II. In contrast, rejection of the first demand in Condition 5/6 was almost always followed immediately by the termination of the game.

4. Analyses of individual data show distinctly different patterns of game-to-game changes in the first period demands. Approximately 15% of the subjects exhibited bargaining behavior that has no apparent learning component to it. Approximately 44% of the subjects

exhibited bargaining behavior that may be roughly characterized as a systematic search for the highest acceptable demand. This search took place despite the fact that the composition of the subjects was changed randomly from game to game and the identity of the opponent was not revealed. The percentages reported above are close to those reported by Ochs and Roth (1989), who found that 55.2% of their subjects were involved in a similar adaptive behavior over games and 21% of their subjects exhibited behavior that had no apparent learning component to it.

If we assume linearity and the maximization of expected utility, the results reported above, especially findings 1 and 2, should lead us to reject the SPE solution as a descriptive model of behavior in the two-person sequential bargaining. This conclusion, however, must be qualified by three important objections. (1) In contrast to the first assumption above, there is ample evidence that maximization of expected utility does not always account adequately for individual choice behavior under risk. (2) There is also evidence that in interactive situations subjects do not always adhere to the instructions to maximize their own gain (even when payoff is contingent on performance, as in the present study). For example, McClintock and McNeel (1966, 1967) suggested on the basis of their data (see also Messick and McClintock, 1968) that players in noncooperative two-person games may be more concerned with maximizing the difference between their own score and the other player's score than in maximizing their own score. (See Bolton (in press) for an analysis of the finite case where bargainers act as if they are negotiating over two Commodities: 'absolute' and 'relative' money.) (3) Although we rotated the composition of the dyads from game to game and kept the identity of the opponents secret, subjects were aware that in a sequence of 24 games they might encounter the same opponent more than once. Consequently, their behavior on some game might have been considered to have implications, albeit indirect, on the behavior of their opponents in subsequent games. If this is the case, we cannot rule out the possibility that at least some of the subjects might not have considered the games they played as mutually independent. The behavior of these subjects, whom we do not know how to identify, may not be used to test the descriptive power of the SPE solution, as it applies only to a one-shot game, not a supergame.

5. Approximately 44% of the subjects changed their demands in the first period in a systematic manner in order to find allocations that would increase their share of the pie while being perceived by their unknown opponent as acceptable. Presumably, these subjects searched for allocations that would be perceived as 'fair.' The question that the present study raises, and previous studies raised as well, is the determination of the effects of strategic variables that affect the perception of 'fairness' in two-person sequential bargaining.

Based on our data and previous results, we offer some suggestions for the solution of this question in terms of a distinction we draw between two types of cues that bargainers may consider when generating demands or responding to them. It is clearly unreasonable to expect that subjects will perform complicated mathematical operations in an attempt to assess the strategic nature of the game. Rather, it is more plausible to assume that subjects will create simplified representations of the task and look for easily accessible cues (Selten, 1987). A major distinction is between 'outcome' cues such as the payoff matrix, disagreement points, and discount factors, and 'pure mechanism' cues referring to the rules of the game. We speculate that these two types of cues will be accessed lexicographically. Because 'outcome' cues are easier to detect than 'pure mechanism' cues, they will be attended to first. Only when 'outcome' variables render the two bargainers symmetric, as in the present study, will 'pure mechanism' cues be accessed. Because the latter are more difficult to quantify, experience with the task will be required in order to understand the strategic implications of pure mechanism cues and the asymmetry that they generate.

According to this speculative view, proposed allocations of the pie will be evaluated as 'fair' or 'unfair' independently of the process only if the outcome cues are perceived to be asymmetric. When outcome cues are perceived to be symmetric, the rules of the games will be considered when generating demands or responding to them. In the latter case learning is expected to be slower. The effects of these two types of cues will be moderated by distributive justice norms determining what sources of power are 'legitimately' exploitable, by context variables such as the history of previous transactions (Knesch *et al.* 1988), and by the framing of the task (Hoffman and Spitzer, 1985).

ACKNOWLEDGEMENT

This research was supported by a grant from the Center for Research in Conflict and Negotiation, The Smeal College of Business Administration, The Pennyslvania State University.

APPENDIX

Instructions to Subjects (Condition 1/3)

The purpose of the present experiment is to study bargaining behavior in situations that resemble bargaining in real life. In these situations, two persons bargain over the division of a valuable object with the knowledge that bargaining may be terminated at any time due to some external circumstances that are not under their control.

The Bargaining Game

We have simulated this situation as follows. You will be divided into pairs. One member of the pair is called Right and the other member is called Left. You will then bargain with your partner on how to divide a fixed sum of $30 between the two of you.

The bargaining within each pair will be conducted as follows. One of you will make a proposal as to how to divide a sum of $30 between the two of you. The person making the proposal must indicate two amounts (that sum up to $30):

(1) the amount he/she demands for himself/herself;

(2) the amount he/she proposes to be given to his/her partner.

If the person to whom the proposal is addressed ACCEPTS it, the bargaining terminates with each member of the pair receiving his/her proposed share. If the person to whom the proposal is addressed REJECTS it, he/she is required to make a counter-proposal.

This bargaining process will continue until you and your partner reach an agreement as to how to divide $30, or until the negotiations are terminated by the experimenter, whichever comes first. If the negotiations are terminated before you reach an agreement, both of you will earn nothing for that game.

The negotiations will not be terminated arbitrarily. Rather their continuation or termination will be determined randomly, by a wheel of chance, as described below.

The Bargaining Process

Assume that the Right member of the pair makes the first proposal. In this case, Right must fill in a Message Form identical to the one below.

RIGHT Proposes: Left gets $______ ; Right gets $______ .
End of Right's message

After Right fills in the two amounts – the proposed shares of Right and Left – the form will be given to the Left member of the pair. Left will then respond by circling either ACCEPT or REJECT on his/her Message Form.

'ACCEPT' terminates the game and credits both players with their agreed shares. If Left circles 'REJECT,' he/she must then make a counter-proposal using the following form:

LEFT Responds: ACCEPT REJECT
If REJECT is circled,
LEFT Proposes: Left gets $______ ; Right gets $______ .
End of LEFT's message.

At this stage the experimenter will spin the wheel of chance that you see in front of you.

If the spinner lands on GREEN, the form filled in by Left will be given to Right and the bargaining will continue.

If the spinner lands on RED, the bargaining will be terminated with zero payoff to both players.

If Right gets the form, then he/she will respond by circling ACCEPT or REJECT. 'ACCEPT' indicates that he/she accepts Left's counter-proposal, and 'REJECT' indicates the opposite. If Right rejects Left's counter-proposal, he/she will make a counter-proposal using the form:

RIGHT Responds: ACCEPT REJECT
If REJECT is circled,
RIGHT Proposes: Left gets $______ ; Right gets $______ .
End of RIGHT's message.

At this stage, the experimenter will spin the wheel of chance to determine whether to continue the bargaining. GREEN will continue the bargaining, whereas RED will terminate it.

The bargaining will continue in this way until an agreement is reached or the bargaining terminated, whichever comes first. The probability that the spinner will land on RED is exactly 1/3 (see the RED area on the wheel of chance). This probability will remain the same during the entire experiment. At the end of the game the Message Forms will be collected, and you will be assigned a new bargaining partner for the next game, whose identity will remain unknown.

Your objective in this experiment is to make as much money as possible. At the end of the experiment, the experimenter will choose randomly three of the games that you have played (including experimenter-terminated games). You will then be paid your average earnings in these three games.

Comment

No communication is allowed except that indicated on the Message Forms. You are only allowed to specify a proposal (two non-negative numbers that sum up to $30), and circle either ACCEPT or REJECT. *Any violation of this rule will render your agreement void and will result in zero payoff for that game.*

Any questions?

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