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Investigating factors affecting cooperative and non-cooperative behavior: An experimental game in the classroom(1)

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Abstract. *Cooperative/non-cooperative behavior of individuals is one of the factors affecting the welfare of society. The prisoner's dilemma is a strategic game that demonstrates the common problem of cooperation in many areas of economic and social life. The basis of the problem of cooperation in this game is that the players in the game follow a worse equilibrium strategy while there is a better equilibrium (Pareto Efficiency) for them. This study aims to examine the cooperative/non-cooperative behavior of the students who are in an exam process by creating a similar situation with the prisoner's dilemma with a question. With this experiment, the possibility of gaining additional points to the exam points was presented to attract the students. These points represent the "pay off" in the prisoner's dilemma game. As a result, it is seen that students act in a similar way to the resulting equilibrium in the prisoner's dilemma game. In addition to these findings, it is determined that cooperative/non-cooperative behaviors of students are significantly affected by gender and course success factors.*

Keywords: game theory, cooperative behavior, non-cooperative behavior, design of experiments

JEL Classification: C70, C71, C72, C90.

Introduction

In the literature, Neumann and Morgenstern's (1944) study is considered to be the first mathematical expression of the concept of "conflict" between individuals. By the development of "Prisoner's Dilemma" concept which formed by Flood and Dresher (1950) and enhanced by Tucker and John Nash's definition of equilibrium with modern non-cooperative games (later called Nash equilibrium), the foundations of game theory are laid.

Game theory plays an important role in understanding economic problems and strategic behaviors in economics science (Gintis, 2000). The concept of the game here can be expressed as the basis of strategic interaction that expresses the constraints defined by the players (economic units) moves and the benefits they will receive as a result of these moves. Game theory is a discipline that proposes analytical and intuitive solutions (equilibrium) and examines the properties of these solutions for these games (Yılmaz, 2009). The Prisoner's dilemma is one of the classic examples of game theory. In the classic form, the prisoners' dilemma scenario is as follows: Two suspects were taken into custody because that they had committed a crime. The police do not have sufficient evidence to arrest them unless at least one of the suspects confesses. Thus, the police put both suspects in two different cells and offer them an agreement. According to the agreement, if both suspects remain silent and do not confess, both of them will be sentenced to one month's imprisonment. If both confess, both suspects will be sentenced to six months' imprisonment. Finally, if one of the suspects confesses and the other remains silent, the confessor will be released and the one who chooses to remain silent will be sentenced to 9 months' imprisonment.

The problem of prisoners is represented by a matrix of 2 × 2 dimensions as follows.

Figure 1. *Prisoner's Pay-Off Matrix*

		Prisoner 2	
		Remain Silent	*Confess*
Prisoner 1	*Remain Silent*	-1,-1	-9,0
	Confess	0,-9	**-6,-6**

So both suspects have to choose between strategies to admit or remain silent. Both suspects are not able to communicate with each other (cooperation is impossible). According to this, the player who is unaware of the other's move will not remain silent and will choose a confession strategy by considering the possibility of serving a 9-month imprisonment. By confessing the crime, he will either accept a prison sentence of less than 1 month or be released. The player here aims to minimize his loss (maximize his pay-off). This means that the player's "admit strategy" is the dominant strategy. Since the pay-off values in the game are the same, in the other word the game is symmetrical; the other side will inevitably confess by acting rationally under the same conditions. Therefore, the equilibrium of the game is the strategy profile of the players' moves (confess, confess) and as a result (-6, -6) the situation also reflects the Nash equilibrium of the game. Thus, the decisions taken by the two sides who do not communicate with each other have increased the imprisonment that they may have less by acting rationally, not in good faith. If both suspects had the

opportunity to communicate with each other, they would cooperate and remain silent and sentenced to less imprisonment (Gibbons, 1992). The importance of the prisoner's dilemma game is that it is a strategic game that demonstrates the common problem of cooperation in many areas of economic and social life. For the players in this game there is a better equilibrium (Pareto efficiency), while they follow a worse equilibrium strategy.

Game theory makes it easy to explain some concepts that seem difficult to understand in strategic interaction between economic agents. In this respect, some games in the game theory have become classic in terms of the situation they describe. Prisoner's dilemma is one of them. The situation described by the prisoner's dilemma is used to analyze the strategic behavior of oligopolistic firms that are aiming at profit maximization. Besides, it is used to discuss a wide range of issues such as the causes of corruption, defence spending decisions of countries etc. (Kofman and Lawarree, 1996).

In order to see the practical examples of classical games used in game theory such as the prisoner's dilemma game, classroom experimental analyses are made in the literature (Nelson and Beil, 1994; Hemestah, 1994; Cooper et al., 1996; Eckel and Grossman, 1998; Holt and Capra, 2000; Alba-Fernandes et al., 2006; Marks et al., 2006; Innocetti and Pazienza, 2006; Nagatsuka and Kawamura, 2016 and Nieswiadomy, 2012). However, not only the prisoner's dilemma game, but also the classic games such as dictator game, trust game, battle of sex, cooperation game, chicken game, bargaining game are applied in the classroom. Players are students in these games. The strategies, goals and constraints of the players are also designed according to the students' classroom environment. For example, Alba-Fernandes et al. (2006) designed a complex classroom environment game for students to understand Nash equilibrium in their classroom experimental study. Eckel and Grossman (1998) made an application of dictator play in their classroom experimental study. In this game, they evaluated student decisions based on the gender factor. They concluded that women were more generous than men. Innocetti and Pazienza (2006) concluded that women exhibit a higher degree of altruism than men for both trust and trustworthiness in the design of classroom play, which was modelled on the gender factor. In the experimental studies of the prisoner's dilemma game, the behaviors (strategies) of the students were evaluated in terms of many factors such as gender, nationality, class and age. Hemestah (1994), in his study between American and Russian students, found that in the case of prisoners' dilemma, Russian students behaved in cooperative rather than acting rationally compared to American students. McPherson and Nieswiadomy (2012) evaluated the prisoner's dilemma status in terms of gender, nationality, class and age factors. According to the findings of the study, it was concluded that female students were more likely to behave in cooperative than male students.

This study aims to examine the students' cooperative/non-cooperative behaviors and the factors affecting these behaviors by creating a similar situation to the prisoner's dilemma with a question asked to the students during the exam process. However, although the literature is extensively vast so far, to the best of our knowledge, no studies have evaluated the cooperative/non-cooperative behavior of individuals (students) during the exam process based on the prisoner's dilemma. Moreover, the design of the game in this study is thought to be original in terms of the method of application of the experiment, also.

The following section includes design and solution of the game (experiment) and Section 3 provides the experimental results and discussion, while Section 4 concludes.

1. Strategic game design and solution (equilibrium)

In the classroom design of the prisoner's dilemma game, the players used as a substitute for the prisoners are students as indicated in the above section. In this study, the designed method of the game is not applied to the students in the classroom environment and with a questionnaire as in the studies in the literature. In the study, the game was designed and implemented in the classroom environment only in the form of the status of students in the midterm exam.

In the mid-term exam, which consists of 22 multiple-choice questions, the students were asked one additional question (question 23) as follows[2]:

Figure 2. *Question designed for strategic game*

> **23)** You can get extra points for your exam by marking the question below. **You can get 5 points by marking option A) or 15 points by marking option B).** But I have a small condition. *If more than 10% of the class marking to option B), you will not get any points* (Only I will see your answer, the rest of class will not see what you answer).
> **A)** 5 points
> **B)** 15 points

With this question, students have the possibility of additional points for exams. So, if the students answer the question, they can get a real pay-off. As a result, the student's interest in the game is expected to increase and will make more realistic decisions. Evaluating the problem of students in the game with a simple 2×2 dimensional matrix can simplify the solution of the game. The matrix in Figure 3 is considered for any student (for example, student-1).[3]

Figure 3. *Pay off matrix of students*[4]

Other Students ($N < \%10$ **)**

		Option A)	*Option B)*
Student-1	*Option A)*	**5 point,** 5 point	**0 point,** 0 point
	Option B)	0 point, 5 point	**0 point,** 0 point

Other Students ($N \geq 10$ **)**

		Option A)	*Option B)*
Student-1	*Option A)*	5 point, 5 point	**0 point,** 0 point
	Option B)	**15 point,** 5 point	**0 point,** 0 point

According to the design of the game, student's strategies and payoffs at the end of the game are as follows:

- If other students mark option A), and if student-1 mark option A), all students in the class will receive 5 additional points *(regardless of the number of students).*
- If only student-1 marks option B) and other students mark option A), if the number of students is greater than 10, student-1 will receive 15 additional points and all other students will receive 5 additional points. If the number of students is less than 10, student-1, 0 additional points other students will receive 5 additional points.
- If other students mark option B), if student-1 marks option A), student-1 appears to receive 5 additional points and the other students will receive 15 additional points. However, since more than 10% of the class in such a case marks option B, all students will receive 0 additional points *(regardless of the number of students).*
- Finally, it seems that if student-1 and other students select B), they will get 15 additional points. However, as this rate reflects the fact that more than 10% of the class marks the option B), all students will receive 0 additional points as a result *(regardless of the number of students).*

In this game, students are forced to choose between strategies A) marking (Cooperative behavior) or B) marking (Non-cooperative behavior). Using the exam environment as an experimental environment prevents students from communicating with each other. Thus, it is thought that this created an experimental environment similar to the situation where the players in the prisoner's dilemma could not communicate.

Student's behaviors can be analyzed in the framework of the prisoner's dilemma game as follows:

First of all, all students know that the number of students taking the exam is greater than 10 ($N \geq \%10$). Therefore, it is not necessary to evaluate the first matrix in Figure 3. Student 1 (any student) who is unaware of the moves of other students will mark option B) considering the possibility of 15 additional points. Thus, he will get 15 additional points with a 10% probability. Here the student aims to maximize her/his pay offs. This means that the student's strategy to marks option B) is a weak dominant strategy. Since the game is symmetrical, there is a possibility that other students will be able to mark option B) by acting rationally under the same conditions. Therefore, the Nash equilibrium in this game can be expressed mathematically as follows. In a class that is supposed to be 100 students, after 11 students marked option B) and 89 students marked option A, every situation where the number of markings of option B) increases, is the Nash Equilibrium. That is, 12B)-89A), 13B)-88A),…, 99B)-1A), 100B)-0A). All of these situations represent the Nash equilibrium. So there is multiple Nash equilibrium in the designed game. Consequently, the Nash equilibrium of the game for $N \geq \%10$ is the strategy profile in which students' moves are [B), B)], and pay offs (0 points, 0 points). Thus, all students who cannot communicate with each other will receive 0 additional points by exhibiting non-cooperative behavior (in a one respect, they make rational decisions). If they had exhibited cooperative behavior, they would have received 5 additional points.

With the implementation of the experiment, we will see which equilibrium strategy the students follow. Also, we will divide the students into different categories with the

equilibrium that will occur in the game and evaluate their balance strategies within the framework of cooperative/non-cooperative behavior.

2. Findings

The experiment was conducted with the students who took the introduction to the Economics midterm exam in the 2016-2017 spring semester of Uşak University School of Applied Sciences. A total of 407 students participated in the experiment but 33 students were not included in the experiment because they left this question blank. Therefore, it was assumed that the experiment was performed with 374 subjects. Cooperative/non-cooperative behaviors of the students included in the experiment were evaluated in 6 different categories. The information about success, gender, nationality, degree, department, and education variables are given in the table.(5)

Table 1. *Descriptive statistics*

Variable	Categories		Min=0	Max=1	Obs.
success	Fail=0	Success=1	154	220	374
gender	Male=0	Female=1	194	180	374
nationality	Domestic=0	International=1	328	46	374
degree	Junior=0	Senior=1	267	107	374
department	IT=0	BF=1	108	266	374
education	Evening=0	Normal=1	171	203	374

When Table 1 is examined, it is seen that 220 out of 374 students who participated in the experiment were successful in the Introduction to Economics course. It is seen that 180 of these 374 students are girls, 46 of them are foreign nationals, 107 of them take courses again, 266 of them are studying in the department of Banking and Finance (BF) and 108 of them are studying in the department of International Trade (IT). Finally, it is understood that 203 of these students are studying in normal education. With the application of the experiment together with the exam, the statistics of the answers given to the 23rd question representing the cooperative/non-cooperative behaviors of the students are shown in Table 2. Table 2 can also be said to represent the equilibrium profile of the designed strategic game.

Table 2. *Equilibrium profile of the game*

Cooperate/Non-cooperate	N	%
Option B) (0)	171	45.72
Option (A) (1)	203	54.28
Total	374	100

According to Table 2, 45.72% of the students marked option B). In other words, 45.72% of the students showed non-cooperative behavior. 54% of the students marked option A). In other words, 54% of the students chose to accept 5 additional points by showing cooperative behavior. However, as stated in the design of the game, no player will receive additional points if more than 10% of the players mark option B). In this case; As a result of the students 'strategies, the students fell into a situation where the prisoners in the prisoner's dilemma game fell. As a result of the experiment, the Nash equilibrium strategy profile of the game is provided, That is, (0 points, 0 points). In other words, while in this

game have a better equilibrium strategy for students (5 points, 5 points), they followed a worse equilibrium strategy (0 points, 0 points).

Evaluating students' cooperative/non-cooperative behaviors in different categories is seen as a separate contribution of this study to the literature. The two main analysis tools that come to the fore are the Probit and Logit models. Probit and Logit models are generally applied when the dependent variable is categorical (Peel et al., 1998). Probit analysis is a model used to find the effect of one or more explanatory variables on a categorical response variable as an alternative to the logit model (Long and Freese, 2006; Dey and Astin, 1993). In this study, the Probit regression model was used to evaluate the student's equilibrium strategies with different categories. Probit Analysis results are shown in Table 3.

Table 3. *Probit analysis results*

Variable	Coefficient	dy/dx	z
success	0.949***	0.037	6.42
gender	0.344**	0.013	2.5
nationality	-0.002	-0.088	0.09
degree	0.134	0.053	0.81
department	0.207	0.082	1.27
education	0.005	0.002	0.04
constant	-0.208		-0.96
	Obs.	374	
	Log likelihood	-256.46284	
	LR chi2 (6)	0.8326	
	Pseudo-R2	0.054	

Note: Dependent variable is the cooperate/non-cooperate variable. ***, **, * reflect the 1%, 5%, 10% level of significance respectively.

According to Table 3, there is a statistically significant relationship between the success variable and cooperative/non-cooperative strategy. The coefficient of the variable is positive, so it is possible to say that those who are successful in the economics course are more likely to choose a cooperative behavior strategy than those who fail. When we look at the marginal effect, it is seen that this ratio is 3.7%.

Again, according to Table 3, another significant variable is the gender variable. There is a statistically significant relationship between gender and cooperative behavior strategy. The coefficient of this variable is positive, also. Thus, it is possible to say that girls are 1.3% more likely to choose a cooperative behavior strategy in gender variable than boys. This result is consistent with the fact that women are more generous, altruistic, gentle, and reliable than men in the experimental economics literature (McPherson and Nieswiadomy, 2012). Since the probability value of other variables is greater than 0.05, it can be said that these variables do not have a significant relationship with cooperative/non-cooperative behavior strategies.

3. Conclusion

This study is a classroom experimental analysis of the prisoner's dilemma game which is one of the classic games in game theory. The importance of the prisoner's dilemma game; in the equilibrium of the game, the situation in which the prisoners fall is to follow a worse equilibrium strategy by acting rationally while there is a better equilibrium for them if they

follow a cooperative strategy for the prisoners. The results obtained from the experimental classroom analysis; 45.72% of the players (students) exhibited non-cooperative behavior (rational) and this means that more than 10% of students marked option B) as stated in the design of the game. In this way, no student could get additional points and they behaved into a situation as in the prisoner's dilemma game. This shows us that the Nash equilibrium strategy profile of the game designed with the experimental findings is similar. In other words, they have followed a worse equilibrium strategy while there is a better equilibrium for students. Along with this equilibrium in the game, the students' equilibrium strategies were evaluated according to different categories such as success, gender, department, degree, nationality, and type of education.

According to the findings; it is concluded that those who are successful in the introduction to economics course are 3.7% more likely to choose a cooperative behavior strategy than those who fail. Another find; It is concluded that girls are 1.3% more likely to choose a cooperative behavior strategy than men. It is seen that this result is consistent with the fact that women are more generous, altruistic, gentle, and trustworthy than men in the experimental economics literature. Other factors were not found to have a significant relationship with cooperative/non-cooperative behavior strategy.

Notes

(1) Abstract version of this paper was presented at SCF Conference, 22-23 September 2016, Turkey.
(2) A copy of the exam paper, including the experiment question, can be seen in Appendix 1. The duration of the exam is 40 minutes. The language of the exam is Turkish. However, only the experimental question was translated into English for this study.
(3) We cannot represent strategic situations with more than two players in matrix form. We do this completely to simplify understanding the game.
(4) The underlined pay off indicate the pay off the student-1 has obtained as a result of her/his best response.
(5) This information is provided from Uşak University Student Information System.
(6) Only the back side of the exam paper, which was asked the experimental question, was added.

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Appendix 1. EXAM PAPER[6]

13) TCBM'nin para arzını azaltarak ekonominin büyümesini yavaşlattığını düşünün. Böyle bir durumda ortaya çıkacak işsizlik türü nedir?

A) friksiyonel işsizlik
B) yapısal işsizlik
C) konjonktürel işsizlik
D doğal işsizlik

14) Hangi ekonomik durumda enflasyon oranlarının düşme, işsizlik oranları artma eğilimlindedir?

A) hiperenflasyon
B) resesyon
C) stagflasyon
D genişleme

15) Türkiye ekonomisnde ölçülen şubat 2015 yılındaki tüketici fiyat endeksi(TÜFE-CPI) 255'tir. Şubat 2016 yılındaki tüketici fiyat endeksi 274'tür. Buna göre Türkiye'nin şubat ayı 2015-2016 yılındaki enflasyon oranı nedir?
A) 7.4%.
B) 12.7%.
C) 8.3%.
D) 6.3%.

Devletin uluslararası sektörün olmadığı keynesyen model çerçevesinde; Megadeth Cumhuriyeti'nin ekonomisi Denklem-1 ile karakterize edilmiştir.

DENKLEM-1:
$C = 500 + 0.9Y$
$I = 300$

16) Denklem-1 'e göre Megadeth Cumhuriyetinin denge gelir(GDP) seviyesi nedir?

A) 10000.
B) 9600.
C) 11200.
D) 8000.

17) Denklem-1 'e göre Megadeth Cumhuriyeti'nin makro ekonomik dengede(*keynesian cross*) sırası ile denge tüketim ve denge tasarruf seviyesi nedir?

A) 7700;300
B) 8700;400
C) 9700;300
D) 6700;400

18) Denklem 1'e göre; Megadeth Cumhuriyetinde çarpan katsayısı nedir?
A) 8
B) 4
C) 6
D) 10

19) Denklem 1'e göre; Megadeth Cumhuriyetinde otonom yatırımlar 350$'a çıkarsa yeni denge çıktı seviyesi ne kadar artar?
A) $100.
B) $200.
C) $500.
D) $800.

20) Sadece özel sektörün olduğu Megadeth Cumhuriyeti'nin çarpan katsayısını etkileyen parametre nedir?

A) beklentiler
B) gelir vergisi oranı
C) marjinal tüketim eğilimi
D) faiz oranları

BONUS: 21 ve 22 soruların sırası ile doğru Türkçe ve İngilizce karşılıklarını bulunuz.

21) Growth-depreciation-interest-employment-output

A) büyüme-dalgalanma- faiz -işsizlik-çıktı
B) aşınma- dalgalanma- faiz -istihdam-üretim
C büyüme-aşınma-faiz-işsizlik-üretim
D) büyüme-aşınma-faiz-istihdam-çıktı

22) daralma- nüfus- milli gelir- genişleme- harcama

A) expansion- population -average income-recession-consumption
B) recession- population -national income-expansion-consumption
C) recession- population -national income-expansion-expenditure
D) expansion- population -average income-recession-expenditure

23) Aşağıdaki soruyu işaretleyerek finalinize ekstra puan alabilirsiniz. İster A) şıkkını işaretleyerek 5 puan, ister B) şıkkını işaretlerek 15 puan alabilirsiniz. Ancak küçük bir koşulum var. Eğer sınıfın %10'undan fazlası B) şıkkı 15 puanı işaretlerse hiçbir puan alamayacaksınız(cevabınızı sadece ben göreceğim sınıfın geri kalanı ne cevap verdiğinizi görmeyecektir.

A) 5 puan
B) 15 puan

Süre 40dk.
Öğr. Gör. Metin TETİK
Başarılar
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