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DISPOSITION EFFECT AND REFERENCE POINTS: AN EXPERIMENTAL STUDY

Abstract:
This study calls into question the default computation of the disposition effect that uses the average purchase price as a reference point. We show, through laboratory experiments, that the reference price of participants can change depending on the experimental behavioral design used. Our first experiment (n=100), which consisted of an investment simulation without any behavioral manipulation of the participants, showed that the five reference points used to compute the disposition effect were equivalent, supporting other experimental and non-experimental studies. On the other hand, in our second experiment (n=118), we showed that with the addition of experimental manipulation concerning the disclosure of the final balance of the participants, the reference prices showed statistically significant differences. The need to display their results caused these participants to use the first purchase price as a reference point when selling their assets. If the behavior of investors in real capital markets is like that of students who have had their behavior manipulated in a laboratory setting, further studies about the disposition effect should take this fact into account.

Keywords: Disposition effect; Reference points; Behavioral finance; Experimental finance; Randomized controlled trial.
JEL codes: G41, D91, C91

Resumo:
Este estudo questiona o cálculo padrão do efeito disposição que utiliza o preço médio de compra como ponto de referência. Mostramos, por meio de experimentos de laboratório, que o preço de referência dos participantes pode mudar dependendo do desenho comportamental experimental utilizado. Nosso primeiro experimento (n=100), que consistiu em uma simulação de investimento sem qualquer manipulação comportamental dos participantes, mostrou que os cinco pontos de referência utilizados para calcular o efeito de disposição eram equivalentes, apoiando outros estudos experimentais e não experimentais. Por outro lado, em nosso segundo experimento (n=118), mostramos que com a adição da manipulação experimental referente à divulgação do saldo final dos participantes, os preços de referência apresentaram diferenças estatisticamente significativas. A necessidade de exibir seus resultados fez com que esses participantes utilizassem o preço de primeira compra como referência na hora de vender seus ativos. Se o comportamento dos investidores em mercados de capitais reais é semelhante ao de estudantes que tiveram seu comportamento manipulado em laboratório, estudos adicionais sobre o efeito disposição devem levar em conta esse fato.

Palavras-chave: Efeito disposição; Pontos de referência; Finanças comportamentais; Financiamento experimental; Teste controlado e aleatório.

1. INTRODUCTION

The behavioral finance literature reports the existence of several anomalies in investor decision making. One of the most studied anomalies is the disposition effect, which consists of the fact that investors tend to hold losing positions longer than gaining positions. The term "disposition effect" was coined by Shefrin and Statman (1985) when they analyzed the percentages of gains and losses in mutual fund transactions in the USA. Another work, among the most cited on the subject, is that of Odean (1998), when he analyzed the operations of clients from a discount brokerage house, also in the USA. Odean (1998) proposed one of the most widely used methods for computing the disposition effect, either for investors trading in the real stock market or for participants in experimental settings.

The disposition effect has been related to some investor characteristics. There is evidence that the disposition effect is lower when there is financial advice (SHAPIRA; VENEZIA, 2001), and when investors are experienced (DA COSTA JR et al., 2013), and that it is higher in inexperienced investors (GRINBLATT; KELOHARJU, 2001; FENG; SEASHOLES, 2005; DHAR; ZHU, 2006), women, and people from certain cultures (FRINO; LEPONE; WRIGHT, 2015).

In his paper, Odean (1998, p.1782) reported that before adopting the average purchase price of a stock as a proxy for the true reference point in the computation of the disposition effect, he analyzed three other possible reference prices: the highest purchase price, the first purchase price, and the most recent purchase price. He found that the four ways of computation showed statistically similar results, opting to use the average purchase price as the reference. It can also be mentioned that Weber and Camerer (1998) and Rau (2015), in experimental settings, also found no differences in computing the disposition effect with either FIFO or LIFO accounting principles.

Based on the results found by Odean (1998), studies about the disposition effect choose to use the average purchase price as the reference point, such as Chui (2001), Brown et al. (2006), Chong (2009), Lehenkari (2012), Li and Yang (2013), Muhl and Talpsepp (2018), and Dierick et al. (2019). More recently, Brettschneider, Burro and Henderson (2021) argued that the average purchase price is the most natural term of comparison and also the appropriate benchmark from an accounting perspective. However, the classification of assets into winners or losers considering only average purchase prices may not actually reflect the psychological processes in investors' minds, as it would be counterintuitive to assume that investors facing a sell decision are not influenced by stock prices at any time other than when they bought the stock.

Although Odean (1998) suggested that the average purchase price shows similar results to the other methods, little is known about the influence that experimental designs can have on the outcome of the disposition effect (its statistical significance), since its level depends on the reference points adopted. In Odean's (1998) study, real data from the financial market were used. In this paper we investigate whether the experimental design can affect the participant's perceived reference point when selling their shares and therefore the level of his disposition effect.

The present study was conducted based on a computational investment simulation applied to undergraduate students. The investment simulation follows the methodology proposed by Weber and Camerer (1998) and Goulart et al. (2015). While Odean (1998) used real data for the evaluation of the disposition effect, we chose to use an experiment due to the greater control it enables over the variables studied. We point out that the discussion about using the average price to compute the disposition effect is also present in laboratory experiment studies (RAU, 2015; HERMANN et al., 2019).

We conducted two experiments. In the first one, we conducted an experiment with students who were invited to participate in an investment simulation with no special

manipulation conditions but ensuring the anonymity of their performance. The second experiment was a randomized controlled trial (RCT). Following the methodology used in Goulart et al. (2015), participants were randomly assigned to two groups: public and private. In the public group, students were invited to perform the computer simulation and make their results public at the end of the experimental session, and a ranking with the positions of all the participants was publicly disclosed. In the private group, the individuals kept their results confidential, as in the first experiment.

The rational behind this last experiment is that there is a wealth of empirical evidence showing that traders in the stock market, when exposed to social interaction (proxied by the public group in our experiment), tend to increase their market share and turnover, as well as the disposition effect (OZSOVLEV et al., 2014; HEIMER, 2014, 2016; HWANG et al., 2015; BROWN et al., 2008).

We emphasize that our goal in this paper is not to propose a method to know in advance which reference point should be used under a given experimental manipulation. Our goal is simpler. It is to show that the experimental environment can influence the choice of reference point by the participants of an experiment and thus bias the results of the disposition effect if this effect is computed by the average purchase price.

Our results show that, for the first experiment, where there was no manipulation of the participants, different reference prices do not present significant differences in the computation of the disposition effect, thus corroborating the use of the average purchase price as a reference. However, this is not the case for participants in the group with public manipulation in the second experiment, where the first purchase price is the only significant one, showing that participants in this public group make their sales based on the first purchase price. The result in the group with no manipulation (private group) in this second experiment is similar to that in the first experiment, which was also conducted with private manipulation of the participants.

These results are relevant because they show the importance that studies on the disposition effect, especially those where experimental manipulations occur, should evaluate the effect according to different reference points. The most common practice that has been adopted in most studies, whether experimental or not, is to use only the average purchase price, possibly due to the prior understanding that other reference prices would show similar results (ODEAN, 1998).

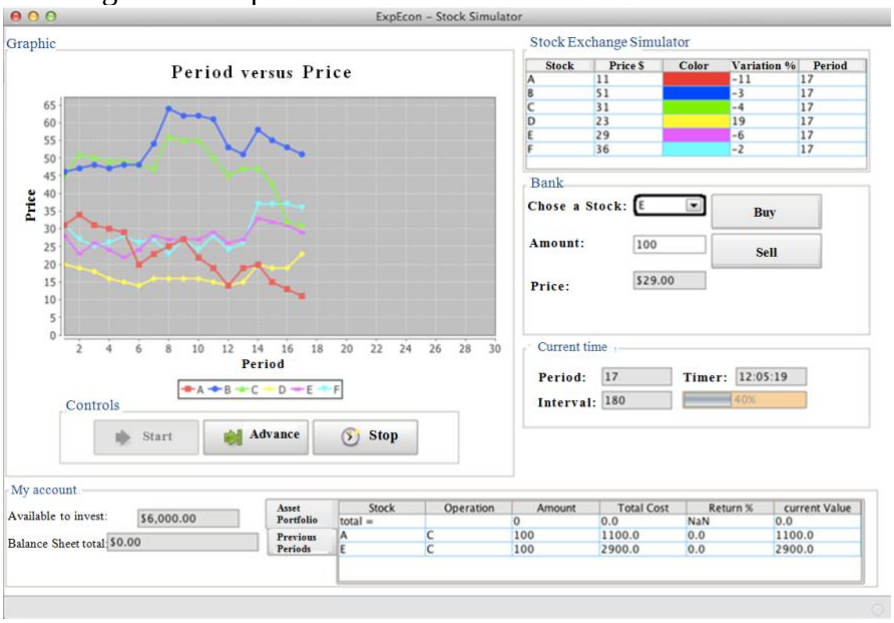
This paper is organized as follows. Section 2 presents the most common way of computing the disposition effect, which is the one based on Odean (1998), and the different possibilities of reference points for the purchase price. Section 3 details the design of the two experiments used in this study. Section 4 presents the results and Section 5 concludes the study.

2. MEASURES OF THE DISPOSITION EFFECT

This research is based on the experimental designs of Weber and Camerer (1998) and Goulart et al. (2015). We attempted to understand the behavior of individuals in relation to the cognitive bias called the disposition effect, which we measured from different reference points. For this purpose, the data for this research were collected in an investment simulation software called ExpEcon. Figure 1 shows the main screen of the ExpEcon[1] software.

[1] ExpEcon is hosted in the Github repository and can be accessed at https://github.com/schmaedech/expecon.

Figure 1 – ExpEcon investment simulator's main interface



ExpEcon is an exogenous investment simulator that has six stocks to trade: A, B, C, D, E, and F. The prices of these stocks can be generated randomly, as in Weber and Camerer (1998), or based on the stocks that made up Ibovespa in previous periods. Ibovespa is the market index with the most liquid stocks in the Brazilian stock market.

The window called "Stock Exchange Simulator" shows the participant the last period's information for each of the six stocks. This information includes the price, color (for viewing on the graph on the left), price variation in relation to the previous period, and information period.

The window named "Period x Price" presents a chart for the participant to visualize the price of the stock in each period and, to facilitate viewing, each stock has a different color. Besides the color, the assets also have a symbol to identify them, which allows colorblind individuals to participate in the study. Thus, as time goes by, the chart is updated with information from the previous period.

The window called "bank" is where the participant effectively carries out his buying and selling operations, chooses the asset to be traded and indicates the desired value. ExpEcon does not allow short selling or financing.

The window called "current time" is where the participant can see the interval between periods (in seconds) and how much time is left before the end of the period (when the bar is full, the software automatically switches to the next period). ExpEcon simulates 30 sub-periods (in the case of this study), and the total simulation time varies by participant, reaching a maximum time of 90 minutes (up to three minutes for each of the 30 sub-periods).

In addition, the window called "my account" shows the amount of available funds (free for trading) and the current value of the portfolio added to the cash on hand (total balance sheet). On the right side, we see the participant's asset portfolio, all the transactions carried out per asset, the amounts traded, the lot cost of the share units, the current value of the shares in the portfolio, and the percentage difference between the current value and the lot cost. In this study, all the participants began the simulation with 10,000 currency units to trade.

The simulation does not provide any information other than the current and past prices of each stock. The software also generates an output file with a report of all asset purchases and sale transactions in each period simulated by the participant.

The main variable of interest in this study is the coefficient associated with the disposition effect of a participant in the experiment. For this purpose, the measure proposed by

Odean (1998) was used, which measures the difference between the proportion of gains and the proportion of losses of each participant. Thus, the disposition effect is calculated as follows:

$$DE_i = \frac{N_{GR}^i}{N_{GR}^i + N_{GP}^i} - \frac{N_{LR}^i}{N_{LR}^i + N_{LP}^i}$$

Where DE_i is the disposition coefficient of individual i; N_{GR}^i (N_{LR}^i) is the number of trades of investor i with a realized gain (loss) and N_{GP}^i (N_{LP}^i) is the number of potential trades for investor i with a gain (loss). The coefficient varies from -1 to $+1$, where $DE_i = 1$ means that the individual made only sales at a profit and $DE_i = -1$ means that the individual made only sales at a loss. $DE_i = 0$ means that the individual has no disposition effect.

A sale is defined as a winner (loser) if the sale price is higher (lower) than the reference price. Odean (1998) reported that the average purchase price, the maximum purchase price, the first purchase price and the last purchase price are all statistically similar when it comes to actual buying and selling transactions by clients of a US discount brokerage firm. In our experimental study, in line with our objective, we looked at five possible reference points: average purchase price (DE_reg), minimum purchase price (DE_minbuy), maximum purchase price (DE_maxbuy), first purchase price (DE_firstbuy) and last purchase price (DE_lastbuy).

As we have already defined, the disposition effect is related to the tendency to realize gains quickly and postpone realizing losses. Therefore, to detect whether the computed coefficient associated with the disposition effect is statistically significant, Odean (1998) suggested the test of difference of means with the following null hypothesis: the number of sales with a gain is equal to the number of sales with a loss. Thus, according to Odean, DE_i can be evaluated by the t-statistic:

$$t = \frac{PGR - PLR}{SE}$$

where PGR is the proportion of gains realized, PLR is the proportion of losses realized, and the standard error SE is given by:

$$SE = \frac{S}{\sqrt{n}}$$

where S is the sample standard deviation and *n* is the sample size.

3 EXPERIMENT DESIGNS AND HYPOTHESES

We divided our study into two experiments with the samples consisting of undergraduate students from a Brazilian public university.[2] The first experiment included students (n=100; 68% males) who simply performed the computer simulation in a laboratory environment, without any further treatment manipulation. The students were invited to participate in the research on a voluntary basis over 6 experimental sessions, and the results obtained by each participant remained confidential at the end of a session. In four sessions, there was an individual monetary incentive that varied according to the final balance obtained in the investment simulation by the student. All sessions were conducted prior to the covid pandemic.

[2] Data from the two experiments can be accessed at https://doi.org/10.6084/m9.figshare.17091719.v1

In the second experiment[3], on the other hand, manipulations were added in order to highlight whether the context in which they are embedded can change the perspective of the reference points for the disposition effect. In this case, an RCT research design was conceived to address some of the empirical challenges, since randomizing subjects into groups allows us to explicitly address the problems of endogeneity, self-selection, and reverse causality (DE MEL et al., 2008).

Participants in experiment II were randomly assigned to two groups: public (n=62; 61.3% males) and private (n=56; 60.7% males). In the first group, we added the need to expose the results at the end of the simulation, as developed by Goulart et al. (2015). Thus, after completing the simulation with ExpEcon, the final balance of everyone was known by the entire group, as each participant had to go to the blackboard and write his/her name, final balance, and ranking among the participants of that experimental session, in descending order. This study was approved by the Research Ethics Committee of the University of Santa Catarina under number 711.395.

According to Goulart et al. (2015), the need for results exposure may drive biased behavior due to individuals' strategic attempt to protect themselves against the embarrassment of ending the trading session at the bottom of the performance rating. Importantly, the participants were informed of this condition before beginning the simulation.

As for the private group, the participants performed the investment simulation, but at the end they did not need to expose their results to their colleagues. The financial results remained confidential. Therefore, we expect to obtain a result similar to experiment I.

For this second experiment, all the individuals received a financial reward for participating in the research according to his/her final balance. 1,000 monetary units of the simulation equals a R$1 cash prize. For example, if at the end of the simulation the final balance, which appears on the simulation screen, is 15,000 monetary units, the subject receives R$15.00 (equivalent to US$4.50 at the time of the experiment). To maintain the secrecy of the result of the private group, at the end of the simulation, the participants received an envelope containing the amount corresponding to their final balance. As in experiment I, all the sessions were conducted prior to the covid pandemic. In both experiments, we excluded from the sample the participants who did not make sales during the period.

From this experimental design, we sought to test the following research hypotheses:

Hypothesis 1: Under experimental conditions without any behavioral manipulation of the environment, the average purchase price (as in Odean, 1998) is equivalent to the other reference points for the computation of the disposition effect.

Hypothesis 2: Under experimental conditions with behavioral manipulations, there can be a significant difference among the disposition effect coefficients according to the reference point used in their computation.

4. RESULTS

4.1 Experiment I

This experiment investigated the disposition effect with a total sample of 100 undergraduate students who performed the ExpEcon computer simulation in a laboratory environment. Table 1 presents the descriptive statistics of the disposition effect coefficients considering the five benchmarks tested. The table also presents the test of difference of means between the proportions (PGR and PLR).

[3] The data used in this second experiment is an "extended version" (n=118 vs n=63) of the one used by Goulart et al. (2015), but now with the disposition effect estimated with five different reference points.

Table 1 – Descriptive Statistics of Experiment I (n = 138).

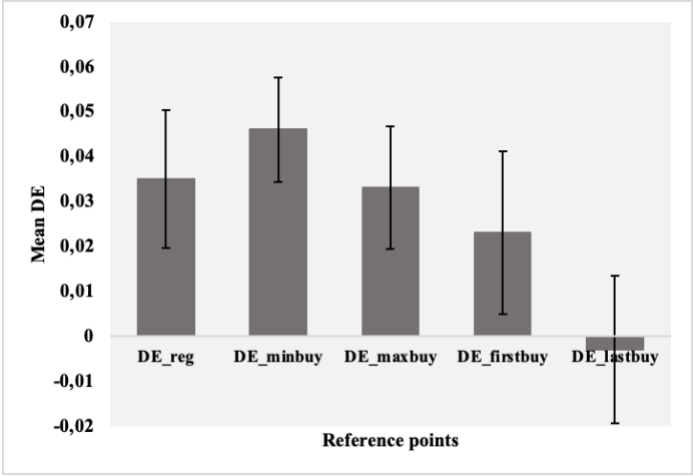
Disposition effect	Mean	Standard Deviation	Minimum	Maximum	*t* test (DE=0)	p-value
DE_reg[1]	0.035	0.154	-0.464	0.533	2.282	0.025**
DE_minbuy[2]	0.046	0.116	-0.277	0.533	3.920	0.000***
DE_maxbuy[3]	0.033	0.137	-0.305	0.571	2.399	0.018**
DE_firstbuy[4]	0.023	0.182	-0.691	0.800	1.276	0.205
DE_lastbuy[5]	-0.003	0.165	-0.694	0.471	-0.155	0.877

Notes:
The estimation of the DE for each reference point used n=100 observations.
[1] Disposition effect with the average purchase price as a reference.
[2] Disposition effect with the minimum purchase price as a reference.
[3] Disposition effect with the maximum purchase price as a reference.
[4] Disposition effect with the first purchase price as a reference.
[5] Disposition effect with the last purchase price as a reference.
*** significant at 1%; ** significant at 5%..

For three of the five benchmarks, the coefficients of the disposition effect were positive and significant, that is, the proportion of realized gains was different from the proportion of realized losses. This fact deserves attention because, as evidenced by Afi (2017) and Choi, Kim, and Kwon (2020), this cognitive bias leads to losses, and the more the traders are subject to the disposition effect, the more losses they will suffer.

Figure 2 presents the averages of each coefficient to better visualize the levels of disposition effect by reference point.

Figure 2 – Graphical representation of the disposition effect coefficients from experiment I.



With Figure 2, we have the first evidence that the disposition effect coefficients have similar behavior. However, to test this hypothesis, we must investigate the coefficient differences between the reference points used. To do this, we used multivariate analysis of variance, which evaluates mean differences between groups (HAIR et al., 2009), by means of one-way ANOVA performed in three tests: homogeneity of variance, F ANOVA or Welch's F and Tukey's HDS or Games-Howell's post-hoc HDS. We sought to assess whether in experimental studies the similarity between minimum and maximum purchase price, first and last purchase price, and average purchase price is maintained, as was verified by Odean (1998) when he checked this difference under real market conditions.

Table 2 – ANOVA test of experiment I.

Variables	Mean	F test	p-value
DE_reg[1]	0.035		
DE_minbuy[2]	0.046		
DE_maxbuy[3]	0.033	1.436	0.221
DE_firstbuy[4]	0.023		
DE_lastbuy5	-0,003		

Notes:
[1] Disposition effect with the average purchase price as a reference.
[2] Disposition effect with the minimum purchase price as a reference.
[3] Disposition effect with the maximum purchase price as a reference.
[4] Disposition effect with the first purchase price as a reference.
[5] Disposition effect with the last purchase price as a reference.

The non-significance of the test shows that the calculated means of the disposition effect are not statistically different, which eliminates the need for the post-hoc test. This result is in keeping with the findings of Odean (1998) for real investors.

Next, we estimated a multiple linear regression model. To avoid the dummy variable trap, we used the average purchase price as the comparison parameter, representing the regression intercept, and included the remaining four dummy variables as independent variables. DE_minbuy is a dummy variable where 1 means that the reference point is the minimum purchase price and 0 any other reference point. For DE_maxbuy, 1 means that the reference point is the maximum purchase price and 0 any other reference point. DE_firstbuy is also a dummy variable, where 1 represents the first-buy price and 0 represents any other reference point. Finally, for DE_lastbuy, 1 represents the last purchase price and 0 any other reference point. As a dependent variable, we used all the disposition coefficients calculated for each participant.

Table 3 – Multiple linear regression for experiment I.

Variables[1]	Coefficient	p-value
DE_minbuy[2]	0.027	0.630
DE_maxbuy[3]	-0.006	0.910
DE_firstbuy[4]	-0.032	0.577
DE_lastbuy[5]	-0.099	0.081
Adj R^2	0.003	
F test	1.436	
p-value	0.221	

Notes:
[1] Disposition effect as dependent variable.
[2] Dummy variable for reference point: (1) minimum purchase price and (0) other reference prices.
[3] Dummy variable for reference point: (1) maximum purchase price and (0) other reference prices.
[4] Dummy variable for reference point: (1) first purchase price and (0) other reference prices.
[5] Dummy variable for reference point: (1) last purchase price and (0) other reference prices.

Table 3 shows that the coefficients were not statistically significant, which reinforces the statistical similarity between the benchmarks tested. We also point out that the model was not significant (p-value = 0.221), given the non-significance of the variables in the model.

4.2 Experiment II

In this experiment, we randomly assigned the students to two different groups - the treatment group, which we called the "public" group, and the control group, which we called the "private" group. The students in the "private" group (n=56) kept their results to themselves, exactly as in experiment I. In the "public" group (n=62), on the other hand, the students had to disclose their final financial results after the operations of buying and selling stocks. Table 4 presents the descriptive statistics of the disposition effect coefficients, as well as the test of difference of means to verify whether the calculated coefficients are significant.

Table 4 – Descriptive statistics of experiment II, by treatment.

Disposition effect	Mean		Standard Deviation		*t* test (DE=0)		p-value	
	Private	Public	Private	Public	Private	Public	Private	Public
DE_reg[1]	0.033	0.053	0.207	0.223	1.189	1.872	0.239	0.066*
DE_minbuy[2]	0.068	0.078	0.154	0.183	3.279	3.365	0.002***	0.001***
DE_maxbuy[3]	0.027	0.029	0.215	0.215	0.933	1.049	0.355	0.298
DE_firstbuy[4]	0.063	0.152	0.281	0.178	1.674	6.738	0.100	0.000***
DE_lastbuy[5]	0.046	0.111	0.181	0.248	1.913	3.515	0.061*	0.001***

Notes:
Private is the treatment where the subjects did not need to report their results (n = 56).
Public is the treatment where the subjects needed to report their results (n = 62).
[1] Disposition effect with the average purchase price as a reference.
[2] Disposition effect with the minimum purchase price as a reference.
[3] Disposition effect with the maximum purchase price as a reference.
[4] Disposition effect with the first purchase price as a reference.
[5] Disposition effect with the last purchase price as a reference.
***significant at 1%; **significant at 5%; *significant at 10%.

The descriptive statistics for the private treatment revealed that only when considering the minimum price (p-value < 0.01), and the last price (p-value < 0.10) as a reference did we find a significant disposition effect. In this case, the proportion of gains was statistically different from the proportion of losses. For the other points, there was no significant difference between the proportion of gains and losses realized. This result alone represents a weak point in the choice of reference price. When researchers analyze the disposition effect only by the average price, they may be missing information and drawing hasty conclusions about the biased behavior of individuals.

When it came to the group of students who were previously aware that they had to expose their financial results after the simulation, the subjects showed significant disposition effect for four of the reference prices tested: average purchase price (p-value < 0.10), minimum price, and first and last purchase price (p-value <0.01).

Another result worth mentioning in the public group is the average of the coefficients, and for DE_firstbuy the average was 0.152, much higher than the other coefficients. Figure 3 presents the averages by reference point and by group for a better visualization of the differences.

Figure 3 – Graphical representation of the disposition effect coefficients of experiment II, by treatment.

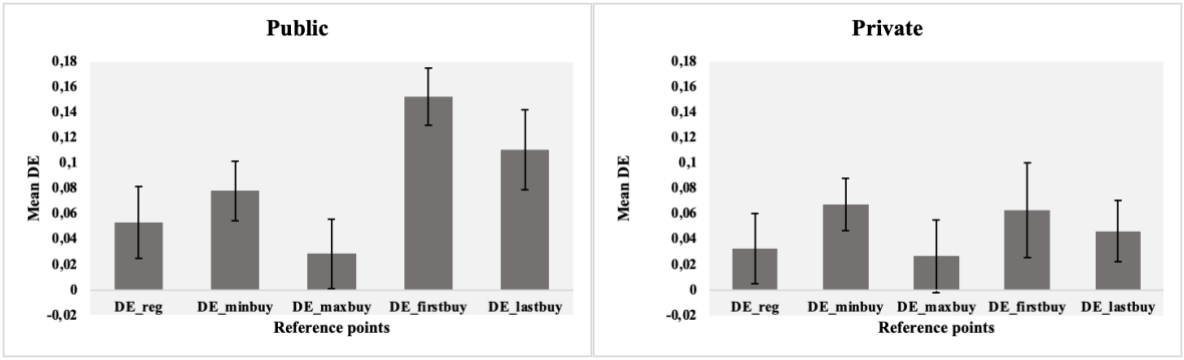


Figure 3 shows evidence that the coefficients may be different. However, next we present the results of the one way ANOVA to understand whether the reference prices remain similar at the time when individuals need to report (or not) their results.

Table 5 – ANOVA test of experiment II.

Variables	Private		Public	
	Mean	F test [p-value]	Mean	F test [p-value]
DE_reg[1]	0.033		0.053	
DE_minbuy[2]	0.068		0.078	
DE_maxbuy[3]	0.027	0.401 [0.808]	0.029	3.284 [0.012]***
DE_firstbuy[4]	0.063		0.152	
DE_lastbuy[5]	0.046		0.111	

Notes:
[1] Disposition effect with the average purchase price as a reference.
[2] Disposition effect with the minimum purchase price as a reference.
[3] Disposition effect with the maximum purchase price as a reference.
[4] Disposition effect with the first purchase price as a reference.
[5] Disposition effect with the last purchase price as a reference.
*** significant at 1%.

Table 5 shows that for the individuals who needed to expose their results after the simulation there was a significant difference between the means of the disposition coefficients calculated by the different reference points.

However, in the private group, no significant differences were found in the coefficients, which corroborates the results found in experiment I, where there was no need for participants to expose their results to everyone. Thus, we reinforce that discussions about gains and losses and reference points need to be enhanced in the context of behavioral finance studies (BRAGA; FÁVERO, 2017).

More important than checking whether there are differences between the coefficients, is attempting to understand where these differences are found. To this end, we used the post-hoc test that lists the means, two by two, to then show which ones present statistical differences. The principle of homoscedasticity of variances was met for both groups and, therefore, we used Tukey's post-hoc test (HAIR et al., 2009).

Table 6 – Tukey's post-hoc test for experiment II, by treatment.

DE	DE	Private	Public

(I)	(J)	Mean difference (I-J)	p-value	Mean difference (I-J)	p-value
DE_reg[1]	DE_minbuy	-0.035	0.908	-0.025	0.964
	DE_maxbuy	0.006	1.000	0.024	0.968
	DE_firstbuy	-0.030	0.945	-0.099	0.069*
	DE_lastbuy	-0.013	0.997	-0.058	0.551
DE_minbuy[2]	DE_reg	0.035	0.908	0.025	0.964
	DE_maxbuy	0.041	0.846	0.049	0.689
	DE_firstbuy	0.005	1.000	-0.074	0.289
	DE_lastbuy	0.021	0.984	-0.032	0.912
DE_maxbuy[3]	DE_reg	-0.006	1.000	-0.024	0.968
	DE_minbuy	-0.041	0.846	-0.049	0.689
	DE_firstbuy	-0.036	0.897	-0.124	0.011**
	DE_lastbuy	-0.020	0.988	-0.082	0.197
DE_firstbuy[4]	DE_reg	0.030	0.945	0.099	0.069*
	DE_minbuy	-0.005	1.000	0.074	0.289
	DE_maxbuy	0.036	0.897	0.124	0.011**
	DE_lastbuy	0.016	0.994	0.042	0.806
DE_lastbuy[5]	DE_reg	0.013	0.997	0.058	0.551
	DE_minbuy	-0.021	0.984	0.032	0.912
	DE_maxbuy	0.020	0.988	0.082	0.197
	DE_firstbuy	-0.016	0.994	-0.042	0.806

Notes:
[1] Disposition effect with the average purchase price as a reference.
[2] Disposition effect with the minimum purchase price as a reference.
[3] Disposition effect with the maximum purchase price as a reference.
[4] Disposition effect with the first purchase price as a reference.
[5] Disposition effect with the last purchase price as a reference.
** significant at 5%; * significant at 10%.

The first point that deserves to be highlighted is the statistical similarity between the reference prices in the private group. In this case, the reference prices were shown to be interchangeable, with no statistical differences among them.

On the other hand, when the participants needed to expose their results to the group, the disposition effect coefficient was higher when we used the first purchase price as a reference, compared to the average purchase price and the maximum purchase price. Due to the statistical difference, this evidence leaves room for questions about the use of the average purchase price as a reference for the disposition effect, mainly because it is widely used in studies in the field, whether in studies with market data or with experimental data.

To corroborate the results in Table 6, we estimated a multiple linear regression model, similar to the one performed in experiment I. We used the average purchase price, represented by the regression intercept, as a basis for comparison, and four dummies were included as independent variables. DE_minbuy is a dummy variable, where 1 means the reference point is the minimum purchase price and 0 any other reference point. For DE_maxbuy, 1 means the reference point is the maximum purchase price and 0 any other reference point. DE_firstbuy is also a dummy variable, where 1 represents the price of the first purchase and 0 represents any other reference point. Finally, for DE_lastbuy, 1 represents the last purchase price and 0 any

other reference point. As a dependent variable, we used all the disposition coefficients calculated for each individual. Table 7 presents the results.

Table 7 – Multiple linear regression for experiment II.

Variables[1]	Private		Public	
	Coefficient	p-value	Coefficient	p-value
DE_minbuy[2]	0.066	0.386	0.047	0.509
DE_maxbuy[3]	-0.012	0.879	-0.046	0.521
DE_firstbuy[4]	0.057	0.455	0.186	0.009***
DE_lastbuy[5]	0.026	0.737	0.108	0.13
Adj R^2	-0.009		0.029	
F test	0.401		3.284	
p-value	0.808		0.012**	

Notes:
[1] Disposition effect as dependent variable.
[2] Dummy variable for reference point: (1) minimum purchase price and (0) other reference prices.
[3] Dummy variable for reference point: (1) maximum purchase price and (0) other reference prices.
[4] Dummy variable for reference point: (1) first purchase price and (0) other reference prices.
[5] Dummy variable for reference point: (1) last purchase price and (0) other reference prices.
*** significant at 1%; ** significant at 5%.

Confirming the results of Tukey's test, Table 7 shows that the dummy variable representing the first purchase price had a significant impact on the dependent variable. The coefficient is positive and, therefore, when anchoring the price to the first purchase price of the stock, individuals in the public group showed an even more biased behavior. In this case, the difference in the level of the disposition effect calculated when dealing with the two reference points (average price and first purchase price) is evident. These individuals sold significantly more shares in the gains domain than in the losses domain when the first purchase price was taken into account in the calculation of the disposition effect. For the private group, as expected, there was no significant impact.

Finally, based on the results reported above, if we were replicating the experiment of Goulart et al. (2015) and comparing the DE of the public group with that of the private group, and using the average purchase price as a reference for both groups (see Table 4 and 5), we would have to compare 0.053 with 0.033, which would give us 0.020 (p-value=0.31), but if we used the first price as a reference for the public group and the average purchase price for the private one, we would get a difference of 0.119 (=0.152–0.033), with a p-value=0.001, showing a significant difference between the DE of the two groups.

5. FINAL CONSIDERATIONS

One of the most documented biases in the field of behavioral finance is the so-called disposition effect, which refers to an individual's greater propensity to sell a stock that has risen in value relative to a certain benchmark than a stock that has fallen in value. This study contributes to the literature on finance and the disposition effect bias by calling into question the default computation of this bias that uses the average purchase price as a reference point.

We showed, through two laboratory experiments, that the reference price of participants can change depending on the experimental design used.

Our first experiment, which consisted of an investment simulation in a laboratory environment and without any behavioral manipulation of the participants, showed that the five reference points used to calculate the disposition effect were equivalent, corroborating our first research hypothesis. On the other hand, in our second experiment, we showed that with the addition of experimental manipulation concerning the disclosure (or not) of the individual financial performance of the simulation participants, the reference prices showed statistically significant differences, corroborating our second research hypothesis.

Little is yet known about the influence that experimental designs can have on the psychological processes of investors' minds and their choice of reference points during their participation in an experiment and, consequently, on the computation of the disposition effect. Furthermore, it remains an open question whether our analysis and its results could be transposed to the real financial market, where other variables could influence investor behavior and the choice of different reference points.

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