An experiment on subjective game valuations

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Abstract

We report experimental results on a prisoners' dilemma implemented in a way which allows us to elicit incentive−compatible valuations of the game. We test the hypothesis that players' valuations coincide with their Nash equilibrium earnings. Our results offer significantly less support for this hypothesis than for the prediction of Dominant Strategy (DS) play.

1 Introduction

In this note we report results from an experiment designed to test whether subjective valuations of a prisoners' dilemma coincide with Nash equilibrium payoffs. This apparently straightforward consequence of individual rationality plays a central role in game theory, being especially useful in the determination of a Subgame Perfect Equilibrium.[1] Our results suggest that subjective game valuations might differ from Nash equilibrium payoffs depending on the utility (or disutility) which individuals experience from being involved in a strategic interaction.

In our experiment, players face a symmetric 2x2 prisoners' dilemma and a set of alternative outside options. Apart from a subject's actual behavior, we are interested in the value he or she assigns to the game. Thus, before playing the game, subjects make binary decisions between their future earnings in the game and a series of fixed payoffs. This elicitation method allows us to obtain the subjective valuation of the game, which otherwise would remain unknown. Apart from the frequency of dominant strategy (DS) adoption, we study the correlation between DS play and subjects' subjective valuations. Finally, we use players' scores in Raven's (1976) non verbal intelligence test to assess whether non-DS play and discrepancies between subjective game valuations and Nash equilibrium payoffs are related to poor decision-making abilities.

We find that, contrary to the prediction that subjective game valuations coincide with the Nash equilibrium payoffs, almost half of our subjects either under- or over-valuate the prisoners' dilemma implemented here.[2] Such deviations are weakly related with a lower percentage of Dominant Strategy (DS) play, which nevertheless, receives systematic support by our results. While no correlation is found between scores in Raven's (1976) non verbal intelligence test and elicited game values, the frequency of dominated strategy play negatively correlates with subjects' scores in the aforementioned test.

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[1]See, for example, seminal papers by Selten (1975) and Kreps and Wilson (1982).

[2]Early experimental studies by Flood (1952), Lave (1962) and Rapoport and Chammah (1965) have reported results on behavior in prisoners' dilemma games, but the issue of game valuation has not been isolated from behavior itself.

2   Experimental Design

The results reported here were obtained from a single experimental session at the Laboratori d'Economia Experimental at the Universitat Jaume I (Castellón, Spain). Participants (N=66) were undergraduate students of Business Administration . Before participating in the main experiment, subjects were faced with Raven's psychometric test of non verbal intelligence, considered by psychologists as a good predictor of performance in decision making tasks. Subjects were informed that all their monetary rewards would be calculated on the basis of their performance in the main experiment alone.

The main experiment is based on the following two-stage game. In the first stage, which is labelled as a proposal to merge with one's opponent, players choose strategies from the pair $\{M, NM\}$ ({ "Merger", "No Merger"}). A merger takes place if both players simultaneously propose to merge (M) and the game is over. Then, both players earn X Euros, for which 7 alternative values are used in a payment card, incentive-compatible elicitation format, where $X \in \{25, 19, 17.5, 16.8, 15.8, 15, 10\}$. Otherwise, players enter into the second-stage decision, which is labelled as a game of reciprocal entry into each other's market. Each subject chooses a strategy from $\{E, NE\}$ ({ "Entry", "No Entry"}).[3] The payoffs of this subgame are given in the following matrix:

Table I: Payoffs (in Euros) for the Game of Entries. $B \in \{1, 12.5\}$

		Player B	
		Entry	No Entry
Player A	Entry	17 , 17	22 , B
	No Entry	B , 22	18 , 18

Two different values of B were used: A relatively high $(B = 12.5)$ and a relatively low one $(B = 1)$. In both cases, this subgame's payoffs yield a prisoner's dilemma whose dominant strategy equilibrium leads to a reciprocal entry by both players into each other's market. Observe that the 7 values of X, corresponding to the merger, range from well above to well below the value of individual payoffs in the DS equilibrium.

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[3]Written and oral instructions with detailed information about the game, payoffs, earnings and tasks to be performed were given to subjects. We also answered questions and gave examples to solve any remaining doubts. Instructions are available upon request.

We have used the strategy method, asking subjects to simultaneously post their strategies in both subgames, for each one of the 14 scenarios resulting from the combinations between each one of the 7 values of X and the two values of B.[4]

Once strategies were posted, one of the 14 scenarios was randomly chosen to be the binding one. Finally, 33 pairs of subjects were randomly formed and each one's payoff was determined according to the two players' strategies in the chosen scenario.

3 Hypotheses and Results

Our results are based on two types of observations. First, a subject's minimum value of X for which he/she prefers the merger to the earnings of the entry subgame. These data are labelled as the subjective value of the entry subgame. Second, subjects' strategies in the entry subgame. We label data generated under the 2 different values of B using the term "subseries"(B=12.5: "first subseries", B=1: "second subseries").

Our hypotheses are the following:

H1: *Subjects will "switch" from NM to M at the lowest value of X exceeding 17.*

Subsequently, we will refer to subjective entry-subgame valuations deviating from this pattern as under- (over-)valuations, depending on whether subjects switch to the merger for a lower (higher) X than that postulated in H1.

H2: *Subjects' elicited valuations of the entry subgame should remain invariant across different values of the dominated strategy payoff.*

That is, within-subject comparison of strategies in the merger subgame should not exhibit significant differences across subseries.

H3: *In the entry subgame, subjects will play the dominant strategy (E).*

We classify subjects into three groups according to their decisions in the merger subgame. Group 2 consists of those who adopt the merger for all

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[4]The corresponding 14 screens were presented to the subjects in a random sequence -different for each subject-, in order for ordering effects to be avoided.

the values of X strictly exceeding Nash equilibrium payoffs of the entry subgame (17) and for only them, that is $X \in \{25, 19, 17.5\}$. Group 1 consists of subjects proposing the merger for a strict subset of the aforementioned values, implying an overvaluation of the entry subgame. Analogously, group 3 consists of subjects willing to merge for a broader spectrum of values of X than the aforementioned ones, including values lying below Nash equilibrium payoffs in the entry subgame. In Table II we present the percentages of subjects that are included in each group, for each one of the two subseries. For each group, we also include the percentage of subjects playing the dominant strategy, E.

Table II: Distribution of Elicited Values and Percentage of DS Play

	Subseries 1 (B=12.5)		Subseries 2 (B=1)	
		% of E		% of E
Group 1 (over)	22.7%	84.76%	9.1%	75.24%
Group 2 (DS Eq.)	51.5%	96.16%	57.6%	91.13%
Group 3 (under)	25.8%	73.28%	33.3%	81.30%

Observe in Table II that **H1** is confirmed by only (approximately) 50% of the subjects. The rest of them "overvaluate" or "undervaluate" the game and the percentage of the former significantly[5] decreases (from 22.7% to 9.11%) in the presence of a lower dominated strategy payoff[6], implying a violation of **H2**.

Let us move now to strategies adopted in the game of entries. Aggregating decisions in the game of entries, around 85% of them confirm **H3**. In fact, 73% of the subjects have played the dominant strategy in all scenarios. From table II we can see that the highest frequencies (respectively, 96.16% and 91.13%) of dominant strategy play coincides (for both subseries) with the population of subjects whose valuation of the game is equal to Nash equilibrium payoffs. However, no significant correlation[7] was found between strategies in the game of entries and elicited values. Interestingly, we find a

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[5]A Wilcoxon ($p = 0.018$) and a sign test ($p = 0.017$) confirm this result at a significance level $\alpha = 0.05$

[6]This is an aggregate result, while within-subject examination indicates that a small percentage (5%) of subjects shifted across scenarios on the opposite direction.

[7]Both Spearman and Pearson correlation coefficients were non significant at a 0.05 level of significance.

positive correlation (Spearman's $\rho = 0.316$, $\alpha = 0.05$) between a subject's performance in Raven's test and the number of scenarios in which the subject has played the dominant strategy. This may imply that not choosing the dominant strategy in the game of entries may be simply the result of a low capacity in decision making tasks. On the contrary, no correlation was found between scores in Raven's test and merger decisions, implying that the reported over- and under-valuations of the subgame of entries cannot be simply attributed to the subjects' low decision-making abilities.

4   Conclusions

We have reported an experiment designed to test whether human subjects' valuations of a prisoners' dilemma game coincide (as assumed, for example, when backward induction is used to obtain a Subgame Perfect Equilibrium) with subjects' Nash equilibrium payoffs. The hypothesis is contradicted by approximately half of our subjects. Subjects confirming the predicted valuation exhibit higher frequencies of dominant strategy play, which is confirmed by the majority of our subjects. Finally, dominated strategy play significantly correlates with low scoring in Raven's (1976) non verbal intelligence test.

References

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