DO RATIONAL AGENTS MAKE THE SAME HEURISTIC ERRORS AS LAYMEN? EXPERIMENTAL EVIDENCE MANIPULATING RATIONALITY

AGENTES RACIONAIS COMETEM OS MESMOS ERROS HEURÍSTICOS QUE LEIGOS? EVIDÊNCIAS EXPERIMENTAIS MANIPULANDO A RACIONALIDADE

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ABSTRACT

Prospect Theory revealed that when resorting to certain psychological biases, individuals violate the expected utility in situations involving risk. Later studies replicated the seminal experiment conducted by Kahneman and Tversky (1979), demonstrating that these biases also involve more rational individuals, with the parameters of rationality being set by different proxies such as academic level, knowledge concerning the decision-making process or capital markets experience. The aim of this article was to conduct a deeper analysis of heuristic errors committed by such individuals by directly manipulating the rationality variable for the experimental group, exposing it to the Expected Utility Theory before applying the questionnaire. The results show that there was no significant divergence between the answers given by the experimental group and the control group. Both made the same heuristic errors, corroborating the assumptions of Prospect Theory.

Keywords: Prospect Theory, Behavioral Finance, Heuristic Bias, Expected Utility Theory, Bounded Rationality

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RESUMO

A Teoria do Prospecto revelou que, ao recair em certos vieses psicológicos, os indivíduos violam a utilidade esperada em situações que envolvem risco. Estudos posteriores replicaram o experimento seminal de Kahneman e Tversky (1979) atestando que tais vieses também incidem sobre indivíduos mais racionais, sendo a variável racionalidade parametrizada por diferentes proxies como nível acadêmico, conhecimento sobre processo decisório ou experiência no mercado de capitais. Este artigo aprofunda a análise dos erros heurísticos cometidos por tais indivíduos ao manipular diretamente a variável racionalidade para o grupo experimental, expondo-lhe a Teoria da Utilidade Esperada antes de aplicar o questionário. Os resultados demonstram que não houve divergência significativa entre as respostas do grupo experimental e de controle, sendo que ambos incorreram nos mesmos erros heurísticos, corroborando os pressupostos da Teoria do Prospecto.

Palavras-chave: Teoria do Prospecto, Finanças Comportamentais, Vieses Heurísticos, Teoria da Utilidade Esperada, Racionalidade Limitada

1 INTRODUCTION

The recent collapse of the financial system caused by the subprime crisis increased the consolidation of Financial Behavior as an emergent theory for explaining the behavior of the capitals market. Its scope is based on the Prospect Theory developed by two Israeli psychologists, Daniel Kahneman and Amos Tversky in 1979. Using a series of experiments involving decision-making in risky situations, the authors concluded that individuals in these circumstances do not make decisions according to the traditional model of maximized expected utility, in accordance with proposal of the classical finance theory, but resort to heuristic biases that are contrary to these rational models.

Herbert Simon (1976) was among the first to question this concept of bounded rationality proposed by the EMH. Among other motives, the author claims that commonly it is impossible to find the optimum solution to certain problems, even when all the information is available because individuals cannot process it unequivocally. Uniting the concepts of Simon's Bounded Rationality and the heuristic biases of the Prospect Theory, the solution found by individuals is not always the optimum one, even when there is abundant information available. Applying this logic to the capitals market, the pricing of assets does not always perfectly reflect the information available about them, as defended by the EMH, and this allows anomalies to arise.

The finding of several anomalies, especially since the 1990s, has afforded legitimacy to the profusion of a number of studies in different markets that replicate the seminal experiments of Kahneman and Tversky (1979). These studies generally corroborate the assumptions of Prospect Theory, even when applied to more rational individuals. However, it is worth pointing out that these studies used the academic level of respondents as a proxy for the rationality variable. This assumption has an important limitation because it does not actually obtain the knowledge of the individuals in question regarding the Expected Utility Theory (EUT) for the purpose of determining whether these individuals who do indeed know this theory (and are therefore more rational) have the same heuristic biases in their choices as less informed individuals.

This study aims to explore this limitation. For this purpose, the original experiment of Kahneman and Tversky (1979) was replicated using two groups (experimental and control), with the information variable being manipulated for the former. Therefore, before answering the questionnaire, the experimental group was exposed to the Expected Utility Theory, while the second (control) group was not. The responses from each group were compared. In the light of Prospect Theory, it was expected that even with the experimental group being exposed to the "rationality" variable, the responses of each group would not diverge because, as stated above, even when individuals have access to abundant information, they do not process it efficiently.

The results of the present experiment did indeed corroborate Prospect Theory because there was no statistically significant difference between the responses of the two groups. Therefore, the magnitude of the results obtained helps to strengthen the behavioral theory, as will be shown in the following sections.

2 THEORETICAL FRAMEWORK

This session is divided in three parts. The first one brings some of the central assumptions of the Efficient Market Hypothesis (EMH) that are related with the subject of the paper. The second brings presents the main arguments of Prospect Theory, contrasting them whit some principles of EMH. Finally, the third part documents a number of authors who have published works replicating the Prospect Theory experiment in Brazil.

2.1 Market Rationality and the Efficient Market Hypothesis

The Efficient Market Hypothesis is based on the understanding that individuals are rational in two ways. First, they "make decisions according to the axioms of expected utility theory and second make unbiased forecasts about the future" (THALER, 1999, p. 12). and thus capable of processing information that is available to them with efficiency. When this premise is applied to the capitals market, it should mean that the pricing of an asset reflects all the information available about it. This would annul any possibility of arbitration by the market. To this end, Fama (1970) states that:

> In general terms, the ideal is a market in which prices provide accurate signals for resource allocation: i.e., a market in which firms can make production-investment decisions, and investors can choose among the securities that represent ownership of firms' activities under the assumption that security prices at any time "fully reflect" all available information. A market in which prices always fully reflect available information is called "efficient". (FAMA, 1970, p. 383)

At first sight, this quantitative and rational view of human beings may appear vainglorious, going against empirical findings that individuals do not always behave rationally. In this sense, it is of fundamental importance to point out that the EMH does not ignore the possibility of irrational agents operating in the market, but rather that the market, as a whole, operates continuously in a rational way. Therefore, possible irrational actions that segregate the price of assets from the information concerning them would be rapidly perceived by the market which, by acting rationally, would immediately take action regarding the asset in question (buying or selling it), thereby redirecting it to a fair price, in accordance with Fama (1970).

Therefore, it is clear that the rational operation of the market is one of the corollaries on which the EMH is based. Its theoretical rigor, in alliance with a series of empirical corroborations raised the EMH to the status of dominant theory for explaining capital markets behavior to the point that Nobel Laureate Michael Jensen stated in an article on this theme, that no other economic hypothesis gathered more solid empirical evidence than the EMH (Jensen, 1978).

The past two decades, however, have seen extremely anomalous behavior that is not in alignment with the expectations of the EMH in the capitals market. If the market operates in a constant equilibrium between price and assets, how can the collapse of the dot-com bubble in 2001 be explained, or the recent mortgage crisis in 2008? In this context, the term coined by the president of the FED, "irrational exuberance", became especially famous. This term was used by Greenspan to describe the behavior of the American stock market shortly before the NASDAQ bubble burst.

These evidences put the rational market model and the maximization of expected utility in check, making way for counter theories in which investors on the whole (including the more rational) do not always make decisions optimizing utility. They incur heuristic errors that would theoretically underlie these anomalies, as will be shown below.

2.2 Prospect Theory and Cognitive Bias

Prospect Theory originated from a series of experiments conducted by psychologists Daniel Kahneman and Amos Tversky in 1979. In general terms, these experiments consisted of questionnaires on a series of hypothetical situations involving decision-making in different situations involving risk. These questionnaires were applied to different groups of individuals.

The following example illustrates one of these prospects:

a) You have received $1,000 and you have to choose between: i) a certain gain of $500; and ii) a 50% chance to gain another $1,000 and a 50% chance of gaining nothing;
b) You have received $1,000 and have to choose between: i) a certain loss of $500; and ii) a 50% chance of losing $1,000 and a 50% chance of losing nothing.

By rationally analyzing one of the two scenarios proposed in situations "a" and "b" in accordance with the Expected Utility Theory (EUT) the choices are:

a) In the first situation the expected utility for each scenario will be:
U_i = 500 x 1 = 500
U_{ii} = 1000 x 0.50 + 0.00 x 0.50 = 500

b) In the second situation, the expected utility for each of the scenarios will be:
U_i = -500 x 1 = -500
U_{ii} = -1000 x 0.50 + 0.00 x 0.50 = -500

According to the assumptions of the EUT and, consequently, with the consideration that the investors are rational, it should be expected that the individuals will be equally divided between the two scenarios of situations "a" and "b", since both result in the same expected utility. However, the authors found that, in the first situation, 84% of the respondents opted for scenario "i", while in the second, 64% opted for scenario "ii".

Therefore, the authors concluded that, in such situations, individuals do not make their decisions by maximizing utility, but rather based on heuristic biases, contrary to the rational model in force at the time. A particular aspect of the prospects described above is that they observed that the alternatives chosen were asymmetrical for the prospect involving a gain (a) and the prospect involving a loss (b). This asymmetry is based on the finding that, in the first situation, involving gain, 84% of the individuals opted for the scenario with the lower level of risk (p = 100%), whereas in the second situation, involving loss, 64% chose the scenario with higher levels of risk (p = 50%).

As these results were repeated in similar prospects, the authors concluded that in general individuals show aversion to risk in situations of gain and seek risk in situations of loss. The authors called this bias the "Reflection Effect".

Other situations with questionnaires involved prospects with a high and low probability of occurring, of which the following is an example:

a) Which of these two alternatives do you prefer? i) a 45% chance of gaining $6,000 and a 55% change of gaining $0; ii) a 90% chance of gaining $3,000 and a 10% chance of gaining $0.

b) Which of these two alternatives do you prefer? i) a 0.1% chance of gaining $6,000 and a 99.9% gaining $0; ii) a 0.2% chance of gaining $3,000 and a 99.8% chance of gaining $0

An analysis of each of the scenarios proposed in situations "a" and "b" using the logic of the EUT would show that:

a) For the first situation, the expected utility of each of the scenarios would be:
$U_i = 6000 \times 0.45 + 0 \times 0.55 = 270$
$U_{ii} = 3000 \times 0.90 + 0 \times 0.10 = 270$

b) For the second situation, the expected utility for each of the scenarios would be:
$U_i = 6000 \times 0.001 + 0 \times 0.999 = 6$
$U_{ii} = 3000 \times 0.002 + 0 \times 0.998 = 6$

Once again, it is clear that according to the rational model of the EUT the utilities of the alternatives are identical. Nevertheless, in scenario "a", 86% of the respondents preferred prospect "ii", while for "b", 73% preferred prospect "i". These results, according to Cruz, Kimura and Krauter (2003), lead to the belief that:

> When they evaluate prospects with a high probability of gain [Prospect a_{ii}], individuals tend to choose more conservative alternatives because they are more certain of a gain (...) On the other hand, individuals remain more gain-seeking even when the chances are smaller [Prospect b_i]. (CRUZ; KIMURA; KRAUTER, 2003, p. 11 – our translation)

The Israeli researchers called this preference for alternatives that were more likely to occur the "Certainty Effect". The robustness of the results, together with other evidence contrary to the rational decision-making model led experiments testing the rationality in decision making process to be replicated in different populations, including in Brazil. Walter, Frega and Silva (2010), for example, made an experiment to evaluate the decisions regarding investment allocation for graduate students, and found that the respondents did not follow the rational model for risk measurement. Similarly, Cavazotte, Dias Filho and Villas Boas (2009) conducted two experiments relating the role of emotions in the process of decision making, and found evidences that support the influence of the emotion in this process, mainly when they are negative. Nascimento el at (2012) present evidences that investment allocation decisions related to retirement plans are affected by cognitive biases, while Esteves et al (2013), in a qualitative study regarding the influence of emotions in purchasing decisions, conclude that this variable has an important impact not only for this decision, but also throughout all the consumption process.

Finally, in a literature review about the main theories regarding the decision making, Pereira, Lobler and Simonetto (2010), highlight the increase in importance of emotions in this field and argue that the common belief of these theories goes beyond the rational model, incorporating cognitive and subjective biases on their framework.

2.3 Brazilian studies replicating the Prospect Theory experiment

The study of Cruz, Kimura and Krauter (2003) was the precursor for the replication of the seminal experiment of Prospect Theory in Brazil. The questionnaire was handed to teaching staff and students at a Brazilian business school. The authors found that the results were generally similar to those of the Israeli researchers in 1979, a sign that culture and nationality do not interfere in the results.

Later, Rogers, Favato and Securato (2008) replicated the experiment again, restricting the population to undergraduate students who were studying management and accounting sciences. Once again, the results validated the assumptions of Prospect Theory, in agreement with the previous study conducted by Cruz, Kimura and Krauter (2003).

Silva et al (2009) refined the two previous studies by reapplying the experiment to students at different levels of their undergraduate courses. The underlying logic of this refinement was to verify whether there would be distortions between the responses of more sophisticated agents (as the students had higher levels of education) and less sophisticated agents. Corroborating the previous results, the experiment revealed that "there is no influence of rational evolution in the decision-making process" (SILVA et al, 2009, p. 383).

The irrelevance of rationality to psychological bias, however, had already been documented by Tversky and Kahneman (1983). In this study, the authors found that there was no statistical divergence between the heuristic errors of laymen and those of specialists (the latter being doctoral students at the program for decision-making processes at Stanford University).

By reinforcing that there is no significant difference between the heuristic errors of more and less sophisticated individuals, these studies corroborate the corollaries of financial behaviors in detriment of the classic EMH model. This is because by proving that even rational agents are subject to heuristic bias, the continuous efficiency of the market would be in check, allowing the price of an asset to be distanced from its fundamentals, as had been seen in some market anomalies.

It is important to highlight that in these articles the "rationality" variable was set as different academic levels for the responding groups. However, how is it possible to verify whether this difference between academic levels does indeed represent evolved rationality in the decision-making process? To answer this question, it would be recommendable to ensure that one of the groups of respondents possessed the necessary knowledge for rational decision-making in order to compare their responses with those of a control group. It is in this respect that this article seeks to make a contribution to the field.

Therefore, the experimental group was composed of individuals who had been clearly exposed to the EUT. From the evidence of the previous studies, it was expected that their choices would be no different from those of the control group, whose members had not been exposed to the theory. This leads to the first research hypothesis:

H1: There was no statistically significant difference between the responses of the experimental group and the control group.

Proof of H1, although necessary, would not be sufficient to corroborate the assumptions of Prospect Theory since a simple difference between the median responses of the groups does not guarantee that the control group has answered in accordance with Prospect Theory. Therefore, to achieve the central aims of this work, it is necessary to add a hypothesis that verifies whether the control group made its choices in agreement with the expectations of Prospect Theory. From this observation, a hypothesis arises that outlines the aim of the article:

H2: The control group incurred heuristic biases forecast by Prospect Theory

It is only by proving the above hypothesis that we can affirm the corroboration of the assumptions of Prospect Theory that even more sophisticated investors commit heuristic errors during their decision-making process.

3 RESEARCH METHODOLOGY

This section outlines the methodology employed to resolve the problem and describe the procedures adopted to conduct the experiment and maintain its internal and external validity.

3.1 Methodological Characterization

As mentioned previously, the methodology adopted to test the above hypotheses is of an experimental nature as it seeks to measure the variations of the dependent variable (heuristic errors) exclusively by manipulating the independent variable (rationality). This impact will be measured from a comparison of the responses of the experimental group (for which the rationality variable was manipulated) with those of the control group. Both were composed of undergraduate students in management at a federal university, with the sample characterized by convenience and, therefore, a quasi-experimental design. The research took place inside the university facilities in the range between September and November 2012.

A comparison of the responses of the experimental group (O1) and the control group (O2) makes it possible to identify whether there was a significant difference between them as a result of the manipulation of the variable, as stated in H1.

It is worth highlighting that in the experimental approach it is necessary to guarantee the internal and external validity of the experiment to ensure that other exogenous variables do not interfere in the behavior of the dependent variable (Straist and Singleton, 2011), representing rival explanations to the measurement of the relationship between cause and effect. In the present experiment, a possible rival explanation would have to do with the effective manipulation of rationality, given that the EUT has been exposed to the experimental group and presuming that this exposure could have occurred partially. In this case, the pattern of responses between the groups would be the same, not because the independent variable has no influence on the dependent, but because the manipulation was ineffective.

To inhibit this rival explanation, a second experiment was conducted with the experimental group, in which the understanding of the EUT was proven, thereby ensuring the manipulation of the independent variable. Therefore, as the experiment in one in which only the experimental groups will be manipulated, its design is pre-experimental. As the experiment designs have now been defined, it is time to describe how they were conducted.

3.2 Description of the Experiment

The experimental group was studying the sixth semester Investment Decisions discipline and during some classes they were exposed to the concept of the Expected Utility Theory as a tool for choosing projects with different risks (probabilities) and returns. This exposure took place naturally and as if it were part of the development of the discipline, respecting the analysis logic of capital projects that are part of the discipline in question. It is worth mentioning that this

theory is not part of the curriculum. Therefore, the students of the control group did not have an appropriate knowledge of the subject.

The experimental group was made up of 35 individuals aged between twenty and fifty years, with an average age of 23.5 years. Most of the group members are single (86%) and work at a private company (69%). The gender distribution was almost even, with 49% men and 51% women.

The control group was composed of eighth semester students who were studying the Special Topics in Finance discipline. These students were not formally exposed to the EUT because this theory is not part of the curriculum in any subject of the management program in the mentioned university. Furthermore, it is worth emphasizing that there were no students common to both who could serve as insiders in the control group.

This group was made up of thirty-one individuals aged nineteen to thirty-one years, with an average age of twenty-three. Most of the group members (81%) are single and work for a private company (71%), with an even gender distribution, with 52% men and 48% women.

Before going into details as to how the experiment was structured, it should be pointed out that some changes were made to the questionnaire based on the works of Cruz, Kimura and Krauter (2003), Kimura, Basso e Krauter (2006), Silva et al (2009) and Rogers, Favato and Securato (2008). These modifications were necessary to adapt the questionnaire to the format of the proposed experiment. As the purpose of the study is to verify whether the group exposed to the EUT adopts this model in order to choose the portfolios offered in the questionnaire, this choice could lead to an impasse when dealing with some questions.

Let us take as an example one of the questions used in the seminal work of Kahneman and Tversky (1979, p. 267) that is also used in this article: "Which of these two alternatives do you prefer? a) a 45% chance to gain $6,000 and 55% to gain $0; b) a 90% chance to gain $3,000 and a 10% chance to gain $0".

When employing the EUT as to which choice is the best prospect, we would find that both have the same utility ($EUT_a = 0.45 \times 6000 + 0.55 \times 0.00 = 270$; $EUT_b = 0.90 \times 3000 + 0.10 \times 0.00 = 270$) and consequently no difference between them. As the original questionnaire did not have an "It's all the same" type of alternative, the individual would be obliged to choose one of the choices offered, and this could bias the results. For this reason, we added a third alternative called "It's all the same" to all the questions. The decision to include it not only in questions with prospects of the same utility was also taken to avoid possible bias, as an extra alternative in only some questions could raise suspicion among the respondents.

Another modification that was made to the questionnaire was the exclusion of qualitative questions concerning a choice of package tours. As the experimental groups was exposed to the EUT using a form of financial logic, the removal of these questions was justified in order to isolate the influence of other variables except the manipulated one, preserving the causality that the experiment was intended to study, as emphasized by Straist and Singleton (2011). The internal validity of the questionnaire was confirmed by specialist professors who also contributed to the modifications outlined above, arriving at the definitive format available in the Appendix A.

The control group was given the questionnaire at the end of their class. Every care was taken to make it clear that this was an experiment in which there was no right or wrong alternatives and that the respondents should make their choices based on personal preference. The experimental group received the questionnaire after a class that involved exercises whose goal was to revise previously seen content of the discipline, and this included choices of projects using the EUT. This was done in an effort to guarantee that the method had been made clear to the group (symmetry of information) before the respondents answered the questionnaire minutes later.

When the respondents received the questionnaire, it was made clear to them that there were no right alternative and respondents should make their choices based on individual preference.

As mentioned above, a second experiment was conducted with the experimental group, in which the respondents' understanding of the EUT was proved, ensuring the manipulation of the independent variable. For this reason, the questionnaire was applied once again on the day of the mid-term test, in which there was a question to be solved in accordance with the assumptions of the EUT, structured as follows:

"Doyter S.A. is conducting a feasibility study for the launch of a new product known as "Ruby" and would like to compare it with another called "Diamond". The chart below (*Chart 1*) shows the NPVs of the two projects for each scenario. The company presumes that the pessimistic and optimistic scenarios each have a 25% chance of occurring, while the realistic scenario has a 50% chance. Using the concepts of the Expected Utility Theory, which of the projects should the company accept?

Chart 1: Question from the mid-term test to gauge respondents' understanding of the EUT

Project	Pessimistic	Realistic	Optimistic
Ruby	-4.0	3.0	9.0
Diamond	-2.0	3.0	8.0

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With this measurement in hand, we took care to compare the responses only of the members of the group who answered this question correctly, ensuring that for the experimental group the variable was correctly manipulated. This could be done because in the questionnaire of Experiment 2, the respondents had to write their names. Once again, it was emphasized that there were no correct alternatives, but that the alternatives should be based on individual preferences. It should also be mentioned that the questions were rearranged from their original order in Experiment 1 and that between one experiment and the other there was an interval of forty days, preserving the historical internal validity.

4 DATA ANALYSIS

Table 1 shows the distribution of choices made by the control group and the responses of the seminal study of the Israeli psychologists concerning the replication of the study in Brazil conducted by Kimura, Basso and Krauter (2006). The vast majority of the questions showed a similarity of results between those obtained by the control group and the sample of Kahneman and Tversky, with the exception of Questions 10 and 11B.

Table 1: Distribution of choices by the control group and comparison with prior studies (Kahneman, Tversky, 1979; Kimura, Basso, Krauter, 2006)

Question	Prospect	Control	Kimura, Basso, Krauter (2006)	Kahneman, Tversky (1979)
1A	A: (2500:33%; 2400:66%; 0:1%)	39%	30%	18%
1B	B: (2400:100%)	61%	70%	82%
2A	A: (2500:33%; 0:67%)	76%	52%	83%
2B	B: (2400:34%; 0:66%)	24%	48%	17%

Question	Prospect	Control	Kimura, Basso, Krauter (2006)	Kahneman, Tversky (1979)
3A	A: (4500:80%; 0:20%)	14%	29%	20%
3B	B: (3000:100%)	86%	71%	80%
4A	A: (4000:20%; 0:80%)	61%	57%	65%
4B	B: (3000:25%; 0:75%)	39%	43%	35%
5A	A: (6000:45%; 0:55%)	23%	23%	14%
5B	B: (3000:90%; 0:10%)	77%	77%	86%
6A	A: (6000:0,1%; 0:99,9%)	91%	72%	73%
6B	B: (3000:0,2%; 0:99,8%)	9%	28%	27%
7A	A: (-4500:80%; 0:20%)	79%	82%	92%
7B	B: (-3000:100%)	21%	18%	8%
8A	A: (-4000:20%; 0:80%)	56%	37%	42%
8B	B: (-3000:25%; 0:75%)	44%	63%	58%
9A	A: (-6000:45%; 0:55%)	74%	75%	92%
9B	B: (-3000:90%; 0:10%)	26%	25%	8%
10A	A: (-6000:0,1%; 0:99,9%)	46%	50%	30%
10B	B: (-3000:0,2%; 0:99,8%)	54%	50%	70%
11A	A: (-400: 100%)	19%	30%	22%
11A'	B: (0:1/3; -600:2/3)	81%	70%	78%
11B	A: (200: 100%)	45%	71%	72%
11B'	B: (600:1/3; 0:2/3)	55%	29%	28%

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The certainty effect, in accordance with Allais (1953), establishes that preferences of prospect can depend on the level of certainty of probable results and not only on the utility present in each one. This effect was tested in Questions 1-6. It should be noted that in this sample most of the respondents opted for prospects with a high probability of return. In Question 6, however, this pattern was reversed because very low levels of probability are involved.

Meanwhile, the reflection effect shows that the individuals are averse to risk in situations that involve gain and reverse this posture in situations of loss, in which they are risk seeking. For this reason, when the expected returns of the prospects are inverted in Questions 7-10, the pattern of responses is expected to be the opposite of the same prospects when the returns were positive (Questions 3-6). With the exception of Problem 8, it should be noted that this was what showed the most equilibrium between the choices of portfolio in the original sample.

Finally, Questions 11a and 11b evaluate violations of the invariance principle, for which different representations of the same problem should produce the same references. According to this principle, the choices of programs should be independent of the formulation of the problem involving 400 dead individuals or 200 living individuals in a population of 600. However, there is a clear variation in the choices of the respondents because of the change in how the question is formulated, violating the invariance principle.

As the control group resorted to the three biases included in the questionnaire (reflection effect, certainty effect and denial of the invariance principle), the conclusion is that the sample replicated the results of the original experiment, corroborating H2 and in accordance

with the replications of the Brazilian samples in the works of Kimura, Basso and Krauter (2006), Rogers, Favato and Securato (2008) and Silva et al (2009). By confirming previous findings, these results also validate the instrument used and the representativeness of the groups that were tested. Consequently, they preserve the results found in the following experiments and exclude possible rival explanations.

4.1 Experiment 1:

The first hypothesis of the article concerns a comparison of the responses of the experimental group and the control group. Both sets of responses were compared using the chi-squared test with SPSS software, taking care to exclude a respondent from the control group who left several questions unanswered. Since the samples were small we tested the hypothesis for both Pearson's chi-square and Fisher exact test. The results are summarized in Table 2:

Table 2: Chi-squared test to gauge the difference in responses for Experiment 1

Experiment 1		
N = 31 (control) and 35 (experimental)		
Question	Pearson	Fisher
P1	0.894	0.458
P2	0.373	0.839
P3	1.379	0.354
P4	3.936	0.142
P5	1.272	0.666
P6	0.230	1.000
P7	2.099	0.526
P8	4.733	0.094
P9	1.844	0.623
P10	0.009	1.000
P11a	1.896	0.397
P11b	2.083	0.338

Font: prepared by the authors

An analysis of the results shows that there was no difference between the responses of the two groups with a significance level of 5%. In other words, even manipulating the rationality variable, the experimental group incurred the same heuristic biases of the control group which, in its turn, maintained a response pattern of the initial findings of Prospect Theory.

Given these results, a possible rival explanation would have to do with the real understanding of the EUT in the eyes of the experimental group. For this purpose, as mentioned above, the experimental group was submitted to a new experiment, the results of which are shown below.

4.2 Experiment 2:

In the second experiment, the questionnaire was handed to the experimental group in the very day of their mid-term test on Investment Decisions in which there was a question involving a choice of projects with different risks and returns that should be solved in accord-

ance with the assumptions of the EUT. When the test was corrected, 97.5% of the respondents answered correctly, showing that the information variable was indeed manipulated because the respondents knew how to apply the rational concepts of the EUT in situations involving risk. The responses of this new experimental group were then compared with those of the first experimental group, using the chi-squared test with SPSS. The results are shown in Table 3:

Table 3: Chi-squared test to gauge the difference between the responses of the second experiment

Experiment 2

N = 31 (control) and 37 (experimental 2)

Question	Pearson	Fisher
P1	1.872	0.221
P2	0.871	0.703
P3	0.129	0.790
P4	6.545*	0.030*
P5	0.595	0.822
P6	8.813*	0.011*
P7	1.645	0.550
P8	0.024	1.000
P9	1.239	0.766
P10	1.224	0.485
P11a	5.107	0.075
P11b	7.987*	0.018*

Note: *Significant at 0.05
Font: prepared by the authors

The findings reveal that there was a difference at a 5% level of significant only between responses 4, 6 and 11a. Therefore, a further analysis of these questions would be required.

On Question 4, the most rational response would be the option offered by Prospect A since, under the EUT, it would result in an expected utility of 800 against 700 offered by Prospect B. Table 4 shows the frequency of responses of the experimental group in Tests 1 and 2:

Table 4: Summary of responses to Prospect P4 from the experimental group in Tests 1 and 2

P4	GROUP	
	Control	**Experimental 2**
Alternative A	77%	49%
Alternative B	23%	46%
Alternative C	0%	5%

Font: prepared by the authors

The difference between the responses in both tests was mostly due to the increased choice of Prospect B in the second test as opposed to the rational choice of the EUT. This suggests that, even if this difference were statistically significant, it was not influenced by the manipulation of rationality. Therefore, this change in the response pattern of the group in Test 2 indicates that the respondents, even though they mastered the logic of the EUT, did not use it when choosing prospects. This demonstrates that sophisticated agents do not always adopt the rational pattern in decision-making, as expected in H1.

On Question 6, since both prospects offer the same expected utility (U = 6.00), the rational response expected from the respondents would be Alternative C, "It's all the same". A summary of the responses of both groups regarding this prospect is shown in Table 5.

Table 5: Summary of the responses to Prospect P6 from the experimental group in Tests 1 and 2

P6	GROUP	
	Control	Experimental 2
Alternative A	87%	54%
Alternative B	6%	30%
Alternative C	6%	16%

Font: prepared by the authors

Following an analysis observe that the difference between the averages occurred mainly in the distribution of responses between Alternatives A and B. In other words, this indicates that the significant difference of the responses between the groups for this question was not due to an alleged improvement in rationality but rather to a spurious phenomenon.

Finally, Question 11 presents two structures, each one with two different options to be made. In the first structure, both options have the same negative expected utility (-400). Similarly, the options of the second structure result in the same expected utility (+200), but now with a positive signal. Therefore, for both structures, the rational response would be "It's all the same". Table 6 shows a summary of the responses to Question 11b for both groups:

Table 6: Summary of responses to Question 11b from the experimental group in Tests 1 and 2

P11B	GROUP	
	Control	Experimental 2
Alternative A	29%	49%
Alternative B	68%	35%
Alternative C	3%	16%

Font: prepared by the authors

There was indeed an increase in the choices of the "It's all the same" option, which could be accounted for as increased rationality in the choice process for this question. However, as there was also a significant increase in the number of choices of Alternative B, the change in the response pattern for this question is inconclusive. To shed more light in this discussion, let's analyze the Question 11a, since both are related to the same dimension: the violation of the invariance principle. Table 7 presents the responses to this Question.

Table 7: Summary of responses to Question 11a by the control group in Tests 1 and 2

P11A	GROUP	
	Control	Experimental 2
Alternative A	29%	27%
Alternative B	68%	51%
Alternative C	3%	22%

Font: prepared by the authors

The table shows that the difference was mainly due to the respondents preferring to answer "It's all the same". Since the two questions (11a and 11b) seek to measure the same dimension, the results show that for this heuristic error there was a qualitative increase in the ration-

ality of the decision-making process as shown by the increase in the number of choices for "It's all the same", Therefore, it may be the most fragile of the biases measured by the questionnaire.

As there was no statistically significant different between the responses in Experiments 1 and 2 in 9 of the 12 questions, and as in the case of the three different responses only one difference can be attributed to increased rationality, it can be concluded that H2 was proved for this sample. Table 8 summarizes the responses of the three groups in both experiments in accordance with their conformity in relation to the EUT. Thus, the responses in agreement with this theory were included in the group "responses in accordance with the EUT" and the others were included as "responses that do not conform to the EUT".

Table 8: Grouping of responses from the groups in terms of conformity with the EUT

Group	Control	Experimental 1	Experimental 2
Responses in accordance with EUT	23%	26%	27%
Responses not conforming with EUT	77%	74%	73%

Font: prepared by the authors

The results suggest that there the manipulation of the variable did not influence the choices of the experimental group towards the EUT options. To test if there is no statistically difference between the choices of these groups before and after the manipulation of rationality, we compared the answers between the groups using both Pearson's chi-square and Fisher exact test. The results are presented in Table 9.

Table 9: Chi-squared test to gauge the difference between the responses of the experimental groups

N = 35 (experimental 1) and 37 (experimental 2)		
Question	Pearson	Fisher
P1	0.182	0.808
P2	2.359	0.352
P3	2.482	0.158
P4	0.583	0.797
P5	2.031	0.619
P6	7.174*	0.025*
P7	0.547	0.832
P8	4.999	0.068
P9	1.000	0.604
P10	1.460	0.490
P11a	4.309	0.122
P11b	2.253	0.325

Font: prepared by the authors

The results show that, except from Question 6, there is no significant difference between the choices of the groups. Therefore, we argue that the manipulation of the variable did not influence the choices of the experimental groups, in accordance with H2. The conclusion that is reached is that even the most rational individuals when faced with situations of risk make heuristic errors similar to those of laypeople. In accordance with other studies referred to in Subsection 2.3 and contrary to the assumptions of the EMH. The immediate consequence for the capitals market is that, if even the most sophisticated agents (as institutional investors) make heuristic errors, then the efficiency of the market is much lower than that expected by the EMH.

Another possible explanation is that when adopting hypothetical prospects, individu-

als make choices through a process that would be different from a real situation. On this point, previous studies (Kahneman and Tversky, 1979; Kimura, Basso and Krauter, 2006; Rogers, Favato and Securato, 2008; Silva and others 2009) were based on the understanding that "choices of alternative proposals on a questionnaire reflect the decision-making process of individuals in real-life situations" (KIMURA, BASSO, KRAUTER, 2006, p.47 – our translation). However, it is worth commenting that in none of the other groups tested has it taken longer than ten minutes to complete the questionnaire. As this questionnaire involved the quantitative evaluation of 24 prospects with different probabilities and a variety of returns, we believe that in a real situation, the time taken would be much longer than what we observed here.

This possibility is further strengthened by the observation that, in the question involving a resolution through the EUT (correctly responded by 97.5% of the members of the experimental group) the students used calculators and wrote out their calculations during the test. However, when they were completing the questionnaire, they did not use calculators; nor did they write down their calculations, except for a small minority. This is a dichotomy between the decision-making process in real life (a test) and a hypothetical situation.

5 FINAL CONSIDERATIONS

The findings of Israeli psychologists Kahneman and Tversky (1979) violated the understanding of individuals as rational and maximizing expected utility, as proposed by the Efficient Market Hypothesis. By claiming that human beings make heuristic errors in situations involving risk, Prospect Theory sowed the seeds of a new and promising field of study in the financial market, enabling an explanation of certain anomalies that are contrary to the classic model in force at the time.

Several works have replicated the seminal experiment of Kahneman and Tversky (1979) and corroborated the results. This has been the case even when the sample involved more rational, i.e., experienced, individuals. Nevertheless, by setting the "rationality" variable in terms of experience, without manipulating it directly, these studies left a gap that could limit the generalization of the results. The present study sought to fill this gap by replicating the original experiment using two groups: the experimental, to whom the Expected Utility Theory (EUT) was clearly exposed, and the control group.

Of the twelve questions included in the questionnaire, in eleven there was no significant difference in the choice of prospects between the two groups that could be explained by an increase of rationality, with both making the same heuristic errors of the original studies. Only for the dimension violation of the invariance principle we reported a qualitative increase on responses according to EUT, possibly meaning that this heuristic error may be the most weak. These results corroborate the previous finding and the assumptions of Prospect Theory in which individuals who are supposedly more "rational" are influenced by the same psychological biases as laypeople.

It is worth to mention that the number of respondents in both samples was small, what can favor the null hypothesis. Therefore, the replication of these experiments to larger sample is recommended. One final comment is that the results were obtained in a hypothetical situation in which the decision-making process, principally that of the experimental group, could be divergent from what was observed. In this sense, experiments whose methodological design seeks to bring hypothetical situations closer to real life situations, especially in terms of feelings of loss and gain, are highly recommended and appear to be a promising agenda for this field of knowledge.

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APPENDIX A - Questions from the questionnaire used in the experiment

Problem 1: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
33% chance of gaining $2500   100% chance of gaining $2400
66% chance of gaining $2400   1% chance of gaining $0

Problem 2: Which alternative do you prefer?
(   ) Alternative C   (   ) Alternative D   (   ) It's all the same
33% chance of gaining $2500   34% chance of gaining $2400
67% chance of gaining $0   66% chance of gaining $0

Problem 3: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
80% chance of gaining $4000   100% chance of gaining $3000
20% chance of gaining $0

Problem 4: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
20% chance of gaining $4000   25% chance of gaining $3000
80% chance of gaining $0   75% chance of gaining $0

Problem 5: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
45% chance of gaining $6000   90% chance of gaining $3000
55% chance of gaining $0   10% chance of gaining $0

Problem 6: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
0.1% chance of gaining $6000   0.2% chance of gaining $3000
99.9% chance of gaining $0   99.8% chance of gaining $0

Problem 7: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
80% chance of losing $4000   100% chance of losing $3000
20% chance of losing $0

Problem 8: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
20% chance of losing $4000   25% chance of losing $3000
80% chance of losing $0   75% chance of losing $0

Problem 9: Which alternative do you prefer?
(   ) Alternative A   (   ) Alternative B   (   ) It's all the same
45% chance of losing $6000   90% chance of losing $3000
55% chance of losing $0   10% chance of losing $0

Problem 10: Which alternative do you prefer?

( ) Alternative A   ( ) Alternative B   ( ) It's all the same

0.1% chance of losing $6000   0.2% chance of losing $3000

99.9% chance of losing $0   99.8% chance of losing $0

Problem 11: Suppose that Brazil is preparing to face an uncommon Asian disease. It is estimated that the disease will kill 600 people. Two alternative programs to fight the disease are proposed. Let us assume that the exact scientific estimates of the consequences of the program are those outlined below.

Structure 1

If Program A is adopted, 400 people will die;

If Program B is adopted, there is a one-third possibility that nobody will die and a two-thirds possibility that all 600 people will die.

Which program are you in favor of?

( ) Program A   ( ) Program B   ( ) There is no difference between them

Structure 2

If Program A' is adopted, 200 people will be saved;

If Program B' is adopted, there is a one-third possibility that everyone will be saved and a two-thirds possibility that none of the 600 people will be saved.

Which program are you in favor of?

( ) Program A   ( ) Program B   ( ) There is no difference between them