

# Evidence of Homo Economicus? Findings from Experiment on Prisoners' Dilemma Game

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*The paper reports on a study of interactive decision-making process by conducting an experiment on evolutionary process of prisoners' dilemma game. Sixteen one-shot prisoners' dilemma games with payoffs perturbation under perfect information had been played during the experiment. The subjects were students and staff of Universitas Gadjah Mada, Indonesia. In contrast to Andreoni and Miller's (1993), Selten and Stoecker's (1986) Cooper's, et.al (1991, 1996) findings, the vast majority of the subjects in this experiment tend to choose Nash equilibrium strategy consistently through out the games. The maximum proportion of Pareto optimum outcome was consistently about 2% or less, whereas Cooper et al (1991, 1996) reported that the outcome was 43% in games 1-5 and became 20% in games 16-20. There were evidences that variability of payoffs influence players' decision making process. In contrast to previous studies above, the results from this study reveals that players tend to follow rationality axiom as prescribed in Economics.*

Field of Research: Experimental Economics, Game Theory, Payoffs Perturbation.

## 1. Introduction

The prisoner's dilemma has been one of the greatest knowledge creations in the twentieth century. From theoretical point of view, it provides an essential philosophy in terms of human interaction particularly when conflict of interest surface. It is also powerful enough to provide justification on how societies behave and are arranged, by explaining tendency of each individual's response (Poundstone, 1992). Furthermore, the theory can be applied to answer inquiries in various disciplines, ranging from international relation, political economics, environmental economics and also public choice theory, and so it establishes itself as a universal concept.s

## 2. Literature Review

A pool of researches has established experiments using prisoner's dilemma framework. A number of monumental experiments seek to explain cooperative decisions among individuals. In contrast to game theoretical proposition that rational players tend to choose Nash equilibrium strategies, various experiments on prisoners dilemma game showed evidence of tacit cooperation among subjects (see

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Selten and Stoecker, 1986, Cooper et al, 1991, 1996, and Andreoni and Miller, 1993).

Selten and Stocker's (1986) and Andreoni and Miller's (1993) supergames explained that individuals respond tacit cooperative behavior as a result of learning process. Cooper et al. (1996) also show similar cooperative result. Experiment on prisoners' dilemma game is also conducted in the context of public goods. Weimann (1994) suggest three types of subjects each with unique decision. Isaac et al. (1994) also confirmed these types of subjects.

Recent evolutionary game theory has been an essential tool in the identification of different types of individuals. Evolutionary stability concept of equilibrium identifies a strategy as evolutionary stable if it has higher reproductive success rate than any other strategy. This theory implies that cooperation may not be the optimal behavioral pattern, however communication of information is essential to justify the existence of cooperation (Brosig, 2002). See also Frank (1987), Harrington (1989), and Frank et al. (1993) for discussion on evolutionary stable outcome and signaling.

### **3. Methodology and Research Design**

This study attempts to establish experiment design using prisoner's dilemma game under evolutionary game theory framework. The experiment consists of two sessions, and each session consists of sixteen one-shot prisoner's dilemma games. A player will only have one chance to meet with particular opponent. In the first session, the subjects faced two possible strategies A and B. In the second session, the framing effect was implanted by replacing strategies A and B, respectively, with 'willing to cooperate' and 'not willing to cooperate'.

Table 1 shows the distribution of payoffs perturbation for each game in order to test whether players change their propensity toward particular strategy through out the experiment. It is expected that the extreme distribution of payoffs are going to ease hypothesis testing on whether individuals are influenced by the variability of payoffs, even in the same structure. The framing effect was introduced in the second session of the game to test whether players' behavior change after the effect.

**Table 1. Payoffs Distribution**

	$d/a \geq 75\%$ and $b = 0$ (low coordination benefit)	$d/a \leq 25\%$ and $b = 0$ (high coordination benefit)
$[(c-a)/a] \geq 75\%$ and $b = 0$ (high coordination cost)	<b>Combination R</b> (Game I, V, IX, XIII)	<b>Combination S</b> (Game II, VI, X, XIV)
$[(c-a)/a] \leq 25\%$ and $b = 0$ (low coordination cost)	<b>Combination T</b> (Game III, VII, XI, XV)	<b>Combination U</b> (Game IV, VIII, XII, XVI)

Notes:

- The value of  $a$  is Rp100,000; if  $[(c-a)/a] \geq 75\%$ , the maximum (minimum) value of  $c$  is Rp200,000 (Rp175,000); if  $[(c-a)/a] \leq 25\%$ , the maximum (minimum) value of  $c$  is Rp125,000 (Rp105,000); if  $d/a \geq 75\%$ , the maximum (minimum) value of  $d$  is Rp95,000 (Rp75,000); if  $d/a \leq 25\%$ , the maximum (minimum) value of  $d$  is Rp25,000 (Rp5,000).

The experiment is open to all students and staff in Universitas Gadjah Mada. Each participant has a chance to earn a maximum (minimum) payoff of Rp200,000 (Rp0). The amount of payoff is subject to player's payoff in particular game which he/she selects randomly at the end of the game. The maximum payoff of Rp200,000 is regarded high among most participants since most of them are undergraduate students. For comparison, the cost of particular lunch menu in faculty's cafeteria is Rp5,000. Therefore, the maximum payoff is a worthy amount for "one-hour job."

The players that participated in the experiments have an average age of 23.9 years old. There are 65.6% of male participants while the rest are female participants. Most participants are undergraduate students which accounted for about 70%. The average monthly income of participants are Rp932,552 or about US\$100. There are 23% of participants with income higher than Rp1 million each month. This statistics signify that the amount of maximum payoff is significant to participants since the amount is about 20% of their average monthly income.

#### 4. Discussion of Findings

Table 2 shows the propensity of strategies in two sessions of the experiment. In the first session, the proportion of players who chose Pareto optimum strategy (A,A) only accounted for 1.2%. The proportion is outstripped by the proportion of players who chose Nash Equilibrium strategy (B,B), which tally for 81.8%. After we established framing effect, the proportion of pareto optimum strategy declined while the proportion of Nash Equilibrium strategy increased by 3%.

**Table 2. Proportion of Players' Strategies**

Session 1	A:A	A:B & B:A	B:B	Session 2	A:A	A:B & B:A	B:B
Game 1-4	1.05	22.9	76.0	Game 1-4	3.2	16.2	80.7
Game 5-8	2.10	16.7	81.3	Game 5-8	0.0	13.6	86.5
Game 9-12	1.1	20.4	78.6	Game 9-12	0.0	16.7	83.3
Game 13-16	0.5	8.4	91.2	Game 13-16	0.0	11.5	88.5
<b>Game 1-16</b>	<b>1.2</b>	<b>17.1</b>	<b>81.8</b>	<b>Game 1-16</b>	<b>0.8</b>	<b>14.5</b>	<b>84.8</b>

This finding does not conform to findings obtained from studies conducted by Selten and Stoecker (1986), Cooper et al (1991, 1996) and also Andreoni and Miller (1993) (see table 3). Table 2 shows that the subjects tend to choose Nash equilibrium strategy and there is little evidence of tacit cooperation. It should be noted that the existence of tacit coordination supports the view that not all individuals follow rationality assumption as stated in economic theory. It also implies that individuals may not perfectly be *homo economicus*. The result from this experiment, however, suggest that the majority of the subjects behaved rationality as prescribed in game theory and also in economic theory.

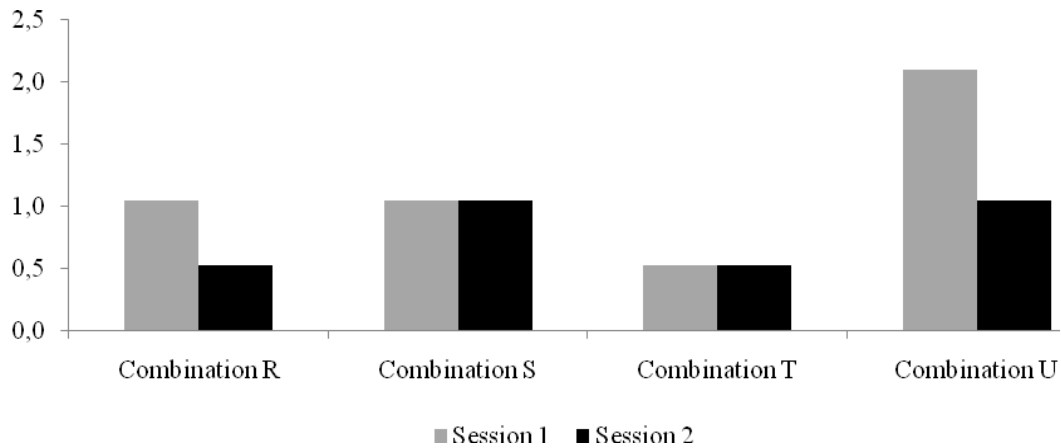
**Table 3. Results of Cooper et al. (1991)**

Games	Proportion of (A,A)
1-5	43%
6-10	33%
11-15	25%
16-20	20%

Source: Cooper et al. (1991)

Figure 1 and 2 revealed the proportion of particular strategy in each payoffs combination group. Figure 1 shows no particular pattern throughout the payoffs combination. It should be noted that the proportion of Pareto optimum strategy is relatively higher in combination U in comparison to the other combinations. This propensity is similar to that of in Figure 1, whereby players tend coordinate where the cost of coordination is low and the benefit of such is high.

**Figure 1. Proportion of Pareto Optimum Strategy in Each Payoffs Combination**



The pattern in Figure 2 is identical to that in Figure 1. The proportion of Nash Equilibrium in combination U is relatively lower. However, the proportion in combination U increases in the second session. It is not surprising since players tend to be rational in the closing stage of experiment.

**Figure 2. Proportion of Nash Equilibrium Strategy in Each Payoffs Combination**

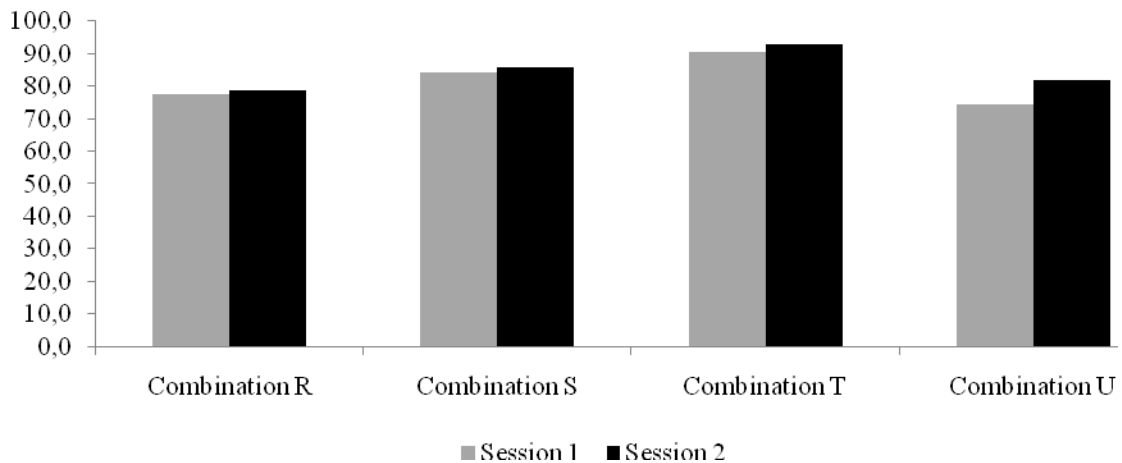


Table 4 shows that majority of players chose strategy B in session 1 with a range of 86.2-95.1%. The range of players not willing to coordinate increased from 89.1 to 96.1% after the implementation of framing effect. The framing effect had been implemented by renaming strategies A and B with strategies 'willing to cooperate' and 'not willing to cooperate'. The results may indicate that players are rational even after the implementation of framing effect.

**Table 4. Proportion of Strategy in Each Payoffs Combination**

<b>Session 1</b>	<b>R</b>	<b>S</b>	<b>T</b>	<b>U</b>
A	11.7	8.3	4.9	13.8
B	88.3	91.7	95.1	86.2
<b>Session 2</b>	<b>R</b>	<b>S</b>	<b>T</b>	<b>U</b>
Coordinate	10.9	7.6	3.9	9.6
Not to coordinate	89.1	92.4	96.1	90.4

## 5. Conclusion

The results of the experiment are quite unique in comparison to that of the previous experiments which mostly were conducted in developed countries. First, we observe no significant difference between male' and female' decision where both tend to choose strategy B and not to coordinate. We also observe that players tend to maximize their gains by choosing strategy B and not to coordinate. Pairs also tend to engage in Nash Equilibrium during the experiment, in contrast, only 1.2% and 0.8% of pairs in the first and second session respectively that chose Pareto optimum strategy. The results also show that proportion of players that choose strategy B accounted for 0.90 and 0.92 in the first and second session respectively. The results suggest that the subjects in this experiment tend to behave rationally. The majority of players tend to maximize their own gains and show little altruism throughout the game.

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