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An Enquiry on the Dynamics of the Finitely  
Repeated Prisoner's Dilemma

A Research Approach and Some Social Considerations

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To Patrizia, Franco and Giacomo

## Aknowledgements

It is always dangerous to write aknowledgements about the people who contributed to your work. It is easy to forget someone, especially, after all the cooperation a person can have in an academic environment. All the people that are not included directly, will forgive me, I hope so.

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## INTRODUCTION

Defining the field of an argument is always difficult, especially when it treats human behaviour. Economics has always been fascinating to me for the insights it gives on human behaviour. Every research starts from a problem, that is, an evidence of a phenomonic event that we experience and we want to explain. The most important thing resides in “feeling” the problem. You have to live the problem in order to endogenize it and face it properly. In light to these facts, I would like to spend a few words explaining the underlying problem of my research and see how I would like to deal with it. Sciences are evolving following an always specializing fashion (fragmentation of knowledge) that departs from the potential universal explanation that is the proper aim of science. A unifying and systematic theory is the objective of every great mind; unfortunately it is not in my means to do so. It is for this reason that I will try to build something at the margin, exploring the limits of the existing field of game theory. A deep contribution is when the limits of a science are demolished and rebuilt; giving new insights on reality and how we conceive it. I am trying to deal with some aspects of game theory that are not revolutionary per se’, nonetheless, they may enlighten a different way of conceiving facts. I will consider the importance of framing effects while modelling experiments. The game I took into consideration is the finitely repeated prisoner’s dilemma. The main reason is that it is an easy game to deal with and furthermore, it gives many interesting insights on human behaviour such as cooperation, trust and defection from efficient equilibrium. Incentives play a great role in the outcome of the game. In social terms, this game seems to provide interesting aspects of human cooperation based on framing effects and social relations. In particular, the moves of the game seems to be socially influenced through a process of endogenous socially constructed preferences. This is verified by running experiments with children. Framing is explored in the literature mainly from the manipulation of payoffs and incentives (quotation needed). Those surely are an important part of framing

but not the only ones. Through some experiments and analysis, I have discovered how different framing may also arise in the wording used while explaining the game. The word “game” per se’ seems to lead to a mood setting in which players conceive the situation as a proper game in which the objective is defeating the opponent. Results show this framing effect as opposed to a situation in which the word game is never used. The underlying questions that are behind those experiments are the following:

- Why do we observe different behaviours from the ones predicted by the theory? What implications have an enquiry on real behaviour observations?
- How can we represent a framing effect in reality? What does it mean? Why do we need to understand people behaviour?
- What happens in a situation in which players are not realizing to play a game at all?

An entire philosophical body of knowledge has been written upon the relation between theoretical models and real observations. It would be interesting to go through it in order to give some philosophical consistency but it would take too much time. Curiosity may also be an optimal foundation to justify the investigation of this relation. Questions about the meaning of things come from the ancient times and I think it is an innate passion of the man. I found interesting to understand why people cooperate and what bring them to do so. From the experiments, I have noticed that people behave in many different ways and the path they choose is really inconsistent with predictions. Why it is so? Is the theory inconsistent? Enquiring those questions mean going towards a paradigmatic shift that may represent the end of the homo economicus in the long run. A future challenge may be represented in the formulation of new models and frames that can better represent human behaviour. Refinement of assumptions might lead to framing situations in a different setting; producing different predictions. The ultimate question of researches may easily fall in a sceptical sphere that produces non-sense. It is very likely to fall in this situation while dealing with human interaction and the aim of it. It is thus

important to give a strong consistency between the foundation of the problem and the treatment of it. Thus it is important to state that the aim of this research is to understand, through, economic investigation and methods, why people in an alike prisoner's dilemma situation decide to defect from the cooperative equilibrium and cheat on another people, while it is obvious that an outcome may be better for both, thus Pareto efficient. This point of view will analyse the connection between the notions of equilibrium and social frames. Interesting results emerged from the experiment.

### **1.1 Presentation of the problem**

The word problem comes from ancient Greek *προβάλλω* (*proballo*, "to throw or lay something in front of someone, to put forward"), where the suffix *προ* means "in front of". Etymology renders one aware of the significance of words. It might seem a bit naïve to talk about those things in economics but I find it relevant in order to give proper foundation to everything. When you enquire a problem, you are put in front of a question of which you partially understand the way to the solution. If the problem were something completely unknown we would not even pose a question about it. It is logical to say that when you recognize a problem is because you pre-comprehend the answer. Whenever you think of something, you are posing a question that is put forward to your thoughts. It is the possibility of knowledge to arise through time and space. It may seem a matter of metaphysic sphere, but it concerns reality and its phenomonic expression. The problem I am dealing with arose during my course in game theory, especially while dealing with the prisoner's dilemma. I could not accept that people could end up in the Nash equilibrium while having the possibility to come up with a solution that was far better for both, namely, the cooperative outcome. At the beginning of the course I have been presented with a game to be played. The first question that came to my mind was: how should I play this game? Probably when I will know something more about game theory I will be a master and I will always win! This gave me the intuition that perhaps game theory is requiring the player to play in a certain way. The rules of games probably give a qualitative direction to the moves of the

player that is quietly the opposite of what an experimenter wants. In order to analyse a real alike situation you may not want the player to be biased on how to play. I remember the pressure I felt while being asked to play a game in class. I always thought of the “best” and most “rational” solution I could adopt not to make a bad performance in front of others. The main field of game theory takes into account rational behaviour founded in pure economics. Most of game theorists are not interested in concepts such as focal points or social influences. They do think of strategies that are consistent with some axioms and produce a path that lead to a possible equilibrium or solution to the game. I have always been told that I was not reasoning in equilibrium, my mind told me that probably I was not good at it. I also thought that I would not have behaved that way in a real situation (this is mainly for every game!). This is not to say that every situation is not taken into account by game theory, rather, it is to stress the importance of “strange” situation that in game theory are not deeply analysed; given the fact they are inconsistent with strategic path that represent an outcome of the game. The outcome of the game is the solution of it. Probably, I have always thought that there was some meta-physical reason for it to occur but I was wrong. I believe that the positive aspect of game theory is easily not confirmed by experiments (see prospect theory, and other experiment, inconsistent lottery and so on). Moreover, people tend to move in different directions from predictions as many studies reveal. I am not able (and not willing) to demolish game theory but behaviour seems to be much more complex than how it is explained by its axioms, i.e. the completely rational individual who has a prefixed aim that has to be consistent with the definition of rationality. Those are impossible constraints to assign to a normal person who lives his life quite differently from a pure mechanic unnatural calculator. In the end, also game theorists are people and as such I hope they have feelings and emotions. Those very basic sides of human behaviour are not often taken into consideration since they are not so easily analytically identifiable, but they exist and they influence human choices and behaviour. Is there any universal moral foundation or justification that can arrogate game theory to appropriate the possibility of prescribing human behaviour? I do not think so. The willingness to understand human



behaviour does not only reside in the possibility to foresee it. It underlines the curiosity to understand why people make determined choices with respect to others that are deemed better by following some principles. As I wrote in the introduction it is quite easy to fall in a sceptical position. We could argue upon what are the basic principles on which we want to base our actions' comparison term. Despite my critical position with respect to rationality axioms, I think that everybody would like to have some utility from the things one does. I will not go into the merit of what utility means. John Stuart Mill did far a better job than I can do now, so I will take into consideration utility as the driver of human actions, (maximization of happiness as utility see Frey, 2000). I will move in the field of behavioural game theory which addresses the same critiques to pure game theory, especially, on the "non ability" of mainstream theory to describe actual choices by people (and also institutions in the case of behavioural game theory radical critique). The way behavioural game theory acts while analysing interactions is divided mainly in three steps (Colin F. Camerer, 1997). The starting point is:

- The presentation of a game or a naturally occurring situation,<sup>1</sup> with the standard game theory bold prediction based on its principles and axioms,

Secondly,

- Notice if observed behaviour is different from the prediction and think of plausible explanation for its deviation from standard theory

Last step consists of,

- Extending, if possible, the field of formal game theory by incorporating these explanations.

One relevant problem that arises in the literature (Camerer, 1997) focuses on the problem of choice and judgement: situations in which players (or

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<sup>1</sup> This distinction is very important. I will not go into depth in the explanation in this section since it will be covered in the next section. Up to this point it is important to state that the distinction between a game and a naturally occurring situation it is important in terms of framing effects.

people) respond to differences in the description of the game rather than to the outcome. This is typically known as a framing effect. I will take into consideration many aspect of the prisoner's dilemma in which changes in frames produce a change in the interaction between the two players. The innovative step consists of trying to understand what is the nature of frames and understand why and how people respond to changes in particular frames. This is a dangerous step because it is like decomposing the parts of game theory and analyse them in particular. The most difficult part is when rebuilding the whole castle. The hope is that it will not go down killing the king. It is necessary now to find the structural link between frame and interaction, especially in the prisoner's dilemma setting. Interaction arises commonly in everyday's activity. A person can interact with people in many different ways. Formalization impose the following definition<sup>2</sup>:

“Interaction is a kind of action that occurs as two or more objects have an effect upon one another. The idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect.”

From this definition we notice the importance of reciprocity. Each player knows or at least it could be in the possibility to know that each move will affect the other person and vice versa. This renders the interaction strategic. The essential aspect to understand is that interaction happens into a context and it is a behavioural phenomenon. As behaviour is put under certain axioms we expect to observe a determined kind of strategic interaction that follow logically. As the fundamental question of behavioural game theory goes: Is game theory meant to describe actual choices by people and institutions or not? (Camerer, 1997). It seems that game theory is following an ever mathematical refinement that ordinary people is not apt to adopt in everyday situation. Its models depart from reality moreover they predict outcomes that are far from people actual choices. The problem resides in the choice mechanism that gives a qualitative path to the choice pattern. It seems counter intuitive. In fact, if we take into consideration a course in game theory and encounter the Bach or Stravinsky game we find two possible Nash equilibria. The chosen one is a matter of focal points and

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<sup>2</sup> Definition as taken from the dictionary.

social interactions. It is not deemed important by game theorists since it is not possible to explain which behaviour will arise. This might seem as a refrain from giving qualitative statements about the outcome of a game. Since the existence of framing effects the outcome of the game receives some qualitative directions by the very moment of its explanation. Nash equilibrium notion involves some how a social sphere that we will analyse in depth in later sections. One thing that game theorists could ascertain in a sound scientific way is the way people have the conditions of possibility of choice. It is not only the way of choosing that it is important rather, the possibility for people to choose. The characterization of this statement may sound too philosophical but it is a highly debated issue (we could say it is at the core of economic science). The link with game theory is that in a way, by giving full axioms about rationality you are giving some qualitative aspects to the process of choice. Rational way of choosing is completely different from the irrational one; but still they are two possible ways of choosing. In reality we do encounter many examples of irrational behaviour or reversal of preferences. In light of these facts, it could be productive to challenge the assumption of the theory in order to refine models and predictions. I would start from the definition of economics as the science of resource allocation. Allocation is a process deriving by choice, thus the first logical thing to do is to justify the process of choice in human behaviour. In order not to give a clear cut qualitative definition I will use the Zermelo axiom of choice in order to found the action of choice in a pure descriptive way. The second step consists of building all the wrapping around this axiom of choice. The outcome will result in some qualitative (ex post) aspects observed during experiments.

## **1.2 The Importance of choice**

In this brief section I will give a really brief description on how I conceive choice. My experiments' aim is to understand how people behave under a prisoner's dilemma setting. It would be required to go through the whole body of decision theory knowledge but it would be out of the scope of this thesis. It is in my aim to understand the characteristics of players' decisions. The methodological step I will follow is to take into account the Zermelo axiom (Zermelo, 1904), in which he establishes the possibility of choice in mathematical terms. This is useful because it does not give any qualitative constraints and I will also assume that all the decision processes enumerated in game theory do not exist, in order to give consistency to the axiom of choice. Why this? I have to base the possibility of choice on a solid ground, but I decided not to use the already pre-existent methods used in game theory. As a result, I will be able to confront my experimental results in a pure way to all the possible decision rules and the link with framing effects will be more evident. If I followed only the game theoretical decision processes my results would be only valid if consistent with the theory. On the other hand, by using a general axiom on the possibility of choice it gives me the chance to examine every situation as a situation in which nothing has been noticed before. I will assume at the beginning of every game that the player will choose thank to its ability of choosing. Afterwards, I will try to see how the framing of the game has affected this process or whether the game is led by socially framed preferences. Every player has a choice function defined on  $X$  for any set  $X$  of nonempty sets. That is to say that each player can always decide what to do and the use of Zermelo axiom prove the possibility of choice. One last important consideration about choice is utility. I assume that people try to get utility from what they consume and choose, so the choice function will take into consideration the elements that give a certain level of utility to the players. It is interesting to see how framing affects utility and changing preferences. In theory they should never change even if experimental results are inconsistent.

### 1.3 Framing Effect

Before presenting the experiment and discussing results it is useful to better define what a framing effect is. In economics, framing is the manner in which a rational choice has been presented to the players. It is useful in order to see how the predictions of the theory change as a function of different framings. Bold theoretical game theory has its say upon framing effects. As Camerer noticed (Camerer, 1997), a framing effect occurs when a difference in description does cause behaviour to change as opposed to the traditional prediction invoked by the axiom of description invariance (Camerer, 1997). The axiom states that differences in descriptions of the game that do not change the actual choices should not alter behaviour. This is related to the perception players have regarding the game or the situation. From experimental results it is possible to evince that players do change perception and the game is conceived in a completely different situation. A famous example of the framing effect is in the experiment of Amos Tversky and Daniel Kahneman (Amos Tversky and Daniel Kahneman, 1981). The experiment “Asian disease” shows that framing can affect the outcome of choice. In light to these results, the two authors came up with the famous Prospect theory, which challenged many of the classical axioms of rational choice theory. In brief, their experiment can be described as follow:

*Tversky and Daniel Kahneman experiment on framing. “the Asian disease”.*

Participants to the experiment, divided in two groups were asked to “imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume the exact scientific estimate of the consequences of the programs are as follows” (from Amos Tversky and Daniel Kahneman, 1981). Now the two groups are presented

with two possible scenarios that are exactly the same a part from the frame. The first group were presented with a choice between two programs:

Program 1) 200 people will be saved

Program 2) there is one third probability that 600 people will be saved, and two third probability that no people will be saved.

The results are the following:

72 percent opted for program 1 the remainder ,28 per cent for program b.

Also the participants of second group were presented with two alternative programs:

Program 3) 400 people will die

Program 4) there is a one third probability that nobody will die, and a two-third probability that 600 people will die.

In this different frame they had the following results:

78 percent preferred program 4 and the remainder, 22 percent opted for program 3. If we take into consideration von-Neumann's expected utility theory hypothesis, in which the final outcome, or better, the expected value of an outcome is the sum of all possible outcomes multiplied by their probability of occurrence. Given this definition, programs 1 and 3 and programs 2 and 4 are identical in accordance to the previous theory. The experienced effect is the reversal of preference due to a change in the framing of the problem. This experiment contributed to the analysis of framing effects in the field of politics and finance with the rise of behavioural finance. A historical consideration imposes the tribute we have to give to the partially unknown statistical work by John Maynard Keynes: "John Maynard Keynes 1921 A Treatise on Probability" in which he criticizes the mainstream conception of probability of events. He proposed his "logical-relationist" theory where probabilities are linked to the subjective perception of the occurrence of events. This justified the great volatility of financial markets. At this point we have enough evidence to

justify the interest in framing effects and the consequences that the study of them can produce on mainstream theories.

#### **1.4 Methodological Considerations**

As I wrote in the introduction, methodology is fundamental in order to produce a coherent outcome. The possibility of following a logical path in the enquiry of one's research is mainly concentration, passion for the subject and of course being keen on it. The route to follow may be conceived as a straight line from the start to the end of the work. Fortunately, it is not that way. While facing an argument you always find different angles from which to analyse the situation, and sometimes they bring to completely different results. This is the most important thing in order to maintain a high intellectual profile. Nonetheless, it is fundamental to recognize where the limits of our thought arise. I will spend more words on those limits in this section, rather than talking on the achievement. Limits are the most important scientific aspect of a theory. Without limits you would not recognize a theory at all. Being aware of limits mean being aware on the scope of the theory. In this ever-evolving world it is better to leave presumption behind one's shoulder and accept the finite aspect of human being that characterizes us. The first consideration is about time and space. I did not have a lot of time in order to think in a more appropriate way about the topic. Space was confined in the possibility I had to develop more sophisticated experiments rather than home made ones. I could say I have personally experienced a framing effect while writing this thesis! Philosophically speaking the problem of induction is very famous in scientific environments so there is no need to go in depth with it. The focus of this research is mainly on framing effects, maybe it could have been implemented with other aspects of game theory that are not included in the present work. The protocol of experiments is not exactly the one exhibited in laboratories; this is due to the fact that I did use my leaving room in order to run experiments. Incentives were personally paid to players.

## SECTION 2

### **A brief introduction of mainstream Game Theory**

If we took the dictionary we would notice immediately how game theory is subject to the effects of framing: “ a game is a competitive activity in which players contend with each other according to a set of rules”. As Osborne noticed the scope of game theory is very much larger. Game-theoretic models tend to study some aspect of the interaction of decision makers. After the analysis the desired results consist of getting non-trivial results upon this interactions. The structural link of this process is the theory of rational choice that is the base of human interaction.

*The theory of rational choice, from economics to game theory*

Rational choice can be defined as a way of acting proper of many economic models especially in game theoretic ones. More specifically, it expresses the way a decision maker chooses its actions or better the best possible action among all the possible actions. If we take into consideration the concept of rationality we would go into a field that is not proper with respect to this argument. Philosophical considerations may arise from the centuries in which the meaning of rationality has been discussed. Fortunately, as economists, we can simplify things and state that rationality is the consistency that links decisions to the various alternative actions. This definition does not take into consideration qualitative aspects of choice even if, it is implying some sort of choice path that leads to some sort of consistency. This process would be clearer if implemented with the notion of preference. It is worthy to give a brief explanation on each theoretical component of game theoretic models, namely:

- Actions
- Preferences and Payoff functions
- Complete structure of the game



### *Actions*

We can think of actions by recalling set theory. Imagine a set  $A$  containing all the actions that are available to a person. These also represent a specification of the decision maker's preferences. If the player faces many different situations he is able to choose among subset of  $A$  depending on the situation. The player must choose a single element from a known subset. Subsets of  $A$  have the characteristic of being independent from the preferences of the player, try to imagine a consumption bundle and a budget constraint; there is a restriction imposed on choice. let us see now how preferences influence the choice since they cannot influence the domain of choice represented by a subset of  $A$ .

### *Preferences and payoff function*

Preferences represent the possibility of a person to compare different pair of actions, he may prefer action  $a$  to  $b$  or he can be indifferent between the two. An important property of preference is consistency of choice that implies transitivity: if  $a > b$ ,  $b > c$ , then,  $a > c$ . those preference can be numerically represented by some functions called utility functions or payoffs functions. Those functions are merely representative of preferences so they will mathematically rely on the assumptions made about preferences.

### *Complete structure of the game*

A game is structured around the interaction of two people who try to act with respect to their preferences and strategically understand the moves of the other player. The sequences or the duration of the interaction depends on the single structure of the game, and time is a very important factor as far as theoretical considerations are concerned. In example in infinite settings we may reach conclusions that are far from those that we might obtain by analysing the same situation under finite time, thus it is important to consider time as a fundamental aspect of the structure of a game. In this specific case time will be treated as finite since it is in my aim to stay closer as possible to a real life behavioural situations, the other reason is that in a finite setting the only conclusion or predicted outcome of the game is that the only possible result, is the inefficient Nash equilibrium. I want to prove that it may not be the case. With respect to this consideration time plays a marginal contribution.

#### **2.1 Explanation of the game**

The game's name comes from a story concerning two prisoners held in two separate cells and both suspects in a major crime. Evidence of having committed this crime is not enough for both prisoners but there is sufficient evidence that they both committed some minor crime, so the investigator hopes one of them will act as an informer. After this story the game is

particularly interesting for the implication it has on real life situations. If we take into consideration the definitions of preferences and utility function we can notice that this game setting has some interesting implications about human rational behaviour. The greatest utility one can reach is by harming his counterparty and cheat on him (and vice versa). The social optimum is far from easily reachable because every player would always have the incentive to cheat. Since both players both cheat they end up in the non-efficient outcome, basically the unique Nash equilibrium of the finite version of this game. The solution is very easy in terms of implications. The social optimum is not attainable since rational behaviour requires it not to be played. In social terms we could reason that incentives may drive out this distortion. Fortunately, some experimental results show that people is not always rational. In my research I argue that framing has an important effect on the understanding of the situation. Optimality may be reached also in this setting by framing the situation in a different way.

Hereby it is shown the payoff matrix:

Prisoner dilemma setting!		
	o3	y1
o3	3,3	0,4
y1	4,0	1,1

This matrix represents the actions a player can adopt. They are of course chosen following the axiom of preferences. Numbers reflect the value given to an outcome of the game. This value is obtained through a utility function that coherently represent preferences. As you can notice, since the outcome is given from the interaction of actions, every position of the matrix has two value corresponding to the value of each player to the outcome. This particular structure represents only the prisoners' dilemma setting. The only "rational" choice is to choose y1v for each player. Since the game is sequential and the setting is finite the only possible theoretical solution is the cheating outcome where both players get 1, hoping that the other player

will choose to cooperate and subsequently being cheated. This reasoning is supported by the microeconomic theory upon preferences. On the contrary in many real situation the outcome can be different.

## **2.2 Some hypothesis**

- Inconsistency of Nash equilibrium predictions.
- Different outcomes from the ones foreseen by the theory.

These are the main hypothesis of my experiment that takes into consideration the effect of framing and social framing that affect the context of human decision theory analyzed in game theoretic terms as an interaction process between individuals. Since game theory has the aim of studying interaction among people, it is important to understand what we mean by interaction. As every science the aim of game theory is to find a regularity in behaviour that are proper of human being and upon those certainties model are built in order to predict the outcome of future possible interactions. With this respect I step in to the picture by sustaining that there are some properties of game theory that I haven't understood. I am not sustaining that they are useless. Predicting human behaviour is very hard to do especially when we recognize that we are different in every respect. The aim of game theory is modeling all kinds of interactions. This implies that people can behave in a predictable way. The problem is that the methodologies of predicting do not take into account some aspects of human behaviour that are fundamental in order to understand how a decision process is made. Probably this critique is not valid for everybody since I affirm that we are all different but in some respects it gives a different perspective on how to conceive the predictive possibilities of game theory. Framing effects are important to be taken in to account, the first one is the word game!

### 2.3 The word game

To me, one of the most influential framing bias is the word “game”. If you think of the meaning of the word as the dictionary definition<sup>3</sup>: an amusement or pastime or a contest with rules to determine a winner. In the definition we can perceive a certain mood or human attitude towards games that is exactly described as in the definition. It means that when a people hear the word game connect immediately to this kind of mood by identifying a situation as a challenge in which the aim is winning. This could be the most important framing effect that could bias the outcome of the game! (I used myself the word game). How can we get around this problem? First of all let us see what we mean by the word game when we use it in game theory. A game describes the interaction of people. This is quite fair when you want to describe a situation but it could give some methodological problems when you deal with experiments. In every situation the experimenter addresses himself to the participants by saying that they will play a game. If you think of a real prisoner’s dilemma to occur there is anything but playing. While you define a game you have to give plenty of knowledge about its rules since a game has to be properly defined (try to play poker without knowing it, it is what happened to me at the beginning and I lost a lot of money). Rules determine, at least theoretically, the conduct to follow while playing so that every player receives qualitative information about how he is supposed to do. This is the worst bias you could introduce in a behavioural analysis since you want to understand how behaviour works. On the contrary, it seems that, experimenters, by defining the situation as a game and giving detailed instructions cannot have many chances of understanding the real behaviour of people. The result might be a misleading effect on behaviour. In the frame the experimenter “imposes” at the beginning it can also find a certain answer to the problem he wants to evaluate. It seems like writing the answer before being asked to. It is said that the experimenter influences the outcome of the experiment.

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<sup>3</sup> Wordreferences.com

In the next section, the experimental one, I will show how this framing argument has an effect on the outcome of the game.

## EXPERIMENTAL PART

Experimental economics is defined as the use of experimentation as an investigating method for economics. We might think of it as a new conception of economics, a new method for dealing with economic phenomena. As far as the methodological part is concerned, it is very important to state that the “method” is the fundamental part of a science, it validates its logical coherence and it gives a philosophical consistency that is behind every science. In Confucio’s words method is the path to follow from a starting point to the arrival, thus it is worthy to give a brief explanation of this new experimental method in economics in order to understand the path of this research logical reasoning.

As in the natural sciences, we are interested in the observation of some phenomena of which we want to understand the underlying functioning. Prediction is the main result we would like to obtain. To express me more clearly, our aim is to understand the inner functioning of phenomena in order to discover the laws that govern them so as to be able to foresee what will happen anytime we will observe alike phenomena throughout nature. All of this translates into the possibility of discovering causal relations among the components of phenomena. In economics the problem is a bit more complicated. We find ourselves in a social dimension that renders observations much more complicated and surely more costly as well. The problem is that representing a natural situation is very unlikely in social sciences so one must be very careful in setting the experiment. Very often you have interaction with a computer and the million of variables that affect one’s behaviour are unobservable and most of the times are different among every person. This is the reason why the practice of experiments in economics is very controversial. Nonetheless it is very useful in order to

challenge formal hypothesis that most of the times rely mainly on sophisticated mathematical assumptions. Of course the coherence of a formal theory may be challenged mostly from another formal formulation. Experiments come in between. If you want to challenge a particular prediction, even if mathematical, it is important that you observe the contrary, find a regular path and formalize it. I think that behind every scientific discovery there is a philosophical background, think of Einstein's relativity theory. In the presentation of my experiment I will not use any formal characterization of the problem rather I will exploit an intuition on the possible scenario that may occur in a particular prisoners' dilemma situation. I think that the notion of cooperation and trust may have different interpretations that can be different from the economic main sense we give to them. Moreover, the effect I would like to test is whether the sense of these words may be observed differently under different frames. The principal aspect of this experimental part is to find some evidence of my philosophy expressed in the theoretical section so that I can evaluate my thoughts in face of evidence. In the conclusion I also explain the limitation of my approach.

### Experimental methodology

My aim is to understand why do people move away from the prediction of the theory. I have set some experiments that have some differences with respect to framing. This has been done in order to capture to some extent a possible framing effect that affects behaviour.

The first thing to change is the way the experiment is presented. This is a fundamental step in experimental economics. The experiment has to be clear and we have to present the player the possible actions they can make. This already implies some qualitative suggestion to the players or people and may be reflected in a behavioural bias in the outcome. Unfortunately, there is no better way to proceed. To sum up, the first step is represented by the explanation of the game. The second step consists of running the experiment



and being an observer of it. It is necessary to give the impression of being an outsider that does not expect anything from them. You should let the players feel as if they incurred in that situation by chance. This aspect is determinant when I wanted to take into account the framing effect of the presentation of the problem firstly as a game and secondly as a natural situation (or at least as closest as possible). Another important aspect to consider is incentives. They are fundamental for the outcome of the game and above all for the interaction of players. By this definition we can immediately notice that they can represent a very large bias for the solution of a game. The analytical part is to evaluate the results and give some considerations about them. Since I am involved with social characteristics of humans I interested in the understanding of why of some behaviours, so I decided to ask the players directly through means of a questionnaire. Also this part represents a controversial aspect of methodology in experimental economics. It is of fundamental importance to decide how to formulate questions and how to interpret answers. In experimental economics there is a distinction among the ways a questionnaire may be proposed. I chose the one in which you ask directly to the player why they have chosen a particular action rather than another possible one. The technical term is hot questionnaire. I will hereby present the main experiments .

I have run a total of four experiments that involved different people for any repetition. I have also modified the setting.

## EXPERIMENTS

The first experiment involved two people that knew each other. I proposed them to play a game and they accepted. (losing precious time for their own thesis). In this first repetition I chose to use the word game and see whether my prediction for the outcome implied a competition between players to gain the final prize. All the results are contained in the appendix. I will present here only the moves the players did. The incentives are represented by money that by assumptions can represent a certain level of utility.

the payoff matrix is the following: Euros

	o3	y1
o3	3,3	0,4
y1	0,4	1,1

I have asked to point out a preference over 20 shots without knowing what the other was about to choose. It means that they chose sequentially and they could only observe previous moves. I have also specified that the final payoff is the arithmetic average of what you get at every stage of the game.

Mattia	Paolo	payoffs	final payoffs	Arithmetic average
Single moves				
o3	o3	3,3	<b>Paolo</b>	<b>1.95</b>
y	o3	4,0	<b>Mattia</b>	<b>2.1</b>
o3	o3	3,3		
y	o3	4,0		
y	o3	4,0		
y	o3	4,0		
o3	o3	3,3		
y	o3	4,0		
o3	o3	3,3		
o3	o3	3,3		
o3	o3	3,3		
o3	y	0,4		
o3	y	0,4		

y	y	1,1
o3	y	0,4
o3	y	0,4
o3	y	0,4
o3	y	0,4
y	y	1,1
y	y	1,1

As you can notice the game is set in such a way that the actions produces only one Nash equilibrium in pure strategies.

The dilemma is present in the payoff 3,3 where you can surely get more than the equilibrium outcome but it is an unstable solution since the other player can always cheat on you. It seems evident that both players understood that cheating was the best possible action to take. They cooperated for 3 consecutives moves understanding that they could get more by doing so. In the end we can notice that each player did not have a clear strategy in mind if not the one to get as more as possible, passing through a certain experimental cooperation that failed as soon as one player defected from that strategic path.

In order to establish whether there is a better strategy within this setting I need to run an analysis of different actions and compare them. I chose to run another experiment always defined as a game. I chose to involve Paolo the one who gained less in repetition number one. The setting is the same. I would like to see whether this time Paolo shall adopt a better strategy that is consistent with my intuition on the effect of the word game.

Game 2 (full description in the appendix)

Luca	Paolo	1	2.6
3	3	<b>Luca</b>	<b>Paolo</b>
0	4	<b>final payoffs</b>	
1	1		
1	1		
4	0		
3	3		
0	4		
3	3		
0	4		

0	4
1	1
1	1
1	1
0	4
0	4
0	4
0	4
1	1
1	1
0	4

The game was presented in the same manner. In the previous tournament Paolo tried to cooperate with Mattia by playing the cooperative strategy 4 times consecutively. By observing the outcome of the second game it is easily observable how Paolo learnt how to play, endogenizing the frame of a game setting. It seems logical to state that the learning process brought him to consider strategies that could maximize his payoff. Nonetheless, this strategy is far from the Nash equilibrium one. The first time a person is playing it seems as if he is not understanding what is doing until the second repetition that is usually introduced by saying : let's play again!

It may be right to ascertain that Game is already indicating a state of mind of participants. We do usually refer to game as amusing situations in which the aim is winning against the other participants of the game. This can represent an indication to follow for the player that could set up an attitude towards the way the game has to be played, as addressed by the definition of game. One could behave as being influenced by the state of mind that the word game could give to him. In order to establish this effect it has been useful to set up an experiment taking into consideration the same "game" or better situation in which the player is firstly introduced to the problem as a game and in the second round he is explained to be in a situation without using the term game. This could anyway represent a methodological

drawback, because the player could be already influenced by the tournament of the previous experiment so it may change a little if the two subjects are the same. On the other hand we cannot take into account factors such as personality that could represent a bias in the outcome if the two rounds are played by different players. The only thing to do seems to be dividing the game in two parts. The first one is presented as a situation in which the players are not presented with the word game but as being involved in a situation in which some actions are possible to occur. In this way they may be much less influenced by the words of the experiments that in some sense is already influencing the outcome of the game through framing. Impersonality is very important in order to give a great level of abstraction from all possible disturbing events. I think that in this way the players will not be influenced by the word game. The formulation of strategies may also arise from some considerations that are not involved in a "I have to win" reasoning. The state of nature of the situation would probably be considered as not being merely fun to play with your friends. With the right monetary incentive to play it may arise a situation in which players may actually think with their head without the experimenter bias may arise. I decided to run another experiment with two different people who did not receive the same explanation of the experiment. I have asked a psychologist and a manager to sit an experiment that consisted of interacting with another person. I have explained that the interaction was such that each player's move would affect the decision of the other. I did mention neither the word game nor the prisoner dilemma. I asked them to imagine as if they were in a situation in which they had to split some money and the split depended on the choice of both players. I simply stated that the actions they could take were free actions that they were free to decide I showed them the payoff matrix indicating the monetary reward they could get, without explicitly mentioning the combination of actions. I just let them see the monetary payoff they could get as a consequence of free choice. This time I extended the length of the experiment up to 50 moves in order to establish whether they had time enough to get into a sort of cooperation through learning. This experiment gave the most interesting results.

Two actions c, d the game is symmetric

PaT Pat Experiment

c	D
40,40	0,50
50,0	10,10

strategy profile

patr alta

patr nana

40	40 c,c
0	50 c,d
40	40 c,c
40	40 c,c
0	50 c,d
10	10 d,d
50	0 d,c
10	10 d,d
40	40 c,c
40	40 c,c
40	40 c,c
50	0 d,c
0	50 c,d
40	40 c,c
40	40 c,c
40	40 c,c
50	0 d,c



**Final Payoff**

pat alta	25
pat nana	25

Those data are really interesting from a theoretical point of view. There is a clear path that points that there is an effort to build some cooperation. This seems the contrary with respect to the other games played in previous repetitions of the experiment. The different frame may be deemed as a determinant of this new outcome. On the other hand, at the very last sequences of the game we can observe a sort of weak trigger strategy that predict the move from the Pareto efficient outcome to the Nash equilibrium. In finitely repeated games trigger strategy is not even contemplated. This strategic path is proper of infinitely repeated setting and it should have happened as soon as one player deviated from the efficient equilibrium. It is interesting to investigate why there is this mix of strategic behaviour. Nonetheless the main trend seems to lead to a sort of cooperation, probably due to a framing effect.



*SOME MORE CONSIDERATIONS ABOUT THE EXPERIMENT OF PAT PAT!*

The game per sé is not so chaotic in the sense that there seems to be a regular path in the behaviour of players. The first thing that came to my mind is to see whether the game is consistent with the prediction of Selten(1985) on end behaviour structure.

The properties of end behaviour through learning consists of following a certain number of cooperative moves and defect at a certain point playing the Nash up to the end of the game.

A game of this kind is defined by Selten as follows:

Definition 1<sup>4</sup>. For a supergame to be called cooperative must satisfy the following conditions:

- a) In the first  $m$  periods, where  $m$  is at least  $4^5$ , both players choose cooperative alternative(C;C).
- b) In period  $m+1$  (for  $m < 50$ ) at least one player chooses the non cooperative alternative (D;C).
- c) In all periods  $m+2, \dots, 50$  (if there are any remaining) both players choose the Nash equilibrium, the non cooperative alternative, (D;D).

See what if  $m$  in a) is equal to 50, where both players cooperate up to the end.

Definition 2. In order for a game to present an end effect it must satisfy the following conditions:

- a') Both players choose the cooperative alternative in at least four consecutive periods  $k, \dots, m$  ( because cooperation could arise also after initial non cooperative moves)

The conditions b) and c) are the same as in the definition of a cooperative play. By definition, a cooperative play is also an end effect play.

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<sup>4</sup> “End behaviour in sequences of finite prisoner’s dilemma supergames.”, a learning theory approach, by Reinhard Selten and Rolf Stoecker.

<sup>5</sup> This number has been arbitrarily chosen, but we can consider it since in my game the number of repetitions and the frame of the game is very similar to the one adept in Selten experiment.

Let us verify whether those conditions are met in our experiment.

Property a) of definition 1 is not satisfied stated in that way but it is valid property a') in fact from move 28 to move 32 the play five times the cooperative outcome so that the game satisfy the property of playing at least four times the cooperative outcome (C;C)

Property b) is satisfied by the fact that at least once every player defected the cooperative outcome. It also seems to be supported by property c) since in all periods  $m+2, \dots, 50$  both players chose the non efficient Nash equilibrium. But this happened after some previous moves involving defection. It seems that also this game is out of the reach of mainstream theory of interaction.

In order to establish whether this framing effect could also arise from a particular process of preference creation I run an experiment with children. I thought that the endogenous process of preference creation may be subject to some sort of social distortion that evolve through time and experience. In his theory of alternative frames, Frey establishes a social production functions that take into account the different process that may lead different people to have different behaviour due to social norms and focal points. It may be straightforward that adult individual may tend to be more selfish relative to children. Nonetheless the Nash Equilibrium of the prisoner's dilemma involves some social notion in the definition itself. In example we may treat trust as an important component that lead people to the inefficient equilibrium. Of course trust has a considerable social components. As a consequence I decided to run an experiment with children to test this hypothesis and conclude that the Nash inefficient equilibrium may be obtained by some social distortions and not only by rational consistency of preferences. I presented to two children a peace of paper where they could see some numbers on it, representing the number of pieces of chocolate they could get. I have further explained that the pieces of chocolate they could get dependent on how many pieces of chocolate the other child wanted to get for himself.

After explaining those simple rules I have asked them : how many chocolate would you like to eat today? And the answer was: a lot! Ofcourse. After explaining how to proceed sequentially I got those astonishing results.

	jack	michael
		3
	3	3
	3	3
	3	3
	3	3
	3	3
	3	3
	3	3
	3	3
	3	3
final payoff		
jack		3
michael		3

After explaining that they could get only the arithmetic average of the total played those 11 years old guys always played the cooperative outcome. They knew that the maximum could only be reached by playing that actions profile. It is surprising above all if compared to the hypothesis of the formation of social preferences that are socially influenced. It would be quite interesting to run more structured experiments of this kind and try to find a model that could take into account those social distortions that are not so easily detectable.

## CONCLUSIONS

Can you learn how to play by playing? In reality you might learn but is the theory really predictive?

Do really people know how to play? The content of the game and its outcome (or outcomes) is rationally conceived by the experimenter and there is no reason why a person should face the problem in the same way as the experimenter. Probably also an economist would not act as prescribed by the theory. In a real situation there are many variables we cannot control and it is thus quite surprising that even experimental outcomes might be far away from the prediction. Why? Because there are many psychological and social aspects that are not taken into consideration. We are stuck with the homo economicus concept and we do not have many means to relax those assumptions without losing grip of our logical coherence. What does understanding a game mean for an experimental outcome?

The understanding of the game it is already a process of indicating the moves to the players, or at least it might give a qualitative suggestion on how to play.

It is necessary to give rules. The important is to learn how to frame those rules and games in order to represent as much as possible a real situation. A real situation consists of what is more likely to occur in a situation where players are not presented with any rules and see how they behave. The super structure imposed by rules and explanations might be determinant as far as the outcome of the game is concerned.

The hypothesis were the following:

-Does the way the game is framed impose qualitative suggestion to players and consequently, does it influence the way the game is played?

What is the relation between framing and reality?

Does framing represent a social super structure? Is framing already intrinsic in the individual?

This led to some consideration about the endogenous framing effect in the individuals.

Since framing might have a social aspect, the frame could change at every stage of life, following endogenous changes in the social position of players. (this could also be tested by using prospect theory)

Endogenizing frameworks seems to be quite evident!

It is the process through which behavior is not only influenced by the framework an experimenter gives ( which is consequently, social since the experimenter is social), but also on his endogenous social influences. This might go from sociological and psychological considerations. There might also be a philosophical consideration on the possibility and the way of endogenizing social aspects. Every individual is deemed to face many different social situations but the process they have endogenized might be the same( preferences?, utility?) this would also go in depth with a re consideration of formal theory and strong assumptions.

As far as the scientific strength of this research is concerned, there are many limitations. Those represent the stimuli to investigate those new conceptions of interactions among people and broaden the field of application to the rest of game theory and not only on a single situation such as the prisoners' dilemma.

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## APPENDIX

### first experiment

the payoff matrix is the following:

	o3	y1
o3	3,3	0,4
y1	0,4	1,1

player 1	player2	payoffs	final payoffs	
o3	o3	3,3	<b>player1</b>	<b>1,95</b>
y	o3	4,0		
o3	o3	3,3		
y	o3	4,0		
y	o3	4,0		
y	o3	4,0		
o3	o3	3,3		
y	o3	4,0		
o3	o3	3,3		
o3	o3	3,3		
o3	o3	3,3		
o3	y	0,4		
o3	y	0,4		
y	y	1,1		
o3	y	0,4		
o3	y	0,4		
o3	y	0,4		
o3	y	0,4		
y	y	1,1		
y	y	1,1		

### Second Repetition

in advance the respective choices.

the payoff matrix was the same as before

those are the following actions the two players played:

there seems not to be a particular strategy for both .

player 1      mattia

player 2      paolo

luca	paolo	<b>Luca</b>	<b>1</b>	<b>2,6</b>
			<b>Luca</b>	<b>Paolo</b>

## final payoffs

3	3			
0	4			
1	1	somma	%	
1	1	72	27,777778	luca
4	0		72,222222	paolo
3	3			
0	4			
3	3			
0	4			
0	4			
1	1			
1	1			
1	1			
0	4			
0	4			
0	4			
0	4			
1	1			
1	1			
0	4			

experiment with money 2players experiment 3

player 1	mattia	actions	
player2	andrea	a	15c in opponent bag
		b	10c in yours

matrix form

	a	b
a	15,15	0,25
b	25,0	10,10

mattia	andrea	
25	0	
10	10	
10	10	
25	0	
0	25	
10	10	
10	10	
10	10	
10	10	
15	15	
10	10	
10	10	
25	0	
10	10	
0	25	
25	0	
10	10	
10	10	
10	10	
0	25	

final	
payoffs	
mattia	12,4
andrea	10,5

Third Repetition

Two actions c, d the game is symmetric

	c	d
c	40,40	0,50

d	50,0	10,10	strategy profile	
	patr alt	patr nana		
1	40	40	c,c	
2	0	50	c,d	Final Payoff
3	40	40	c,c	pat alt 25
4	40	40	c,c	pat nana 25
5	0	50	c,d	
6	10	10	d,d	
7	50	0	d,c	
8	10	10	d,d	
9	40	40	c,c	
10	40	40	c,c	
11	40	40	c,c	
12	50	0	d,c	
13	0	50	c,d	
14	40	40	c,c	
15	40	40	c,c	
16	40	40	c,c	
17	50	0	d,c	
18	50	0	d,c	
19	50	0	d,c	
20	0	50	c,d	
21	0	50	c,d	
22	0	50	c,d	
23	10	10	d,d	
24	50	0	d,c	
25	10	10	d,d	
26	40	40	c,c	
27	0	50	c,d	
28	40	40	c,c	
29	40	40	c,c	
30	40	40	c,c	
31	40	40	c,c	
32	40	40	c,c	
33	10	10	d,d	
34	10	10	d,d	
35	50	0	d,c	
36	0	50	c,d	
37	40	40	c,c	
38	40	40	c,c	
39	50	0	d,c	
40	10	10	d,d	
41	10	10	d,d	
42	10	10	d,d	
43	10	10	d,d	
44	10	10	d,d	
45	10	10	d,d	
46	10	10	d,d	
47	10	10	d,d	
48	10	10	d,d	
49	10	10	d,d	
50	10	10	d,d	



