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Efficiency in Bargaining Games with Alternating Offers

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Abstract

Bargaining games model situations in which the realization of potential benefits is jeopardized by conflicting bargaining powers. Most of the literature on bargaining behavior focuses on bargaining over gains. Exploration of behavior in situations under which agents bargain over losses has received only limited attention from the profession. An important question is whether the negative effect of competing bargaining powers on the efficiency of agreements is more severe in bargaining over gains or over losses. Another understudied research question is how the likelihood that the outcome of a negotiation will actually be implemented affects efficiency of bargaining. We design an experiment that addresses these two questions. We find that in alternating offers games, outcomes of bargaining over gains are more efficient than outcomes of bargaining over losses. We also find that the likelihood that an interaction is implemented has a positive effect on the efficiency of bargaining.

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1. Introduction

Experimental literature on bargaining behavior is extensive. Bargaining behavior in the lab has challenged both non-cooperative and cooperative theory of bargaining (Roth 1995; Binmore 2007). In contrast to strong institutions such as markets, bargaining is a weak institution (Friedman and Sunder, 1994) in the sense that outcomes are strongly affected by individual preferences. In addition, conventional non-cooperative bargaining games have many equilibria.[1] Subgame perfection is probably the most appealing equilibrium selection criterion; it is the one that has attracted most attention in applications. It has, however, been a poor predictor of behavior in controlled experiments (Guth, Schmittberger and Schwarze 1982; Roth et al. 1991; Gale, Binmore and Samuelson, 1995; Ensminger 2004). Social preferences and fairness norms have been called upon to reconcile data with subgame perfect equilibria; the approach has seen little success (see Binmore et al. 2002; Andreoni and Blanchard 2006). The topic of this paper, however, is the performance of institutions rather than exploration of determinants of strategic behavior. We ask whether efficiency of bargaining negotiations is affected by: a) costs of exploring implications of alternative strategies; and/or b) the domain of payoffs. Our choice of bargaining negotiations is a two-stage game with alternating offers.

In our experiment, costs of experimenting with different strategies are related to the likelihood that an outcome of a negotiation is implemented. As early as Smith (1962) and as late as Binmore (2007), experimentalists have argued that proper testing of any model in the laboratory requires opportunities for trial-and-error learning. This brings up the following question: if performance of one-shot games is to be studied and learning opportunities are to be provided then what payoff protocol should be used? Selecting one outcome randomly for payment at the end of the experiment is often used in empirical studies that aim at exploring behavior in one-shot games but require that subjects make more than one decision. To the best of our knowledge, our paper reports the first study in the experimental literature of bargaining that includes alternative payoff mechanisms as treatments. In our experiment, subjects play the same game (but with different partners) six times. In one treatment each of the six negotiations can pay out for real; the probability of a round being selected is 1/6. In another treatment, only the fifth negotiation pays out for real while the others are hypothetical.

Another dimension incorporates the domain of payoffs, negative versus positive. The research question is whether outcomes of negotiations are more efficient when people bargain over losses or over gains. The literature on bargaining behavior over losses includes Camerer et al. (1993), Buchan et al. (2005) and Lusk and Hudson (2010). With the exception of Camerer et al. (1993), in all these papers the object of study is behavior in one-stage ultimatum bargaining games when losses have to be shared. Camerer et al. (1993) uses a three-stage alternating offer game; their main interest was in exploring general principles of experimental subjects' reasoning in these games.

2. Bargaining Games with Alternating Offers

The focus of this study is a conventional two-stage bargaining game with alternating offers. In a gain version of the game two agents are bargaining over how to split a positive amount of money whereas in a loss version of the game negotiation is over sharing a negative amount of money. If

[1] Cooperative approach suffers from similar problems: there are many bargaining solution concepts such as the Nash solution, the Kalai-Smorodinsky solution, and the egalitarian solution to mention some.

there is no agreement reached in stage 1 then in stage 2 the positive amount for share decreases whereas the total amount of loss increases. This property of opportunity sets, shrinking-gains or expanding-losses, makes a stage 1 agreement more efficient than a stage 2 agreement, which is more efficient than no agreement at all. In both versions of the game, in each stage the set of allocations that are Pareto efficient to the disagreement point is not empty. In addition, for any agreement in stage two there are many feasible options in stage one with higher payoffs for both players and no greater inequality. Therefore, reaching an agreement in stage 1 is not only efficient but it is optimal regardless of whether people have inequality-averse preferences or altruistic preferences or selfish preferences.

Another feature of our study is a variation on the cost of learning about the bargaining behavior of others and signaling one's own type. Our subjects played the same game six times with six different partners. What differs across two treatments is the cost of experimenting with different strategies. In one treatment, OT (or one task pays) the only round that pays out is round five; in another treatment, RLM (random lottery mechanism) there is a 1/6 probability that each round pays out for real. The question is whether people are more successful in reaching efficient agreements when opportunities for learning and experimenting are (directly) costless, as in OT but not in RLM.[2]

2.1 Bargaining over gains

In the gain version of the game there are opportunities for both players to earn positive amounts of money. In stage 1 both players can earn together a total amount of \$50. One of the players, player A, makes a proposal to the other player, B asking a for himself and hence offering player B the amount b=50-a. Player A's choice of a can be any nonnegative integer between 0 and 50. If player B agrees then the proposal is implemented and the game ends. If player B rejects the proposal then the game continues to stage 2 which has a lower positive amount to share, \$20. In this stage, it is player B's turn to make a proposal and player A's turn to accept or reject it. Player B can propose to ask for himself any amount b in full dollar amounts between \$0 and \$20 and leave \$(20-b) for player A. If player A agrees then the proposal is implemented. If she rejects the offer then each player earns \$5. Efficiency requires that the second stage is never played; in case stage 2 is reached, in the continuation game efficiency requires no settling at the disagreement point.

Reputation building and experimentation with different strategies suggest that the game might reach not only stage 2 but also the disagreement point; this is expected to happen more often in the rounds that do not pay money than in rounds that pay with probability 1/6, and even less often in a round that pays for sure. So, our first hypothesis is that the efficiency, E_{RLM} in RLM is higher than the efficiency, $E_{OT(r\neq5)}$, in non-paid rounds of OT, but lower than the efficiency in round five of the OT treatment:

(1) $H_a{}^p : E_{OT(r\neq5)} < E_{RLM} < E_{OT(r=5)}$

We are less interested in comparison of efficiencies if all OT data, from both paid and unpaid rounds are used. Nevertheless, for the sake of completeness, we look at this as well. Note that the inequalities in statement (1) suggest that efficiency over all rounds might be larger or smaller in the OT treatment than in the RLM treatment. However, if subjects are experimenting

[2]In this paper we are interested on bargaining efficiency, not on the distribution of outcomes.

and taking opportunities for building a reputation as tough bargainers then we should expect to see lower efficiency over all rounds in OT than in RLM:

(2) $H_a^{pp} : E_{OT} < E_{RLM}$

These hypotheses remain valid for the bargaining over losses version of the game that is described in the following section.

2.2 Bargaining over losses

In a two-stage bargaining game with alternating offers on the loss domain, players bargain over how to share a loss. In stage 1 of the game in our experiment the loss is \$50. Player A can make a proposal to the other player, B offering to pay amount a herself and letting player B pay b=50-a. Player A's choice of a can be any nonnegative integer between 0 and 50. If player B agrees then the proposal is implemented and the game ends. If player B rejects the proposal then the game continues to stage 2 and the amount of loss to be shared increases to \$80. In this stage, it is player B's turn to make a proposal and player A's turn to accept or reject it. Player B can propose to pay any amount b in full dollar amounts between \$30 and \$50 and leave \$(80-b) to be paid by player A. If player A agrees then the proposal is implemented. If she rejects the offer then each player has to pay \$45. Hence, in the loss version of the game, as in the gain version above, efficiency requires that the second stage is never played and, again, if it is played then we should observe no disagreement outcomes since a disagreement at this stage comes with a total loss of \$90 (each player pays \$45).

In implementing the loss version of the game, each subject is given at the beginning of the experiment a certificate for \$50. A careful look at the figures used in the parameterization of the games reveals that for subjects who perfectly integrate the initial endowment with the outcome from the bargaining game, the opportunity sets on the final payoff space in loss and gain versions of the game are identical. These two games are isomorphic for preferences that are selfish or altruistic or inequality averse. Indeed, consider function, T that maps player i's strategy (in the bargaining over gains game) $s_i = (ask\ x, f_i(.))$ where $x \in \{0, \dots, S_i\}$, and $f_i: \{0, \dots, S_{-i}\} \to \{accept, reject\}$ to a strategy $T(s_i) = (pay\ 50 - x, g_i)$ in the loss game, such that $g_i(50 - y) = f_i(y), \forall y \in \{0, \dots, S_{-i}\}$, where S_A is 50 and S_B is 20. Transformation $\mathbf{T} = (T, T)$ is a pair of bijections that preserves final payoffs, (π_i) since for all $i \in \{A, B\}$, for all feasible strategy profiles, $\boldsymbol{s}$ one has[3]

(*) $\pi_i(\boldsymbol{s}) = \pi_i \circ \mathbf{T}(\boldsymbol{s})$.

Statement (*) implies that for all $i \in \{A, B\}$, for all feasible strategy profiles, $\boldsymbol{s}$

[3]It is easy to verify this; an illustration will suffice. Consider a strategy profile $\boldsymbol{s}$ in the gain domain in which player A asks x and $f_B(.)$ in strategy s_B is such that at information set {x}, $f_B(x) = \{accept\}$. Then the outcome of the strategy profile $\boldsymbol{s}$ is a deal made in stage 1; proposer A and responder B earn, resp., $\pi_A(\boldsymbol{s}) = x, \pi_B(\boldsymbol{s}) = 50 - x$. Next, consider $\mathbf{T}(\boldsymbol{s})$, the strategy profile in the loss domain that profile $\boldsymbol{s}$ is mapped to by transformation $\mathbf{T}$. By construction, if $f_B(x) = \{accept\}$ then $g_B(50 - x) = \{accept\}$, therefore proposer A's offer to pay $50 - x$ is accepted and the deal is made in stage 1 of the loss game; proposer A and responder B earn, resp. $50 - (50 - x)$ and $50 - x$. Hence, $\pi_{A^\circ}\mathbf{T}(\boldsymbol{s}) = x = \pi_A(\boldsymbol{s})$ and $\pi_{B^\circ}\mathbf{T}(\mathbf{s}) = 50 - x = \pi_B(\boldsymbol{s})$.

$$u_i(\pi_A(\boldsymbol{s}),\pi_B(\boldsymbol{s})) = u_i(\pi_A \circ \mathbf{T}(\boldsymbol{s}),\pi_B \circ \mathbf{T}(\boldsymbol{s})).$$

It follows from the last statement that transformation $\mathbf{T}$ preserves each player's preference ordering since for all $i \in \{A,B\}$, for all feasible strategy profiles, $\boldsymbol{s}$ one has

$$\boldsymbol{s} \succ_i \boldsymbol{s}' \text{ if and only if } \mathbf{T}(\boldsymbol{s}) \succ_i \mathbf{T}(\boldsymbol{s}').$$

Thus, our bargaining games with alternating offers on loss and gain domains are isomorphic, which implies the following null hypothesis on experimental income integration

(3) $\quad H_o^{\,i} : E_L = E_G$.

There are, however, many studies in decision under risk that find no income integration (e.g. Cox and Epstein, 1989; Cox and Grether, 1996). Other studies find that the majority of people make choices that are consistent with risk seeking over losses and risk aversion over gains (Kahneman and Tversky, 1979; Wakker 2010). From the latter finding the efficiency, E_G when people bargain over gains is expected to be higher than the efficiency, E_L when people bargain over losses (Camerer et al., 1993), so our last hypothesis is

(4) $\quad H_a^{\,g} : E_L < E_G$.

3. Experiment Results

The experiment was conducted in the laboratory of the Experimental Economics Center (E*x*CEN) at Georgia State University in Spring 2012. A total number of 160 subjects participated in the experiment, with 40 subjects in each of four treatments: (i) in GRLM and LRLM treatments all rounds were equally likely to be selected for payment and the game with alternating offers was implemented in the gain (GRLM) and loss (LRLM) version, respectively; whereas (ii) in GOT and LOT treatments only round five paid out for real (and this was common information) but they differed from each other with respect to whether subjects were bargaining over gains (GOT) or losses (LOT).

To test hypotheses stated in section 2 we constructed an efficiency variable, E that takes values: 2 or 1 if an agreement was reached in stage 1 or stage 2; 0 if no agreement was reached in either stage. Table I reports a summary of the distribution of this variable across different treatments. Figures in Table I suggest higher efficiencies in: (i) Gain domain than in Loss domain; and (ii) in RLM than in OT sessions in case of all rounds but the pattern reverses if *unpaid* rounds are not included. Both patterns are consistent with hypotheses in statements (1) and (4).

Table I. Observed Frequencies (in %) of the efficiency variable across treatments

E (Efficiency)	All Rounds				Rounds that paid for sure	
	LOT	LRLM	GOT	GRLM	LOT	GOT
0	25.00	14.17	10.00	1.67	10.00	0.00
1	7.50	18.33	10.00	4.17	5.00	0.00
2	67.50	67.50	80.00	94.17	85.00	100.00
Nr. of pairs	120	120	120	120	20	20

Table II reports ordered probit estimations when the dependent variable is the efficiency variable.[4] To estimate the effects of the different costs of experimentation and reputation building we constructed a dummy variable, RLM that takes value 1 for data from sessions where all rounds had an equal probability (1/6) of being selected to pay out. Another dummy variable, Loss takes value 1 for data from sessions in which players were bargaining over losses and 0 if subjects were bargaining over gains. Other self-explanatory dummies are LOT, LRLM and GRLM. In all models reported in Table II, the independent variables include dummies on the treatments; in models 5-8, demographics are added as regressors.

Table II. Ordered Probit Regressions

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Round pays with prob.	1/6 or 0	1/6 or 1	1/6 or 1 round=5	0, 1/6 or 1	1/6 or 0	1/6 or 1	1/6 or 1 round=5	0, 1/6 or 1
LOT	-0.438*			-0.465**	-0.451**			-0.467**
	(0.013)			(0.008)	(0.007)			(0.005)
LRLM	-0.207			-0.334	-0.228			-0.356*
	(0.277)			(0.076)	(0.205)			(0.047)
Loss		-1.136**	-1.201**			-1.219**	-1.427**	
		(0.000)	(0.000)			(0.000)	(0.003)	
GRLM	0.869**			0.739**	0.890**			0.760**
	(0.000)			(0.000)	(0.000)			(0.001)
RLM		-0.587	-0.773*			-0.692*	-0.981*	
		(0.055)	(0.037)			(0.028)	(0.027)	
age					0.009	0.013	-0.011	0.005
					(0.747)	(0.652)	(0.801)	(0.863)
male					0.152	0.297	0.892*	0.166
					(0.541)	(0.390)	(0.043)	(0.509)
black					0.302	0.463	0.536	0.316
					(0.173)	(0.107)	(0.202)	(0.155)
birthorder					-0.112	-0.149	0.097	-0.089
					(0.293)	(0.311)	(0.617)	(0.408)
δ_0	-1.155	-2.755	-2.875	-1.270	-0.828	-2.302	-1.782	-0.950
δ_1	-0.713	-2.179	-2.218	-0.845	-0.378	-1.695	-1.046	-0.518
Nobs	440	280	80	480	440	280	80	480
Log-likeli.	-293.5	-144.6	-37.46	-311.2	-289.4	-139.5	-34.41	-307.1

Ordered Probit Model: $\Pr(E=0)=F(\delta_0-\boldsymbol{\beta X})$, $\Pr(E=1)=F(\delta_1-\boldsymbol{\beta X})-F(\delta_0-\boldsymbol{\beta X})$, and $\Pr(E=2)=1-F(\delta_1-\boldsymbol{\beta X})$ where F(.) is the standard normal c.d.f.;
Two-sided p-values are in parentheses: ** p<0.01, * p<0.05.

[4]With the exceptions of columns 3 and 7, we ran the ordered probit regression with subject clusters to allow for correlated errors across rounds within a subject.

Columns 1 and 5 in Table II report ordered probit regressions with data from RLM and only *unpaid* rounds in OT. The results are used to test the validity of the alternative hypothesis stated in the first inequality of statement (1). According to that hypothesis we expect positive estimates for GRLM and larger estimates for LRLM than for LOT. The estimated coefficients for GRLM are positive and highly significant. The null hypothesis that the estimates for LOT and LRLM are the same is weakly rejected in favor of the alternative hypothesis that efficiency is higher in LRLM (one-sided p-values are 0.042 and 0.056 for models in columns 1 and 5, resp.). We conclude that our data support the hypothesis stated in the first inequality of H_a^p in statement (1); the effect is weak in the loss domain. Next, hypothesis H_a^g in statement (4) predicts negative estimates for LOT and smaller estimates for LRLM than for GRLM. The estimated coefficients for LOT reported in Table II are significantly negative. Post regression tests reject (p-value < .001) the null hypothesis that estimates for GRLM and LRLM treatments are not different in favor of the alternative hypothesis of a larger estimate for GRLM. Thus our data reject the null hypothesis on experimental income integration, H_o^i (see statement (3)) in favor of the alternative hypothesis, H_a^g; data reveal that people bargain more efficiently over gains than over losses.

Columns 2 and 6 in Table II report ordered probit estimates using data from RLM and only the one paid round from OT.[5] The regression analysis is used to investigate the validity of the hypothesis stated in the second inequality of statement (1) and the hypothesis in statement (4). According to the former hypothesis we expect negative estimates for RLM; the latter one predicts negative estimate for Loss. Consistent with hypothesis in statement (4), the estimated coefficients for Loss are negative and highly significant. The signs of the estimates for RLM are negative (p-values are 0.055 and 0.028), providing support for the hypothesis in the second inequality of H_a^p in statement (1). Alternatively, if we focus our attention only on the data from round 5 (that paid for sure in OT treatment and with probability 1/6 in RLM treatment) then we get estimates reported in columns 3 and 7 of Table II. The signs and the statistical significances of these estimates are similar to the ones reported in columns 2 and 6, so the conclusions that follow from them are the same as above. These inferences from the ordered probit analysis are consistent with the ones from the Fisher's exact and Mann-Whitney tests. Data from round 5 reject the null hypothesis of equal efficiency in OT and RLM treatments in favor of the alternative hypothesis, H_a^p (second inequality in statement (1)) of higher efficiency in OT (two-sided p-values are 0.075 and 0.044 for the Fisher's exact and Mann-Whitney tests). In case of the payoff domain effects, both tests report significantly higher efficiencies when subjects bargained over gains than over losses (p-values are 0.012 and 0.006 for the Fisher's exact and Mann-Whitney tests). Thus, the efficiency is higher when the round pays for sure (OT) than when it pays with probability 1/6 (RLM); it is also higher for subjects who bargained over gains than for the ones who bargained over losses.

To provide more insight into the magnitude of effects of the treatments on the probabilities of the high (E=2) and the low (E=0) levels of efficiency, we here report changes in probabilities that are predicted from the ordered probit model with demographics for round 5 data (column 7). Increasing the probability of payment from 1/6 to 1 causes the estimated probabilities of the high efficiency to increase by 0.15 (up from 0.82 in RLM to 0.97 in OT) whereas the estimated

[5] In the GOT session in round 5 (the round that paid for sure) all pairs reached an agreement during stage 1 (see Table I, the right-most column), so we can run regressions only with dummies on Loss and RLM.

probabilities of the low efficiency decrease by 0.046 (down from 0.05 in RLM to .004 in OT). With respect to the payoff domain, the effect of bargaining over losses is a decrease by 0.22 (down from 0.98 in Gain to 0.76 in Loss) on the estimated probabilities of the high efficiency and an increase by 0.078 (up from 0.002 in Gain to 0.08 in Loss) on the probabilities of the low efficiency.

Finally, conclusions with respect to the overall efficiency across these four treatments can be drawn from estimates reported in columns 4 and 8 since in these regressions data from all rounds were used. Referring to the hypothesis in statement (2) we expect positive estimates for GRLM and larger estimates for LRLM than for LOT. The signs of the estimates for GRLM are indeed positive and highly significant; thus data support hypothesis H_a^{pp} in statement (2) when subjects bargain over gains. Post regression tests report that the LRLM estimates are not significantly different from LOT estimates (p-values are 0.393 and 0.438 for the models in columns 4 and 8 resp.). We conclude that hypothesis (2) is supported by data in the gain domain but not in the loss domain. Hypothesis in statement (4) predicts a negative estimate for LOT and a smaller estimate for LRLM than GRLM. Data are consistent with both predictions: given payoff protocol, overall efficiency is larger in the gain domain than in the loss domain.

4. Conclusions

Learning about the distribution of types of opponents and signaling own type call for experimenting with different strategies. To the best of our knowledge, there are no previous studies on bargaining games that look at how costs of experimenting with different strategies affect the likelihood of efficient agreements. In addition, literature is thin on bargaining behavior in situations that involve sharing losses.

This paper reports an experiment designed to investigate effects of the cost of exploration and experimentation on the efficiency of negotiations and test whether findings are robust across positive and negative payoff domains. Data in our experiment show that in our parameterized two-stage bargaining game with two alternating offers, outcomes are more efficient when bargaining takes place over gains than over losses. Data also reveal that the likelihood that an interaction is implemented has a positive effect on the efficiency of bargaining outcomes; the effect is stronger in the gain domain.

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