Risk aversion, the disposition effect and decision-making in groups

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Keywords: Disposition effect, Risk aversion, Group decisions.

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Resumo

Este artigo apresenta os resultados de um experimento de laboratório conduzido com o propósito de investigar a forma pela qual o efeito disposição afeta a decisão de investimento de indivíduos e grupos. Foram realizadas seis sessões experimentais com 174 estudantes de graduação. Os estudantes exibiram o efeito disposição enquanto decidiam sozinhos, porém o efeito deixou de ser estatisticamente significativo quando as decisões foram tomadas por grupos de dois ou de três indivíduos. Também foi possível observar que o efeito disposição foi resultado de uma alta proporção de ganhos realizados, indicando que os indivíduos foram mais avessos ao risco do que os grupos.

Palavras-chave: Efeito disposição, Aversão ao risco, Decisões em grupos.

Abstract

This paper presents the results of a laboratory experiment conducted to investigate the manner in which the disposition effect affects individuals' and groups' investment decision making. We conducted six experimental sessions with 174 undergraduate students. We found that the students exhibited the disposition effect when working alone, but that the effect was no longer statistically significant when they made decisions together in two and three-member groups. We also observed that the disposition effect was the result of a high proportion of gains being realized, indicating that the individuals were more risk averse than the groups.

Keywords: Disposition effect, Risk aversion, Group decisions.

JEL Code: C91, C92, G02, G11

1 Introduction

Do groups take better decisions under risk than individuals? This article presents an analysis of how groups of people behave when taking decisions under risk, with reference to the behavioral bias known as the disposition effect.

The disposition phenomenon is considered an anomaly in the standard behavior of financial agents and is manifest in their reluctance to realize losses. Within the stock market, for example, people tend to hold stocks that have lost value compared to their acquisition price longer than stocks that have gained value since purchase (Schlarbaum et al. 1978; Shefrin and Statman 1985; Odean, 1998).

This behavior has been observed in several different contexts within finance and economics, including among holders of stock options (Heath, Huddart and Lang, 1999), futures traders (Locke and Mann, 2005 and Coval and Shumway, 2005), mutual fund investors (Shu et al., 2004), sellers in the housing market (Genesove and Mayer, 2001), students being studied in experimental economics laboratories (Myagkov and Plott,1997; Weber and Camerer, 1998; Da Costa Jr. et al., 2008) and even among institutional investors (Grinblatt and Keloharju, 2001; Shapira and Venezia, 2001).

The inspiration for this article comes from Cooper and Kagel's observation (2005, p. 478) that the majority of investment decisions taken in the financial market and also the strategic decisions taken within firms are the result of a consensus reached between two or more people. This insight contrasts with the greater part of financial and economic theories and their respective empirical tests, since they do not differentiate between decisions taken by groups and those taken by individuals.

Some researchers are beginning to analyze the predictions made by theory with relation to the behavior of groups, including scholars working in areas such as international relations (Levy, 1997), game theory (Kocher and Sutter, 2005; Bornstein and Yaniv, 1998), strategy (Cooper and Kagel, 2005), and decision making under risk (Rockenbach et al., 2007; Shupp and Williams, 2008),.

One theory that has been used to attempt to explain the disposition effect phenomenon is Prospect Theory, which was developed by Kahneman and Tversky (1979). At this point it is important to point out that, while this article draws on prospect theory, it does not aim to propose technical enhancements to the theory that would increase its compatibility with the behavior of groups, even though it was originally developed on the basis of observation of the behavior of individual people when faced with choices under risk (Kahneman and Tversky, 1979). To do so would demand a high degree of mathematical complexity to deal with non-linear probability weighting functions, for example, not to mention many other problems. The objective here is simply to attempt to detect differences between individual and group behavior. It may be hoped that such findings and observations could in turn provide a basis for a technical enhancement of prospect theory that would allow it to predict the behavior of people in aggregated terms, thereby making it more realistic. Among others, Fiegenbaum and Thomas (1988), Whyte (1993) and Levy (1997) have applied prospect theory to the study of group behavior, with reference to organizational behavior, sunk costs and international relations, respectively.

This paper attempts to answer the following questions: (a) Can the disposition effect be detected in groups of people tested under controlled laboratory conditions? (b) Is this effect different (greater or smaller) when the experiment is conducted with individuals? (c) Does the effect change as the size of the group is increased?

The remainder of this paper is structured as follows. The next section presents the theoretical framework, the third section describes the methodology employed, the fourth section presents and discusses the results and the last section concludes.

2 Prospect theory, the disposition effect and group decision making

According to Thaler (1999, p.12), modern economic and financial theory is based on the assumption that the "representative" economic agent takes decisions as predicted by expected utility theory and takes unbiased decisions with relation to the future. Those who defend this paradigm argue that the theory is not invalidated by the fact that some people take sub-optimal, irrational decisions, as long as the marginal investor is rational. Irrational decisions end up canceling each other out.

These concepts were considered to be robust, with the result that the study of stock market investor behavior was not considered an attractive research avenue. Financial and economic research was therefore more concerned with studying the behavior of prices. Notwithstanding, studies undertaken to investigate anomalies in the financial markets found evidence of inconsistencies in decision-makers' reasoning, making it clear that there was a need to understand other models of human behavior, such as those studied in the social sciences. Of particular interest among such models is work published by the Israeli psychologists Amos Tversky and Daniel Kahneman.

2.1 Prospect theory

Kahneman and Tversky (1979) developed a descriptive theory called prospect theory on the basis of the results of a series of laboratory experiments. This theory challenges the basics axioms of von Neumann and Morgenstern's (1944) utility theory. One of the most important elements of Kahneman and Tversky's work (1979, p.268) is a description of an experiment conducted with students at three different universities (in Israel, the United States and Sweden), showing that the decisions individuals take with regard to losses are an inverse reflection of the choices they make with regard to gains. This experiment can be described as follows.

Suppose that a person is required to choose between the options available in the following prospect[1]:

(1) 80% chance of $4 thousand return and 20% of zero return; or

(2) 100% chance of $3 thousand return.

The prospect above is normally shown in the following compact form:

Option 1: ($4,000, 80%; $0, 20%) or Option 2: ($3,000, 100%)

Although the expected return from the risky option is higher (at $3.2 thousand), 80% of the people who took part in the experiment chose the guaranteed three thousand.

[1] According to Kahneman and Tversky (1979), a prospect (or gamble) is a contract that yields result x_i with probability p_i, where $p_1 + p_2 + \cdots + p_n = 1$. A prospect offering "n" possible choices can therefore be shown as $(x_1, p_1; x_2, p_2 ; . . . ; x_n, p_n)$.

Kahneman and Tversky (1979) then offered a different prospect to another sample of people. This time 92% of the interviewees chose the riskier option (option 1), even though the expected loss of $3.2 thousand was greater than the sure loss of $3 thousand. This prospect can be shown as follows:

Option 1: (-$4,000, 80%; $0, 20%) or Option 2: (-$3,000, 100%)

Kahneman and Tversky (1979), in common with many other researchers (Allais, 1953, Ellsberg, 1961, Machina, 1982, Fishburn, 1982, and others), found that this asymmetrical pattern appears systematically across a wide variety of experiments. While understandable, this behavior is incompatible with the assumptions of rational behavior defended by expected utility theory, which is itself one of the pillars of neoclassical economics and of modern finance.

2.2 Risk aversion and the disposition effect

Tversky and Kahneman (1991) observed that there is strong evidence to be found in people's behavior to support the existence of a loss aversion phenomenon. They found that variation in the price of an asset has a greater impact when the variation is seen as a loss than when the same degree of variation is seen as a gain; in other words "losses loom larger than gains".

In order to try to explain the apparently irrational behavior of people when faced with prospects such as those described above, Kahneman and Tversky (1979) proposed a value function (shown in Figure 1). There are two other characteristics, in addition to loss aversion, that are essential to determining the asymmetrical "S" shape described by this function: the first is its "reference dependence", meaning that the curve is centralized around a reference point, and the second is the fact that the marginal value of both gains and losses reduce in line with magnitude, indicating "diminishing sensitivity".

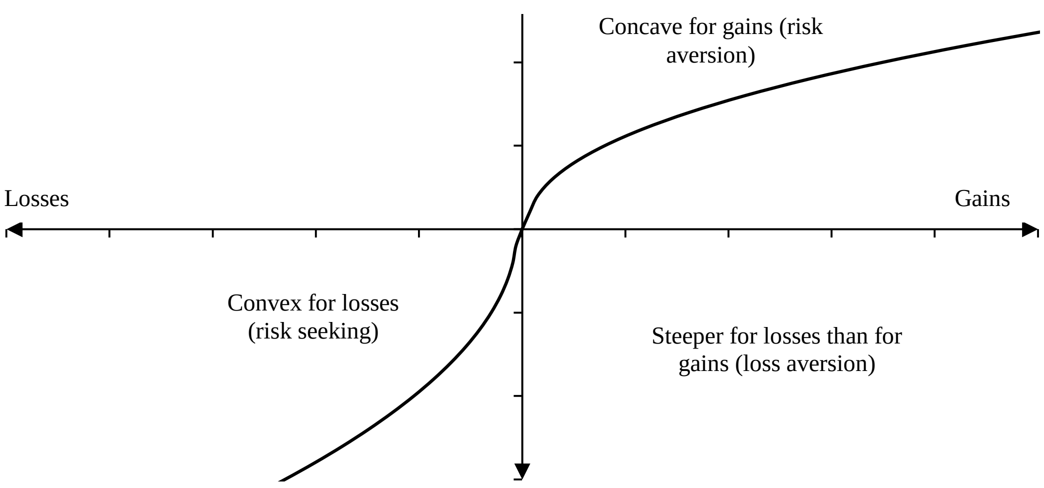

Figure 1. The prospect theory value function

According to Shefrin and Statman (1985, p.779), the disposition effect becomes apparent when several factors are present in combination. First, decision-makers (investors, in this case) make their choices in a very specific manner (Kahneman and Tversky [1979] have labeled this the editing phase). During this phase, decision makers formulate all possible choices in terms of gains and losses, with relation to a fixed reference point. During the second phase, called the evaluation phase, decision makers use a value function (shown in Figure 1). This function is concave in the gain region and convex in the loss region, reflecting risk aversion in the gain region and a propensity towards risk in the loss domain. The characteristic loss aversion is shown by the steeper curve on the loss side, compared with the gain side.

An example adapted from Shefrin and Statman (1985, p.779) and Weber and Camerer (1998, p.170) provides a good illustration of why the disposition effect is a consequences of loss aversion. Consider an investor who bought a given stock at a certain time in the past when the price was $100 and now finds that it is trading at $80. This investor must now decide whether to realize the loss or to continue holding the stock for a further period of time. To keep the example simple, assume there are no taxes or transaction costs. Additionally, assume that there are two possible results that may occur during the next period: either a $20 rise in the share price or a $20 fall, both with the same probability of taking place. According to prospect theory, such an investor would make choices on the basis of the following prospect, or gamble:

A - sell the stock now, thereby realizing what would be a loss of $20.

B - hold the stock for one more period, with a 50% chance of losing a further $20 and a 50% chance of gaining $20, thereby recovering what has been lost previously.

Since the choice between the two possible results of this prospect is within the convex part of the "S" shaped value function, prospect theory predicts that option B will be chosen rather than option A. In other words, the investor will choose the risky option and hold the losing stock. An analogous argument can be used to show that, according to prospect theory, the same investor would choose to sell the stock if this involved a gain.

2.3 Groups

The literature on the decision-making behavior of groups and individuals within financial contexts is still recent and because of this there is not yet consensus on whether groups take better decisions than individuals.[2] Some studies have found evidence for the superiority of groups (Blinder and Morgan, 2005; Rockenbach et al., 2007), and others for the superiority of individuals (Whyte, 1993; Kocher and Sutter, 2005), while yet others have reported indefinite results (Bone et al., 1999; Shupp and Williams, 2008). Studies have also been conducted to investigate factors

[2] In general, a group is formed when two or more people work together to accomplish a common task. In psychology, a small group is made up of no more than 15 members and normally would not pass 10 (Tuckman,1965). Slater (1955), for example, considered small groups to have from three to seven members.

other than the number of members in decision-making groups, such as for example, whether differences can be linked to sex, educational level or the location (country) in which the research subjects live.

Blinder and Morgan (2005) attempted to determine whether groups of five people performed better than individuals, analyzing decision-making in two different experiments: the first dealt with questions of monetary policy while the second was a purely statistical task. When analyzing their results, Blinder and Morgan (2005) found that in the first experiment (monetary policy) groups were superior to individuals by 3.5 percentage points, while in the second experiment (urns) groups were superior to individuals by 3.7 percentage points. The authors therefore concluded that groups performed better than individuals in both experiments and also noted that they did not take any longer than individuals to arrive at their decisions.

Kocher and Sutter (2005) conducted an experiment using a “beauty-contest game” designed to determine whether there are differences in terms of reasoning, learning and efficiency when decisions are taken by individuals or by groups of three people. They found that, as the game was repeated, groups exhibited a greater capacity to learn the game’s dynamics and achieve better results.

Kugler et al. (2007) studied a game in which players were either groups of three people or individuals and which was designed to identify the level of trust in decision making. The game involved two players: (i) a sender and (ii) a responder. The sender is given an endowment and may send any fraction to the responder. The sum sent is tripled and the responder may send any fraction of the tripled amount back to the sender. The authors found that when groups were playing as senders, they normally exhibited less trust than individuals, but they found no difference between the returns sent by groups and by individuals.

Sutter (2005) investigated the decision-making process in groups of four and of two members and compared the results with those for individuals. The size of the groups was varied in attempt to supplement work by Kocher and Sutter (2005), in which groups had achieved higher returns than individuals, but which had not varied the number of group members.

In common with the study by Kocher and Sutter (2005), the study Sutter (2005) conducted also used the beauty-contest game. He found that groups with four members were superior to individuals but that two-member groups did not perform significantly differently from individuals. On this basis, he claimed that group size is a relevant variable for determining team performance.

Bornstein and Yaniv (1998) analyzed decision-making under risk by groups and individuals using a game called ultimatum. In this game there are two players who must interact to decide how to divide a sum of money that has been given to them. Player A makes the offer, proposing how the sum will be divided between the two players. Player B may accept or reject player A's offer. If player B rejects player A's offer, then neither of the players will receive any money. If B accepts the offer, then the sum will be duly divided as proposed by A. Additionally, the game is only played once. Bornstein and Yaniv (1998) analyzed the results for 20 groups of three people (30 player As and 30 player Bs) and for 20 individual players (10 player As and 10 player Bs). They found that groups behaved more rationally that individual decision makers, because they offered less when they were playing the A role and demanded less when they were in the player B receiving role, thereby demonstrating better understanding of the game's structure, particularly when playing the offering role (player A).

Bone et al. (1999) tested the consistency of group decision-making against individual decision-making using a game called Common-Ratio. Players analyzed 12 probabilities during three stages of the game, playing stages one and three individually and stage two in groups. In this case there was little evidence that the groups were more consistent than individuals. Notwithstanding, the authors noted that having participated in groups helped individuals to increase their consistency of reasoning in the final stage of the game. They therefore concluded that individuals achieved better results after having participated in a group decision-making stage, acquiring improved rational consistency.

Rockenbach et al. (2007) published an article specifically related to risk in finance, analyzing groups' behavior under risk on the basis of expected utility theory and portfolio selection theory. These authors did not find evidence that groups and individuals behaved differently with relation to expected utility theory, but they did find substantial differences in consistency with relation to portfolio theory. Groups performed better than individuals in terms of risk-adjusted returns. Rockenbach et al. (2007) considered that the groups' advantage lay in avoiding excessive exposure to risk, which individuals often failed to avoid.

Shupp and Williams (2008) found that, on average, groups are more risk-averse in high-risk situations. In contrast, groups behave with less risk-aversion in low-risk situations.

3 Methodology

3.1 Experimental design and ExpEcon software

The experiments were conducted with undergraduate students who took investment decisions using software called ExpEcon, designed to simulate a simplified share market (Goulart et al., 2008).

ExpEcon was developed with reference to an experiment described by Weber and Camerer (1998) that involved dealing in six shares over 14 simulation periods. It should be noted that both Weber and Camerer's experiments (1998) and the ExpEcon software simulate an exogenous market in which prices are preset and are not affected by the buying and selling decisions of the game's participants.

The database used for the experiments was sub-sampled to provide four different configurations. Each configuration tracked the share prices of six stocks, each identified by letters (A, B, C, D, E or F). The six stocks' share prices were based on the monthly variation in the prices of the most liquid stocks in the São Paulo stock market's index (the IBOVESPA index) and each configuration covered a 30-month period selected at random from the interval 2000 to 2010. Figure 2 illustrates the four configurations utilized.

Three different experimental designs were used, with players varying as follows: (i) individuals; (ii) groups of two people; (iii) groups of three people. The experimental participants were 174 undergraduate students studying for degrees in Management, Accounting, Economic Science or International Relations at the Universidade Federal de Santa Catarina. This sample was divided as follows: 30 individuals, 30 pairs and 28 groups of three. Data were collected in six experimental sessions.

A system for rewarding participants was included in order to the increase internal validity of the experimental sessions.[3] At the end of each session those participants (whether playing individually or in groups) whose results were in the top quartile in terms of payoff were entered into a draw to win a prize. The prize awarded was calculated as follows: each player began the simulation with 10,000 monetary units at their disposal; when the winning group or individual was drawn, their final number of monetary units (payoff) was divided by 1000 and each member of the group was paid that number of Reais. For example, if a three-member group was drawn and had a payoff of 15,000 monetary units, then each member would receive a total of R$ 15.00, making R$ 45.00 prize money for the whole group.

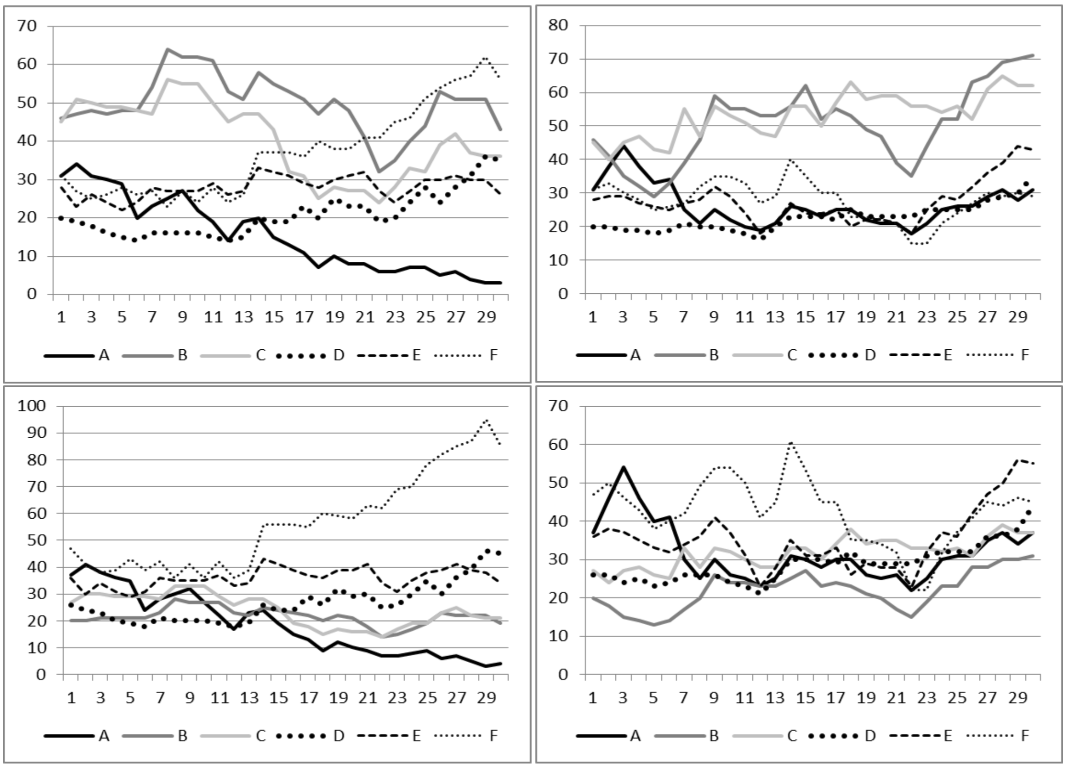

Figure 2. The four simulation configurations

[3] For a discussion of the importance of employing reward mechanisms in experiments see Smith (1976) and Friedman and Cassar (2004).

3.2 Estimating the disposition effect

The methodology used to measure the disposition effect was based on Odean (1998). An individual or group was considered to exhibit the disposition effect if their Proportion of Gains Realized (PGR) was greater than their Proportion of Losses Realized (PLR) over the period analyzed. The result of subtracting PLR from PGR was termed the Disposition Coefficient (DC). A positive DC indicates the presence of the disposition effect, since it shows that the investor has realized a higher percentage of gains than losses. The variables described above are now presented below:

$$\frac{\mathrm{RG}_i}{\mathrm{RG}_i + \mathrm{PG}_\mathrm{i}} = \mathrm{PRG}\ _i \tag{1}$$

$$\frac{\mathrm{RL}_\mathrm{i}}{\mathrm{Rl}_\mathrm{i} + \mathrm{PL}_\mathrm{i}} = \mathrm{PRL}_i \tag{2}$$

$$\mathrm{DC}_i = \mathrm{PRG}_i - \mathrm{PRL}_i \tag{3}$$

where, RG represents realized gains, PG stands for paper gains, which are unrealized or potential gains, PGR is the proportion of realized gains, RL is realized losses, PL is paper losses, PLR the proportion of realized losses, DC is the disposition coefficient and *i* the individual or group investor.

The Disposition Coefficient is generally given in two forms: (i) individual and (ii) aggregated. In the first case, DC is calculated for each experimental unit. In the second, an overall DC is calculated for each treatment. Since the results for both methods were similar, we chose to present only the individual data. The aggregate data is shown in Appendix A.

As shown by Kahneman and Tversky (1979), it is necessary to calculate a reference point before gains and losses can be estimated (RG and RL). The reference point used here was the Average Purchase Price. There are other methods for calculating a reference point, such as the highest purchase price, the first purchase price or the latest purchase price. However, we chose to follow Odean (1998) and Weber and Camerer (1998) in using the average purchase price.

The average purchase price was calculated by dividing the cost of the shares bought by the number of shares in the portfolio. Each time an individual or group bought additional quantities of a stock that they already held in their portfolio, their average purchase price was weighted using the initial purchase price and each subsequent purchase price. Therefore, a sale operation was considered a gain if the price obtained was higher than the average purchase price; and a sale operation was considered a loss if the price obtained was lower than the average purchase price.

After the proportions of realized gains and losses had been obtained, the disposition coefficient was calculated (Equation 3) for each experimental unit (individuals, pairs and three-member groups). In order to verify whether the disposition coefficient really exists from a statistical point of view, two possibilities can be tested: (i) $H_0: DC = 0$ and $H_1: DC > 0$; (ii) $H_0: PRG = PRL$ and $H_1: PRG > PRL$. Tests of these two hypotheses were therefore conducted for both means (t test) and medians (Wilcoxon signed rank test and Mann-Whitney U-test). (Wilcoxon, 1945; Mann and Whitney, 1947).

After testing the significance of the results of tests conducted up to this point, we attempted to verify whether DC, PGR or PLR differed across treatments. To achieve this, we first conducted simple linear regression for which dependent variables were DC, PGR and PLR; and the independent variable was a dummy variable for groups (including pairs and three-member groups in the same variable), as shown in Equation 4[4]:

$$y_i = \alpha + \phi GROUPS_i + \varepsilon_i \qquad (4)$$

where Y_i can be DC (disposition coefficient), PGR (Proportion of Gains Realized) or PLR (Proportion of Losses Realized); $GROUPS_i$ is a dummy variable that takes $GROUPS_i = 1$ for groups (with two or three members), and $GROUPS_i = 0$ for individuals.

We also conducted a multivariate regression that differs from Equation (4) in that two dummies were included, one to indicate two-member groups and the other for three-member teams, as shown below:

$$y_i = \alpha + \phi_1 PAIRS_i + \phi_2 TRIOS_i + \varepsilon_i \qquad (5)$$

where Y_i can be DC, PGR or PLR; $PAIRS_i$ is a dummy to indicate whether the group is a pair (1 if a pair, 0 if not); $TRIOS_i$ is a dummy to indicate whether the group is a three-member group (1 if a three-member group, 0 if not).

3.3 Simulations with robots

In addition to the analyses of the results from the experimental sessions, we also conducted a number of randomized simulations on the ExpEcon software. The simulations followed the following rules: (i) the database configuration to be used (from the four shown in Figure 2) was chosen at random for each simulation; (ii) the trade (whether purchase or sale) and the stock to be traded were selected at random; and (iii) the value of each trade was also

[4] Both Equation 4 and Equation 5 have been corrected for heteroskedasticity as recommended by White (1980).

selected at random. For each buy trade a random percentage of the amount of monetary units held at that point was generated. If a sale was chosen, then the percentage of stock sold was randomized from the total number of shares of the stock to be traded that were held at that point. Sales of assets that had not yet been bought were ignored. Thirty simulations were run in this manner.

The purpose of conducting these simulations was to make it possible to compare the results obtained with each of the three treatments tested experimentally (decisions taken by individuals, by two people or by three people) with results obtained from entirely unbiased decision-making, i.e., decisions taken at random. These data were analyzed using the same methodology adopted for the data obtained from the experiments with the students.

4 Results

This section presents the study results. Table 1 lists some of the statistics for the data from the simulations using ExpEcon. It can be observed that mean returns were greatest among three-member groups and that, curiously, the mean number of trades conducted during experiments was the same for individuals as for groups. Table 1 also shows that individuals generally held more diversified portfolios than groups.

As was explained in the methodology section, the disposition effect can be measured either as an aggregated figure (calculating a single disposition coefficient for each sample based on the sum of realized gains and losses) or as an individual figure (calculating one disposition coefficient for each sample unit, thereby obtaining several coefficients and making it possible to conduct statistical tests for differences between means and medians, for example). In this section, only the results for the individual level are shown. The aggregated results are given in Appendix A.

Table 1. General statistics

	Overall Results	Individuals	Pairs	Three People	Robots
Observations	88	30	30	28	30
Mean return	31.7%	28.9%	24.6%	42.2%	16.5%
Mean number of trades	42	42	42	42	28
Total number of trades	3703	1251	1265	1187	834
Mean number of stocks in portfolio per period	3.3	2.8	3.7	3.5	3.7

Note: The overall results columns in this table and the next do not include the data from the robots, only from the individuals, pairs and three-member teams.

Table 2 contains descriptive statistics for the data. With the exception of the random simulations (robots), means and medians for Proportion of Gains Realized (PGR) were always higher than the means and medians for Proportion of Losses Realized (PLR). This meant that there were positive Disposition Coefficients for all three experimental treatments (individuals, pairs and three-member groups) and for overall results.

Table 2. Descriptive statistics

	RG	RL	PG	PL	PGR	PLR	DC
Overall							
Mean	8.2	5.9	37.2	35.7	0.219	0.164	0.054
Median	8.0	5.0	37.0	34.5	0.176	0.101	0.058
SD	5.3	5.3	22.2	19.2	0.163	0.184	0.203
Maximum	22	26	95	91	0.800	0.944	0.550
Minimum	0	0	2	0	0.000	0.000	-0.521
Total	721	519	3276	3141	19.235	14.454	4.781
Individuals							
Mean	7.0	4.8	28.5	29.1	0.263	0.152	0.111
Median	5.5	4.5	25.0	26.5	0.223	0.095	0.072
SD	4.8	4.4	20.5	17.0	0.204	0.146	0.241
Maximum	16	18	84	64	0.800	0.600	0.550
Minimum	0	0	2	1	0.000	0.000	-0.236
Total	211	144	856	874	7.891	4.549	3.342
Pairs							
Mean	9.4	6.4	42.7	41.4	0.193	0.146	0.047
Median	8.0	4.5	44.0	41.5	0.171	0.098	0.066
SD	5.6	6.4	19.7	17.4	0.110	0.186	0.193
Maximum	22	26	86	75	0.467	0.944	0.454
Minimum	0	0	8	1	0.000	0.000	-0.521
Total	281	191	1281	1241	5.790	4.380	1.410
Three people							
Mean	8.2	6.6	40.7	36.6	0.198	0.197	0.001
Median	7.5	7.0	37.0	41.5	0.171	0.109	0.034
SD	5.3	4.9	24.4	21.6	0.156	0.218	0.153
Maximum	21	19	95	91	0.800	0.833	0.280
Minimum	1	0	4	0	0.023	0.000	-0.357
Total	229	184	1139	1026	5.554	5.526	0.029
Robots							
Mean	3.9	3.6	56.9	47.4	0.063	0.072	-0.009
Median	3.5	3.0	58.5	47.0	0.060	0.064	-0.009
SD	2.1	1.9	19.8	15.9	0.034	0.037	0.059
Maximum	8	8	94	83	0.159	0.161	0.104
Minimum	0	1	4	22	0.000	0.018	-0.120
Total	117	107	1708	1422	1.900	2.173	-0.273

Notes: Presentation of data, where RG is realized gains, RL realized losses, PG is paper gains, PL is paper losses, PGR and PLR are proportions of realized gains and losses and DC is the disposition coefficient. The values shown (mean, median, standard deviation, maximum, minimum and totals) relate to data in the individual (non-aggregated) format, used to calculate the Disposition Coefficients and for the statistical tests.

While not shown in the tables, the Jarque-Bera and Anderson-Darling tests of normality were applied to DC distributions. In no case was the null hypothesis, that the variable's distribution was normal, rejected (p-value < 0.10). However, the same tests were used for PGR and PLR and the results did indicate rejection of the null hypothesis of normality (p-value > 0.10). In view of this, the results for the *t* test for differences between means (shown in Table 3) are more robust for the case $H_1: DC > 0$ than for the proportions of gains and losses ($H_1: PRG > PRL$). Table 3 also lists the results for the Wilcoxon and Mann-Whitney tests, which are nonparametric and do not therefore demand normal distribution.

The *t* test of means for the hypothesis $H_1: DC > 0$ was statistically significant for overall results, for individuals and for pairs (individuals: p-value < 0.01; pairs: p-value < 0.10). For $H_1: PRG > PRL$, H_0 was rejected for overall results and for individuals, with p-values of < 0.05 and < 0.01, respectively. Tests of means did not achieve statistical significance for the three-member groups.

The result of the tests of medians is similar to those for the means. The Wilcoxon test results for one sample ($H_1: DC > 0$) indicate statistical significance for individuals (p-value < 0.05), for pairs (p-value < 0.05) and for overall results (p-value < 0.01). The Mann-Whitney test also detected statistical significance for individuals (p-value < 0.05), for pairs (p-value < 0.01) and for overall results (p-value < 0.01). In common with the means, the tests of medians did not return statistically significant results for three-member groups.

The results obtained from the randomized simulations with robots, shown in Table 3, did not achieve statistical significance for any of the tests conducted. In other words, the randomized simulations were free from the disposition effect bias (PGR and PLR were both similar and statistically indistinguishable). Figures 3 and 4 illustrate this situation.

Table 3. Disposition Coefficients (calculated at the individual level)

	Overall Results	**Individuals**	**Pairs**	**Three People**	**Robots**
Observations	88	30	30	28	30
Tests					
t test ($H_1: DC > 0$)	2.49***	2.51***	1.31*	0.04	-0.84
teste t ($H_1: PRG > PRL$)	2.08**	2.46***	1.19	0.01	-0.98
Wilcoxon ($H_1: DC > 0$)	2482***	310**	315**	222	189
Mann-Whitney ($H_1: PRG > PRL$)	8912***	1060**	1093***	872	854

*Significant to 10% **Significant to 5% ***Significant to 1%

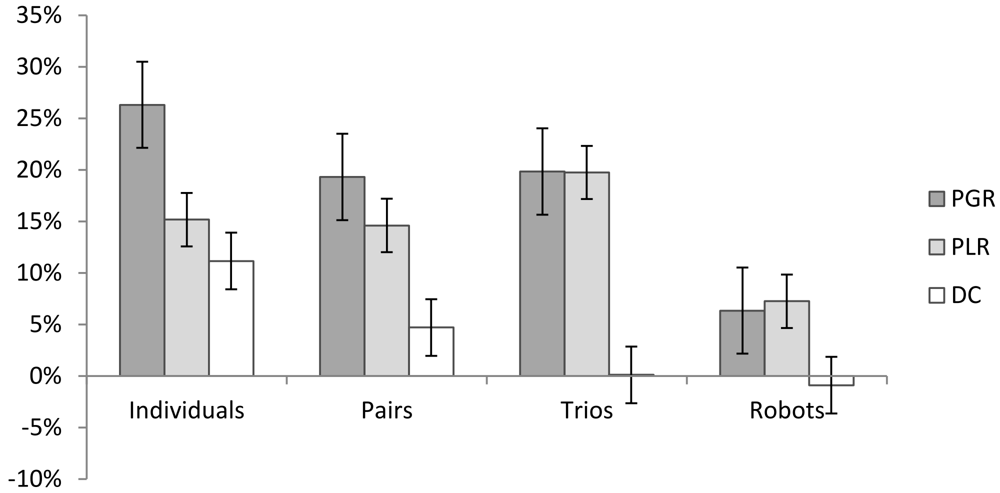

Figure 3. Means

Figure 5 illustrates the empirical Cumulative Distribution Function for the Disposition Coefficients, based on a normal distribution. This function is appropriate since H_0 was accepted in the Jarque-Bera and Anderson-Darling tests of normality. Figures 3, 4 and 5 show that DC reduces gradually as the number of group members increases. Furthermore, this difference in DC between treatments appears to be greater in the gains zone (when the Proportion of Gains Realized is greater than the Proportion of Losses Realized, i.e. $DC > 0$) than it is in the losses zone (DC$<$ 0).

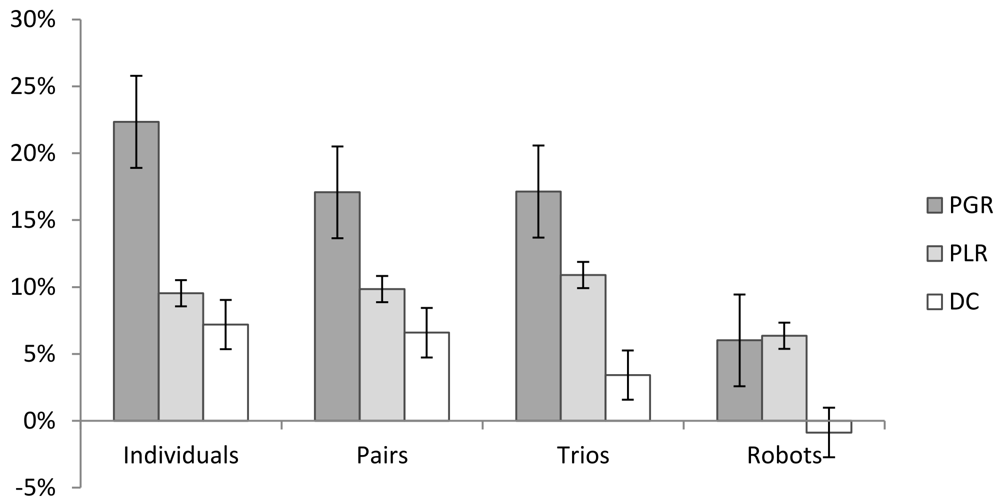

Figure 4. Medians

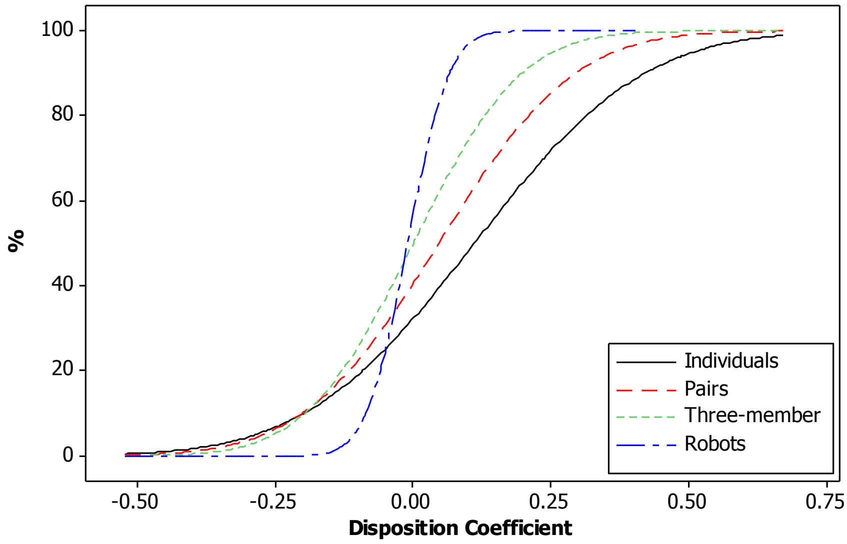

Figure 5. Empirical cumulative distribution

Observing the means and medians for PGR and PLR in Table 2 and Figures 3 and 4, it will be noted that PGR for individuals was greater than for both sizes of group (pairs and three-member groups). It can also be observed from Table 2 and Figures 3 and 4 that PLR was greater for three-member groups than for individuals or for pairs. Simple linear regression and then multivariate linear regression with dummy variables were conducted in order to test whether these differences were statistically significant. These regressions are described by Equations 4 and 5and their results are shown in Tables 4 and 5, respectively.

Models (1) from Table 4 and (4) from Table 5 provide confirmation that the classification of decision makers into groups or individuals reveals a difference in terms of the results for disposition coefficients, with lower coefficients for groups (especially three-member groups) than for individuals. The second model from Table 4 shows that the lower PGR for groups than for individuals was confirmed statistically by the regressions ($F = 3.48$, p-value < 0.10). The higher PGR for individuals than for groups may indicate that individuals are more risk averse, since they realize more gains than the groups do. This difference is also apparent in Figures 3 and 4. Although significant differences were detected for Proportions of Realized Gains (PGR), no significant differences were detected for Proportions of Realized Losses (PLR), as can be seen in the results for models (3) and (6) in Tables 4 and 5.

Table 4. Results of Equation 4

Model	Dependent variable	Dummy groups			R^2	F
		Coefficient	SE	t		
(1)	DC	-0.087	0.042	-1.75*	0.042	3.72**
(2)	PGR	-0.067	0.034	-1.65*	0.039	3.48*
(3)	PLR	0.019	0.033	0.51	0.02	0.21

Notes: The results shown in this table are derived from the equation: $y_i = \alpha + \phi GROUPS_i + \varepsilon_i$, where y_i takes the value of DC, PGR or PLR In turn, $GROUPS_i$ is a dummy variable for both sizes of group (1 for groups and 0 for individuals).
*Significant to 10% **Significant to 5% ***Significant to 1%

Table 5. Results of Equation 5

Model	Dependent variable	Dummy pairs			Dummy three-member groups			R^2	F
		Coeff.	SE	t	Coeff.	SE	t		
(4)	DC	-0.064	0.049	-1.14	-0.110	0.043	-2.10**	0.050	2.24
(5)	PGR	-0.070	0.035	-1.65*	-0.065	0.042	-1.36	0.039	1.73
(6)	PLR	-0.006	0.041	-0.13	0.046	0.037	0.93	0.015	0.66

Notes: The results shown in this table are derived from the equation: $y_i = \alpha + \phi_1 PAIRS_i + \phi_2 TRIOS_i + \varepsilon_i$, where y_i takes the value of DC, PGR or PLR In turn, $PAIRS_i$ and $TRIOS_i$ are dummy variables for pairs and three-member groups respectively (1 for pairs or three-member groups, as appropriate, and 0 for other cases).
*Significant to 10% **Significant to 5% ***Significant to 1%

Finally, as explained in the methodology section, experiments were conducted using four different database configurations (see Figure 2) which were allocated to participants at random at the start of each experiment. In order to test whether the disposition coefficient had been influenced by the initial simulation configuration selected, a one-factor analysis of variance (ANOVA) was conducted with the whole-sample disposition coefficient as dependent variable and the factor defined as a series from 1 to 4, to represent the different initial configurations used ($DC_{i,j} = DC_i + t_j$, where i is the experimental unit and j represents the effect of the four treatments). The results did not reveal any statistical significance (p-value = 0.43). In other words, the four initial configurations used for the experiments did not affect the resulting disposition coefficients.

5 Final comments

The experimental sessions conducted for this study confirmed the presence of a disposition effect among the individuals. However, the disposition effect appeared to become attenuated as more members were added to groups. The analyses conducted were unable to statistically confirm the disposition effect for the three-member groups. Among pairs, the effect was detectable but at a lower level than among the individual investors.

The results of this study with respect to individual decision makers confirm what has been observed by other authors, such as Weber and Camerer (1998) and Da Costa Jr. et al. (2008) under laboratory conditions. However, it was observed that groups did not exhibit the disposition effect and, furthermore, when the Proportion of Gains Realized (PGR) and Proportion of Losses Realized (PLR) were analyzed, it was found that individuals had higher PGR than groups, but that PLR did not differ statistically between groups and individuals. With respect to the sample described here, it can therefore be stated that the disposition effect exhibited by the individual investors was the result of a greater inclination to realize gains. Such behavior may be an indication that the individuals were more risk-averse than groups when the prices of the shares they were holding in their portfolios were at highs. In contrast, the groups' behavior was more uniform for both shares at highs and at lows, with relation to the average price of purchase (based on the proximity of the proportions of gains and losses realized - PGR and PLR). In this respect, the groups' behavior was closer to what is expected according to traditional financial theories.

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Appendix A

This appendix contains the results of the aggregated analysis of the disposition coefficients. Here, rather than calculating a DC value for each experimental unit, an aggregated DC was calculated for each of the three treatments (individuals, pairs and three-member groups) and for the randomized simulations (robots). For each treatment, PGR was compared with PLR to see if it was greater and, if so, the difference was tested for statistical significance. In view of this, the Z test for differences between proportions is an appropriate method for illustrating the differences. The standard error calculation used for the denominator of the equation shown below was adapted from Odean (1998, p. 1784) and Shefrin and Statman (1985, p. 789):

$$Z_i = \frac{PGR_i - PLR_i}{\sqrt{\frac{PGR_i(1 - PGR_i)}{(RG_i + PG_i)} + \frac{PLR_i(1 - PLR_i)}{(RL_i + PL_i)}}}$$

where, Z_i is the Z statistic for each treatment i. P-values can be obtained from tables of critical values for the Z statistic.

Table 6. Statistics for Disposition Coefficients at the aggregated level

Overall Results	Overall Results	Individuals	Pairs	Three people	Robots
Realized Gains (RG)	721	211	281	229	117
Realized Losses (RL)	519	144	191	184	107
Paper Gains (PG)	3276	856	1281	1139	1708
Paper Losses (PL)	3141	874	1241	1026	1422
PGR=RG/(RG+PG)	0.180	0.198	0.180	0.167	0.069
PLR=RL/(RL+PL)	0.142	0.141	0.133	0.152	0.075
disposition coefficient (DC)	0.039	0.056	0.047	0.015	-0.007
Standard error of DC	0.008	0.016	0.013	0.014	0.010
Test Z	4.604***	3.439***	3.515***	1.062	-0.730

Notes: Overall results do not include the results for the robots, i.e. they only combine results from individuals, pairs and three-member groups.

*** Significant to 1% ** Significant to 5% * Significant to 10%

Table 6 lists the aggregated results, which are similar to those obtained at the individual level. It will be noted that PGR is greater than PLR and that the difference is statistically significant for overall results, individuals and pairs. While the results for pairs indicated a DC that is significant to 1%, it will be noted that the DC for pairs (0.047) was lower than the DC for individuals (0.056). In other words, Table 6 reflects the same pattern that can be observed in Figure 3, in that the DC for individuals is greater than the DC for pairs, which is in turn greater than the DC for the three-member groups. Figure 6 illustrates the aggregated data in the form of a graph, clearly showing how PGR falls progressively from the first to the third treatment, indicating that groups realized fewer gains than individuals. Similar results for PGR were also produced by the regressions, as can be observed in Tables 4 and 5.

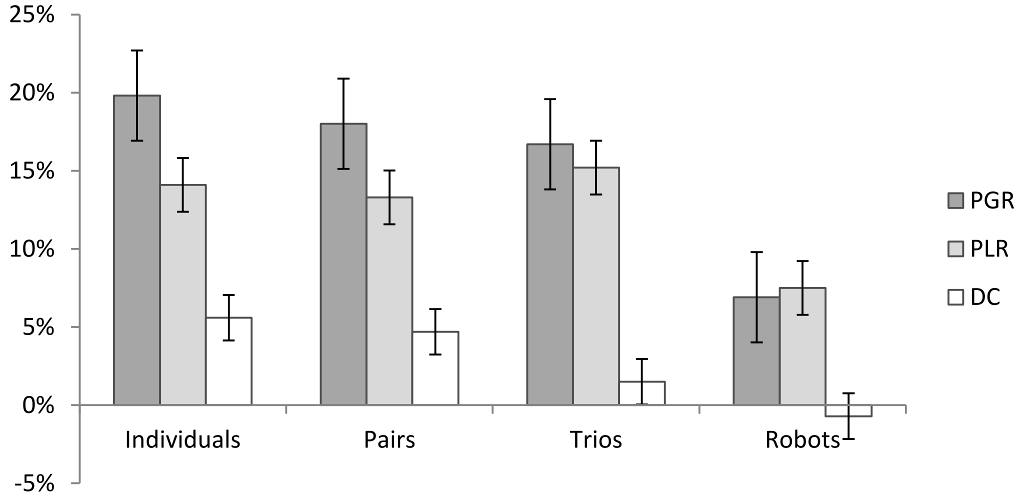

Figure 6. Aggregated Data