Forward Induction and Other-regarding Preferences Arising from an Outside Option: An Experimental Investigation

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Abstract

Based on forward induction, existing experimental studies have shown that an outside option, when offered to one of the two players who later participate in a battle-of-the-sexes game, facilitates coordination. However, the particular outside-option payoffs that these studies used may have led to certain kinds of other-regarding preferences which worked against the forward induction prediction. The current paper hypothesizes that an appropriately chosen outside option which controls for these preferences raises the predictive power of forward induction. The experimental results presented in the paper support the hypothesis.

Keywords: forward induction, other-regarding preferences, outside option

1. Introduction

The forward induction principle, a game theoretic concept, has the potential for mitigating coordination problems in certain situations. According to this principle, when a player rejects an appropriately set outside option offered to her before she and another player participate in a battle-of-the-sexes (BOS) game, that may signal her intended play in the BOS game; the signal facilitates coordination and equilibrium selection in the BOS game. The goal of the current paper is to test experimentally whether certain kinds of other-regarding preferences arise from the outside-option payoffs used in previous studies and whether controlling for those preferences improve the predictive power of forward induction.

The BOS game (Figure 1) is a symmetric 2×2 coordination game in which two players, Row and Column, simultaneously and independently choose between strategies 1 and 2. BOS has two pure-strategy Nash equilibria, $(1, 2)$ and $(2, 1)$, which do not differ with respect to either risk or payoff dominance. (Note 1) In the mixed-strategy Nash equilibrium, both players choose strategy 1 with probability ¼. Figure 2 shows a second game, named BOS-300, which adds an outside option to the BOS game. It proceeds in two stages. In the first stage, Row is offered an outside option. If Row takes the outside option (*Out*), then the game ends and each player receives a payoff of 300. If Row rejects the outside option (*In*) instead, then the players play the BOS subgame in the second stage. $((Out,1),\ 2)$ and $((In,2),\ 1)$ are the two pure-strategy subgame-perfect Nash equilibria (SPNE) that BOS-300 has. (Note 2, Note 3)

		Column 1	Column 2
Row	1	0, 0	200, 600
	2	600, 200	0, 0

Figure 1. BOS

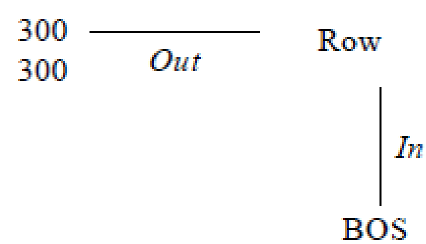

Figure 2. BOS-300

According to forward induction, if Row chooses *In* in BOS-300, then Column should treat it as a signal that Row intends to obtain a payoff higher than 300. So, Column should assign a probability of 0 to the instance that Row chooses *In* in the first stage and strategy 1 in the second-stage BOS subgame. As a result, Column chooses strategy 1. In the first stage, therefore, Row chooses *In*, the BOS subgame is played and $(2, 1)$ is attained. This is the *forward induction prediction* in BOS-300. Out of the two SPNE's, forward induction thus eliminates $((Out,1), 2)$ and selects $((In,2), 1)$. (Note 4, Note 5)

Cooper, DeJong, Forsythe and Ross (1993) (CDFR, hereafter) and Shahriar (2009) test the above forward induction prediction in lab experiments. Table 1 shows their results from the last 11 rounds. (Note 6) The coordination problem in BOS is evident in both the studies. Subjects attain the equilibrium outcomes only 41% (48%) of the time in CDFR (Shahriar, 2009). In their BOS-300 treatment, however, coordination is significantly higher. Conditional on the subgame is played, the $(2, 1)$ outcome is attained 90% (62%) of the time (in contrast to only 19% (22%) of the time in BOS) and the frequency of disequilibrium outcomes goes down to 10% (33%) in CDFR (Shahriar, 2009). These results provide support for forward induction.

Table 1. Results of experiments from the last 11 rounds of BOS and BOS-300

Games		Outcomes			
		Outside Option	(2, 1)	(1, 2)	Disequilibrium: (1,1) and (2,2)
Cooper el. al (1993)	BOS	-	31 (19%)	37 (22%)	97 (59%)
	BOS-300	33	119 (90%)	0 (0%)	13 (10%)
Shahriar (2009)	BOS	-	37 (22%)	43 (26%)	85 (48%)
	BOS-300	55	68 (62%)	6 (5%)	36 (33%)

Note: Figures in the parentheses show the frequency distribution in each treatment among four outcomes – (1, 2), (2, 1), (1, 1) and (2, 2).

Both studies, however, find that in BOS-300 the outside option is taken more frequently than expected. The option is taken 33 times (20% of the time) and 55 times (33% of the time) in CDFR and Shahriar (2009), respectively. Given the frequency of outcomes observed in the subgame (Table 1), these frequencies are quite high. (Note 7) Since the outside option gives equal payoffs to the players, whereas the $(2, 1)$ outcome produces unequal payoffs, it is possible that a Row player's choice between *Out* and *In* is influenced by her inequality aversion. An inequality-averse person derives disutility from an unequal distribution of payoffs even when she has the higher payoff. According to the inequality aversion models in Fehr and Schmidt (1999) and Bolton and Ockenfels (2000), an inequality-averse Row player may prefer the outside option over the $(2, 1)$ outcome in BOS-300. (Note 8) As a result, when Row believes that the $(2, 1)$ outcome will be attained following her choice of *In*, she may actually choose *Out*. This works against the forward induction argument and may provide an explanation to the high frequency with which the outside option was accepted in the earlier studies described in Table 1.

Moreover, when Row chooses *In* and signals her intension for the $(2, 1)$ outcome in the subgame, it may trigger negative reciprocity from Column. The lower payoff in $(2, 1)$ (compared to what Column may consider as equitable) may lead to the negative reciprocity. According to both Rabin (1993) and Dufwenberg and Kirchsteiger (2004), the choice of *In* by Row can be regarded by Column to be an unkind action. As a result, Column may choose to negatively reciprocate by choosing strategy 2. (Note 9) This reduces the predictive power of forward induction and we suspect that some of the disequilibrium outcomes observed in Table 1 may have resulted from Column's reciprocity.

We hypothesize that an outside option that controls for Row's inequality aversion and at the same time makes the rejection of the option to not appear to be unkind to Column will raise the rejection rate of the option and enhance coordination on the outcome forward induction predicts. The goal of the current paper is to test this hypothesis. To achieve this goal, the paper (1) considers a new game which is similar to BOS-300 in which forward induction applies while the outside option possesses the characteristics mentioned in the hypothesis, and (2) reports results from a laboratory experiment on this game to test the hypothesis. The experimental results support the hypothesis.

The rest of this paper is organized as follows. Section 2 discusses the experimental design, Section 3 describes the experimental results and Section 4 makes some concluding remarks.

2. Experimental Design

In order to test for our hypothesis mentioned in the previous section, we consider the BOS-SOCIAL game in Figure 3. In the first stage, Row decides between an outside option and playing the BOS subgame. If she takes the outside option by choosing *Out*, then the game ends; Row receives 400 points and Column receives 0 points. This game has the same two pure-strategy SPNE's as in BOS-300 – $\left((Out,1),\ 2\right)$ and $\left((In,2),\ 1\right)$, and Row is able to indicate her intention of receiving 600 in the subgame by rejecting the outside option. So, forward induction again selects $\left((In,2),\ 1\right)$.

The outside-option payoffs in BOS-SOCIAL ensure that, for all possible values of the parameters in the Fehr and Schmidt (1999) and Bolton and Ockenfels (2000) models, an inequality-averse Row prefers $(2,\ 1)$ over the outside option. (Note 10) Moreover, according to both Rabin (1993) and Dufwenberg and Kirchsteiger (2004), the rejection of the outside option by Row is not regarded by Column as an unkind action, making Column more likely to choose strategy 1 (as forward induction suggests). (Note 11) Our hypothesis, therefore, is that the rejection of the outside option will be higher in this game than in BOS-300, and Column will choose strategy 1 with a higher frequency leading to higher coordination on $(2,\ 1)$ in this game than in BOS-300.

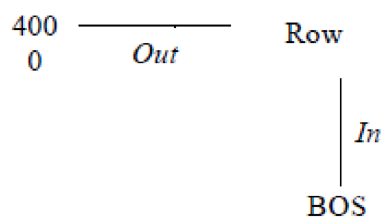

Figure 3. BOS-SOCIAL

The experimental design used in this paper is adopted from CDFR and Shahriar (2009). Three sessions are run; each session recruited 11 subjects. Upon arrival at the lab, a subject was seated in front of a computer terminal and was given a copy of the instructions. (Note 12) The instructions were also read aloud. Each session consisted of 22 rounds of M-BOS-100 and lasted for about an hour. (Note 13)

In each round, one subject was matched with another subject. Thus, in each round there were 5 pairs; one subject was sitting out. Within each of the 5 pairs in a round, one subject was assigned the role of Row and the other Column. At the beginning of each round, subjects were privately informed of their assigned roles via the computer terminals in front of them. In a random manner, each subject played exactly twice with another subject (once as Row and once as Column) and seated out once during the entire session. So, in each session, each subject participated in 20 rounds; playing as Row in 10 rounds and Column in the other 10 rounds.

At the end of each round in a session, a subject earned points according to the choices made. This point determined the probability of winning in a binary lottery with two outcomes – \$0 and \$3. To implement the lottery, at the end of each round, the computer generated random numbers between 0 and 1000 for each subject separately. If this number was less than or equal to the points a subject earned, then the subject earned \$3; she earned \$0 otherwise. (Note 14) Through out the session each subject accumulated her earnings which were paid in cash at the end of the session. The average earnings were about \$20.

The experiments were run at the Economic Science Lab (ESL) at the University of Arizona. 33 undergraduate students were recruited for these experiments. All the sessions were computerized using zTree (Fischbacher, 2007).

3. Results

The results from the experiment on M-BOS-100 along with those on BOS and BOS-100 from Shahriar (2009) are summarized in Tables 2 and 3. (Note 15) Table 2 reports the frequencies of the outcomes in the first and the last 11 rounds separately; the latter in italics. In a similar manner, Table 3 lists the frequencies of strategies played.

Table 2. Frequencies of outcomes in first and last 11 rounds

(Last 11 rounds in italics)

Treatment	**Outside Option**	**Outcomes in the Subgame**			
		(2, 1)	**(1, 2)**	**(1, 1)**	**(2, 2)**
BOS	-	36	45	25	59
		(21.8%)	(27.3%)	(15.2%)	(35.8%)
		37	***43***	***21***	***64***
		(22.4%)	***(26.1%)***	***(12.7%)***	***(38.8%)***
BOS-300	75	39	8	10	33
	(45.5%)	(43.3%)	(8.9%)	(11.1%)	(36.7%)
	55	***68***	***6***	***5***	***31***
	(33.3%)	***(61.8%)***	***(5.5%)***	***(4.5%)***	***(28.2%)***
BOS-SOCIAL	41	80	5	12	27
	(24.8%)	(64.5%)	(4.0%)	(9.7%)	(21.8%)
	50	***86***	***3***	***6***	***20***
	(30.3%)	***(74.8%)***	***(2.6%)***	***(5.2%)***	***(17.4%)***

Note: Percentages are given in parentheses; for outcomes in the subgame, the percentages show the distribution of the outcomes only within the subgame. The percentages for the outside option show the proportion of 165 observations in which the outside option was taken.

Consistent with our hypothesis, the outside option is taken with a lower frequency in BOS-SOCIAL than in BOS-300 (Table 2); the difference is significant in the first half of the experiments (χ_{first} = 14.5, $p < 0.001$ and χ^2_{last} = 0.2, p = 0.655). (Note 16, Note 17) The relative frequency of $(2, 1)$ in the subgame is significantly higher in BOS-SOCIAL – 64.5% (74.8%) in BOS-SOCIAL compared to only 43.3% (61.8%) in BOS-300 in the first half (second half) (χ^2_{first} = 8.64, p = 0.003 and χ^2_{last} = 3.80, p = 0.051). The frequency distributions of the subgame outcomes in BOS-SOCIAL and BOS-300 are significantly different in the first half of the experiments (χ^2_{first} = 10.5, p = 0.015 and χ^2_{last} = 5.5, p = 0.139) and the frequency of $(2, 1)$ as a proportion of all equilibria observed is also significantly different, again, in the first half (χ^2_{first} = 22.6, $p < 0.001$ and χ^2_{last} = 1.38, p = 0.240). The results of BOS-SOCIAL thus confirm that, consistent with our hypothesis, controlling for other-regarding preferences in an appropriate manner can provide stronger support for forward induction; this effect, however, somewhat diminishes as the subjects become relatively experienced. (Note 18)

Table 3. Frequencies of strategies played in first and last 11 rounds

(Last 11 rounds in italics)

Treatment	**Row's Outside Option**	**Column's Outside Option**	**Row's Subgame Play**		**Column's Subgame Play**	
			Str. 1	**Str. 2**	**Str. 1**	**Str. 2**
BOS	-	-	70	95	61	104
			(42.4%)	(57.6%)	(37.0%)	(63.0%)
			64	***101***	***58***	***107***
			(38.8%)	***(61.2%)***	***(35.2%)***	***(64.8%)***
BOS-300	75	-	18	72	49	41
	(45.5%)		(20.0%)	(80.0%)	(54.4%)	(45.6%)
	55		***11***	***99***	***73***	***37***
	(16.7%)		***(10.0%)***	***(90.0%)***	***(66.4%)***	***(33.6%)***
BOS-SOCIAL	41	-	17	107	92	32
	(24.8%)		(13.7%)	(86.3%)	(74.2%)	(25.8%)
	50		***9***	***106***	***92***	***23***
	(15.2%)		***(7.8%)***	***(92.2%)***	***(80.0%)***	***(20.0%)***

In the comparison of the subgame strategies choices in BOS-300 and BOS-SOCIAL (Table 3), we find that they are not significantly different for Row ($\chi^2_{first} = 1.08$, $p = 0.299$ and $\chi^2_{last} = 0.11$, $p = 0.740$) but they are for Column – she chooses strategy 1 with a significantly higher proportion in BOS-SOCIAL ($\chi^2_{first} = 8.19$, $p = 0.004$ and $\chi^2_{last} = 4.67$, $p = 0.031$). This is perfectly consistent with our hypothesis that the absence of a negative reciprocal motive for Column in BOS-SOCIAL (unlike in BOS-300) will lead her to choose strategy 1 more frequently. Thus, the lower coordination level in BOS-300, compared to that in BOS-SOCIAL, is a result of Column's reaction when Row rejects the outside option in BOS-300 – Column punishes Row by choosing strategy 2. (Note 19)

4. Conclusion

Based on forward induction, an appropriately chosen outside option offered to one of the two players who later play a BOS game, has the potential to solve the coordination problem in the BOS subgame. Previous experimental studies have tested this prediction in lab experiments and have found support for the prediction. The particular outside option considered in these studies, however, may have sometimes led the player who is offered the option to choose the option (due to inequality aversion) which is contrary to what forward induction predicts, and conditional on the option being rejected, may have led the other player to choose a strategy not predicted by forward induction (due to reciprocity). The current paper hypothesizes that controlling for these other-regarding preferences by choosing an appropriate outside option will raise the predictive power of forward induction. The experimental results presented support the hypothesis.

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Notes

Note 1. The two elements in a strategy profile (e.g. (1, 2)) correspond to strategy choices by Row and Column, respectively.

Note 2. For the remainder of the paper, in a two-stage game such as BOS-300, a strategy for a player specifies her choice regarding the outside option (if available) and then those in the BOS subgame. So, for example, the strategy profile $((In, 2),\ 1)$ implies that Row rejects the outside option by choosing *In* and then chooses 2 in the BOS subgame, and Column, who is not offered an outside option, chooses 1 in the subgame.

Note 3. BOS-300 has another equilibrium in which Row chooses *Out*; this is supported by the belief that Column will play according to the mixed-strategy Nash equilibrium in the subgame.

Note 4. In general, the rest of the paper relies on the description of the forward induction prediction by Van Damme (1989): "in generic 2-person games in which player *i* chooses between an outside option or to play a game Γ of which a unique (viable) equilibrium e^* yields this player more than the outside option, only the outcome in which *i* chooses Γ and e^* is played in Γ is plausible." See Kohlberg and Mertens (1986) and Van Damme (1989) for elaborate theoretical discussions on forward induction.

Note 5. Recent development in the literature on forward induction has focused on formalization of the concept. Battigalli and Siniscalchi (2002) have theorized the concept of forward induction as "rationality and common strong belief of rationality" (RCSBR). Battigalli and Friedenberg (2012) show that RCSBR is characterized by the concept of "directed rationality".

Note 6. There were 165 observations in total in the last 11 rounds of each treatment in both the studies.

Note 7. By choosing *Out* Row gets only 300 while, based on the frequency of outcomes in the subgame shown in Table 1, the expected payoff to Row for choosing *In* is 540 (=0.9(600)) and 382 (=.62((600)+.05(200)) in CDFR and Shahriar (2009), respectively.

Note 8. According to Fehr and Schmidt (1999), when the sensitivity to advantageous inequality (β) is large enough, then Row prefers the outside option to (2, 1). In Bolton and Ockenfels (2000), it is possible that Row prefers the outside option to (2, 1) when the unequal payoffs corresponding to (2, 1) sufficiently reduces the value of her motivation function.

Note 9. According to the model in Dufwenberg and Kirchsteiger (2004), Column may prefer strategy 2 to strategy 1 when she believes that Row will play according to the forward induction prediction and that Row believes that Column will play according to the forward induction prediction.

Note 10. Since Row receives a higher payoff in (2, 1) than in the outside option, and payoff inequality between players is the same in both outcomes, according to the Fehr-Schmidt model, Row prefers (2, 1) over the outside option. Again, since Row receives a higher payoff in (2, 1) than in the outside option and her payoff as a proportion of the sum of payoffs to the players is closer to ½ in (2, 1) than in the outside option, according to the Bolton-Ockenfels model, Row prefers (2, 1) over the outside option.

Note 11. According to the model in Dufwenberg and Kirchsteiger (2004), Column prefers strategy 1 to strategy 2 when she believes that Row will play according to the forward induction prediction and that Row believes that Column will play according to the forward induction prediction.

Note 12. A copy of the instructions for BOS-SOCIAL is available at www-rohan.sdsu.edu/~qshahria/Instructions-BOS-SOCIAL.pdf.

Note 13. We acknowledge that repetitive games are not quite an appropriate design when controlling reciprocity is a goal. This design was adopted only to make the current study comparable to the earlier ones.

Note 14. The points a subject earned divided by 1000 gave the probability of winning $3. So, higher points gave higher probability of winning.

Note 15. The experiments reported in this study and those in Shahriar (2009) are run using the same subject pool and the same experimental design and protocol. So, the results are comparable across these two studies.

Note 16. Within the parenthesis, we report the test results for the first and the last halves of the sessions, respectively. In the remainder of the paper, whenever we report two results in this manner the results are to be interpreted this way.

Note 17. All the tests reported in this paper are two-tail Chi-square tests.

Note 18. This is similar to the findings in experiments on repeated ultimatum games where it has been observed that offer amounts and rejection rates decrease (usually insignificantly) over time (Roth *et al.*, 1991; Knez and Camerer, 1995; Slonim and Roth, 1998; List and Cherry, 2000).

Note 19. This result is similar to the findings in ultimatum and dictator games where Responders reject positive offers which they perceive as unfair. The Proposers are, however, mostly self-interested. See Camerer (2003) for an excellent review of the related literature.