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The disposition effect: who and when?*

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Abstract

The disposition effect (DE) is a common investment bias consisting of the tendency to sell profitable assets and hold losing assets. We investigate individual determinants of the DE in a standard experimental environment as well as one with transaction costs and one with a competitive payment scheme. Overall DE is positive and significant in all trading environments. In line with previous results in the literature, we find that women are more reluctant to sell losing assets than men in the standard environment. However, this difference disappears in the presence of transaction costs. Contrary to earlier reports, we do not find a significant gender difference in the DE in any environment. Novelty, we find that the most significant psychological predictor of the reluctance to realize losses is the difficulty in recognizing one's errors. This constitutes novel direct evidence that *"investors are also reluctant to accept and realize losses because the very act of doing so proves that their first judgment was wrong"* (Gross, 1982, p. 150).

Keywords: Behavioral Finance, Experimental Economics, Disposition effect, Transaction costs, Gender differences.

JEL classification numbers: C91, D70, D81, D91.

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1 Introduction

Originally coined by Shefrin and Statman (1985), the disposition effect (DE) is the tendency to sell winning assets too early and hold losing assets too long. Such a tendency has been persistently observed in empirical studies of investor behavior and is among the most established findings in Behavioral Finance.¹

Experimental studies, starting with the work of Weber and Camerer (1998), have confirmed the prevalence of the DE in a controlled environment where such a tendency is unambiguously suboptimal. However, few studies have investigated individual heterogeneity or the role of environmental factors.

This paper contributes to the literature on the DE in several ways. Firstly, we check for the robustness of the DE to important institutional features of financial trading environments outside the laboratory, such as transaction costs and competitive payment schemes. Secondly, we examine the impact of gender and other individual factors, such as psychological characteristics on the DE. Finally, we investigate the plausibility of the various reference prices proposed in the literature to compute the DE and assess the robustness of our findings to the various specifications.

We shall here summarize our main results. Both men and women fall into the DE in all scenarios we have considered. In line with previous results, we find that women tend to hold losing assets longer. However, this effect is not large enough to create a gender difference in the DE and disappears in the presence of transaction costs. Contrary to recent findings in the literature, we do not find that women incur more or less than men in the DE. Questionnaire responses reveal that the tendency to hold losing assets is strongly correlated with subjects' reluctance to recognize their own mistakes. To the best of our knowledge, this is a novel result in the literature which provides direct evidence of a cognitive dissonance interpretation of the DE.

The remainder of this paper is arranged as follows. Section 2 reviews the related literature. Section 3 describes the experiment. Section 4 reports our experimental findings and Section 5 concludes.

2 Related work

2.1 Disposition effect

There are several empirical studies that have documented the existence of the DE.

¹ See, for example, Shefrin and Statman (1985), Odean (1998), Grinblatt and Keloharju (2001), Shapira and Venezia (2001), Dhar and Zhu (2006), Brown et al (2006), Barber et al (2007).

Odean (1998) finds that individual investors have a strong preference for selling winners and holding losers, except in December when tax motivated selling prevails. Using a comprehensive data set of stock market investors in Finland, Grinblatt and Keloharju (2000, 2001) find that investors are about twice as likely to sell a stock at a moderate gain than at a moderate loss. Shapira and Venezia (2001) confirm the prevalence of the DE among independent investors and professional brokers in Israel. Dhar and Zhu (2006), Brown et al (2006) and Barber et al (2007) document similar findings among investors in the US, Australia and Taiwan.

In addition to this empirical work, there have been several experimental studies of the DE. The laboratory has the advantage that it allows one to isolate the variables of interest, in this case, those that can affect the DE. Weber and Camerer (1998) conduct a pioneering experiment in which individuals have the opportunity to buy and sell units of six risky assets with constant, but unknown, probabilities. Contrary to Bayesian optimization, subjects in this environment also exhibit a positive DE. Using an alternative approach, Magnani (2015) confirms the existence of the DE in an experiment involving the exercise of a put option. Here, subjects take too long to exercise their put option when the share price is falling and cash the value of the asset too early when its price is increasing. Frydman et al (2014) employ a simplified version of the design in Weber and Camerer (1998) and continue to find a strong DE. Interestingly, functional magnetic resonance imaging (fMRI) reveals that subjects' neural activity is consistent with the "realization utility" theory of the DE. This theory posits that investors derive positive (negative) utility directly from the act of realizing gains (losses).

We are still, however, far from a full understanding of the underlying causes of the DE. In addition to realization utility, several alternative behavioral explanations have been put forward. These include irrational beliefs in mean-reversion, mental accounting, loss aversion, regret aversion, self-control or cognitive dissonance, among others. In a review of the various explanations and their relative merits, Kaustia (2010) concludes that the evidence favors an explanation based on cognitive dissonance theory rather than one based on preferences (prospect theory) or beliefs (mean reversion).

According to cognitive dissonance theory (Festinger, 1957), individuals tend to hold consistent beliefs, attitudes and actions, while events that upset this consistency are psychologically costly and are often avoided. Applied to financial decisions, selling a losing asset carries an additional psychological cost to an investor because it involves an

acceptance that her prior beliefs and actions were wrong. On the other hand, selling a winning asset would please an investor because it confirms her previous beliefs and actions. This general theory, therefore, provides a framework for other mechanisms suggested in the literature such as self-justification, realization utility, regret aversion or pride.

2.2 Gender, individual heterogeneity and environmental factors

Despite the large literature on gender and financial risk taking,² only two studies focus specifically on gender differences in the DE, to our knowledge. Da Costa et al (2008) find suggestive experimental evidence that men exhibit a larger DE on average than women, although the experiment was conducted using hypothetical payoffs. Rau (2014), on the other hand, finds a significant DE for women and not for men using a similar experimental design with real monetary incentives. Interestingly, Rau also finds that the DE is entirely driven by women's reluctance to sell capital losses. However, his results rely on a relatively small sample size ($N = 55$) and on one particular specification of the DE.³

Weber and Welfens (2007) test empirically and experimentally for individual differences, stability and learning in individual DE. Although not the focus of their study, their field data reveal no evidence of gender differences. However, this could be simply driven by the fact that they have a much smaller proportion of females in their sample. They also find that learning and experience reduce the DE.

Feng and Seasholes (2005) find an overall DE among Chinese investors which is moderated by experience. Similarly to Rau (2014), they also find that female investors are more reluctant to sell losing stocks. Dhar and Zhu (2006) analyze the trading records of a major discount brokerage house and find that the DE is weaker for older, wealthier and more experienced investors.

Little is known about the causes of individual heterogeneity in the DE beyond differences in expertise. An interesting and scarcely researched source of heterogeneity is that of psychological characteristics. To the best of our knowledge, there are no published studies on psychological correlates of the DE. Our evidence fills this important gap in the literature, and offers direct support to cognitive dissonance as a key

² See reviews by Byrnes et al (1999), Eckel and Grossman (2008), Croson and Gneezy (2009) and Bertrand (2011).

³ See Section 4.1

determinant of the DE (see Section 4.4).

Another interesting avenue of research looks at the specific institutional factors that may affect investors' propensity to incur in the DE. Notably, Weber and Camerer (1998) find that the DE is greatly reduced when assets are automatically sold after each period in their experiment. That is, subjects are not as likely to repurchase losing assets once these are sold after each period. Another important finding is that the DE seems to be less prominent, or to disappear altogether, for mutual funds investments (Calvet et al, 2009; Ivkovic and Weisbenner, 2009; Chang et al, 2015). A possible reason for this is that, as with automatic selling, investors feel a smaller responsibility for her past decisions when they invest in mutual funds, rather than in regular stocks. To the extent that poor investment decisions can be blamed on an outside source (like the fund management), individuals might be less compelled to hold onto losing stocks. Chang et al (2015) confirm this conjecture conducting experiments in which the salience of the delegation is manipulated. Along similar lines, Jin and Scherbina (2011) find that mutual fund managers are more likely to sell losing stocks when they are inherited from previous managers.

A yet unexplored factor is whether a competitive environment helps to reduce the DE. Competitive payment schemes are very common among professional traders and have been shown to affect their portfolio choices, improving stock selection ability (Elton et al 2003) but also affecting portfolio volatility (Brown et al, 1996; Dijk et al, 2014). On the other hand, Gneezy, Niederle and Rustichini (2003), Gneezy and Rustichini (2004) and Niederle and Vesterlund (2007) find that competitive situations can improve effort and performance for men, but not for women. Together, these findings suggest that competitive payment schemes could result in a gender gap in the DE.

Finally, transaction costs may also affect the DE. Odean (2000) analyzes the investments of nearly 70,000 households and finds that the average cost of a round-trip trade over \$1000 was around 4%. Transactions costs are, therefore, typically large and difficult to avoid for households. As Odean puts it, "*trading is hazardous to your wealth*": because of transaction costs, households' net returns are significantly below the market weighted average return. Odean (2000) and other authors conclude that the primary reason why investors incur in such deleterious behavior is overconfidence.⁴

⁴ See, for instance, Barber and Odean (2001), Bhandari and Deaves (2006), and Grinblatt and Keloharju (2009).

Investors trading in a market with large transaction costs must be very confident in their ability to select the right stocks. This might increase the psychological costs involved in selling losing stocks and, hence, promote a higher DE. However, the effect of transaction costs on the DE has not been investigated in the literature as far as we know.

3 Experimental Design

192 individuals, 95 men and 97 women, participated in this study. Experiments were conducted in 8 sessions of 24 subjects each. All subjects were recruited from the undergraduate population of the University of Alicante. The experiment was programmed in z-Tree (Fischbacher, 2007). Subjects were recruited using ORSEE (Greiner, 2004) and earned on average 19.1 Euros.

We borrow the experimental design from Weber and Camerer (1998) and Weber and Welfens (2007) with some modifications. In our baseline treatment, subjects can buy and sell units of six risky assets (A, B, C, D, E, and F) over 9 periods using experimental currency, to which we refer as “pesetas”. Each asset follows a different price path, independently of subjects' actions. We introduce two variations of the baseline treatment: a trading tax and a competitive payment scheme. All subjects go through the baseline treatment, the tax treatment, the competitive treatment, and the competitive & tax treatment. The treatment order changed every two sessions.⁵ Individuals are endowed in each treatment with 5,000 pesetas to trade in the market.⁶

3.1 Prices

Subjects are assigned randomly into groups of two men and two women. They know that they are in a group of four but are not told the identity or gender of their group mates.⁷ Subjects are also told that each group of four faces the same price path of the six assets. The history of each market begins in period -3 with the same initial price of 100 pesetas for all assets. From period -2 onwards, prices could go up by 6% or down by 5%. Subjects are told that each asset could have a different probability of a price increase, but were not told the specific probabilities. However, they are informed that,

⁵ Sessions 1 and 2: baseline, competitive, tax, competitive & tax; sessions 3 and 4: tax, competitive & tax, baseline, competitive; sessions 5 and 6: competitive, baseline, competitive & tax, tax; sessions 7 and 8: competitive & tax, tax, competitive, baseline. Subjects played a short trial period before each treatment.

⁶ Exchange rate 1000 pesetas =1€

⁷ To ensure that subjects perceive a similar gender-balanced environment in every session, their positions in the laboratory are always male, female, male, female... This is done by asking subjects to randomly draw a number from one of two boxes: one containing odd numbers for men and another one containing even numbers for women. Subjects are then seated on the cubicle corresponding to their drawn number.

for each asset, the probability of a price increase is constant over the whole treatment and that price changes are independent from previous prices and also independent of subjects' actions. In particular, we assigned randomly to each asset a probability of a price increase that was chosen without replacement from the set {0.6, 0.55, 0.5, 0.5, 0.45, 0.4}. This implements a market in which there are always two "good" assets (those with probabilities 0.6 and 0.55), two "neutral" assets (probability 0.5), and two "bad" assets (probabilities 0.45 and 0.4).

Since the probability of a price increase for each asset is unknown but constant, a rational subject should infer that appreciating assets are more likely to continue appreciating than depreciating assets. This implies that rational subjects should be more likely to sell losing (depreciating) assets than winning (appreciating) assets. Therefore, a positive DE clearly constitutes a costly decision-making bias in this environment.

Individuals observe prices from period -3 to 10, but can only trade from period 1 to 9. Prices at period 10 are only used to liquidate portfolios. To elicit subjects' beliefs about the asset types, in periods 1, 6, and 10 we ask them to guess which asset has the highest, second highest, lowest and second lowest probability of a price increase, respectively. The task is incentivized by paying subjects 100 pesetas each time they guess all asset types correctly.

3.2 Treatments

All subjects participate in the four treatments. In the baseline treatment, they earn the value of the portfolio upon liquidation (period 10) plus their remaining cash. In the competitive treatment, only the winner in each group of four earns the value of her portfolio plus the remaining cash, multiplied by two. The remaining three members of the group do not receive the value of their portfolios nor their remaining cash. In the tax treatment, subjects have to pay a fee in each transaction. The fee is a fixed rate, chosen from the set {1%, 4%, 7%} so that a third of the groups in each session face each fee. All individuals in a given group face the same fee throughout the treatment. The fee is the same for purchases and sales. Finally, in the competitive & tax treatment, we combine the features of treatments 2 and 3. To elicit subjects' self-confidence, they are asked to guess at the beginning and at the end of each treatment their position in the group in terms of earnings. Again they receive an additional 100 pesetas every time they guess their position correctly.

3.3 Individual measures

At the end of the experiment subjects complete a survey including the Financial Literacy Test (FLT, Lusardi and Mitchell, 2011) and several socio-demographic questions. We also use a number of self-assessed psychological measures gathered using a Likert-type scale including a brief version of the Big Five Test,⁸ questions regarding indecisiveness (Germeijs and De Boeck, 2002), self-control (Tangney et al, 2004), difficulty recognizing errors, optimism, enjoyment of risk, confidence, competitiveness, enjoyment of winning and decisiveness (see Appendix A for the exact wording of these questions).

Before the beginning of the trading period we elicit risk preferences of individuals with a Multiple Price List (Holt and Laury, 2002) in which subjects go through a sequence of 21 binary decisions between a lottery and a safe option. The lottery is always the same: 5,000 or 0 pesetas with equal probability. The safe option ranges from 0 to 5,000 pesetas.

4 Results

To calculate the disposition effect, we follow Odean (1998) by computing the number of units sold at a price above the reference price (“Realized Gains”), the number of units sold at a price below the reference price (“Realized Losses”), the number of units not sold and whose price exceeds the reference price (“Paper Gains”), and the number of units not sold and whose price is below the reference price (“Paper Losses”). The DE is defined as $DE = PGR - PLR$, where:

$$\text{Proportion of Gains Realized, } PGR = \frac{\text{Realized Gains}}{\text{Realized Gains} + \text{Paper Gains}}, \text{ and}$$

$$\text{Proportion of Losses Realized, } PLR = \frac{\text{Realized Losses}}{\text{Realized Losses} + \text{Paper Losses}}.$$

PGR and PLR are between 0 and 1, so DE is between -1 and 1.

4.1 Reference prices

The first problem when calculating the DE is defining a reference price from which

⁸ We use a Spanish translation of the brief form (Benet-Martinez and John, 1998; John and Srivastava, 1999).

gains and losses are computed. As Odean (1998, p. 1782) points out, “*Any test of the is a joint test of the hypothesis that people sell gains more readily than losses and of the specification of the reference point from which gains and losses are determined.*”

A number of different reference prices have been used in the literature, such as the weighted average price, the first period price, the last period price, or the FIFO and LIFO criteria. To see how the weighted average reference price is computed, suppose that an individual has 10 units of asset A in period 6. She bought 3 units in period 2 and 7 units in period 5. Then, the reference price for asset A in period 6 is the price in period 2 multiplied by (3/10) plus the price in period 5 multiplied by (7/10). If we use the initial price as the reference price, then it is always 100. The last period price is just the price in the previous period. FIFO and LIFO take as the reference price of an asset being sold the price at which that asset was purchased, according to a “first-in first-out” principle or a “last-in first-out” principle, respectively. In the example above, reference prices according to FIFO and LIFO are the price in period 2 and the price in period 5, respectively.

Most empirical studies follow the seminal work by Odean (1998) by using the weighted average price. However, experimental studies are more varied: Weber and Welfens (2007) use the weighted average price; Weber and Camerer (1998) use FIFO and LIFO; Da Costa et al (2008) use LIFO and last price; Rau (2014) uses only LIFO; Frydman et al (2014) use the purchase price in an experiment in which FIFO, LIFO and the weighted average price coincide.

Since there is no agreement over the reference price from which to compute gains and losses, we begin by computing the DE, PGR and PLR for our baseline treatment, using each of the five reference prices mentioned above.

Table 1. DE, PGR, and PLR in the baseline treatment for different reference prices

		Reference prices				
		Average	Initial	FIFO	LIFO	Last
DE	Mean	0.0685***	0.0177*	0.1205***	0.0243**	0.0994***
	St. Error	(0.0228)	(0.0244)	(0.0193)	(0.0171)	(0.0176)
	Obs.	163	154	164	145	165
	p-value	0.0021	0.0685	0.0000	0.0294	0.0000
PGR	Mean	0.2452	0.2222	0.2402	0.0901	0.2124
	St. Error	(0.0170)	(0.0151)	(0.0163)	(0.0115)	(0.0148)
	Obs.	164	164	164	145	165
PLR	Mean	0.1771	0.2109	0.1183	0.0608	0.1123
	St. Error	(0.0147)	(0.0192)	(0.0108)	(0.0106)	(0.0101)
	Obs.	164	155	166	157	166

Note: Standard errors in parentheses. From a total of 192 individuals, each reference price generated some missing observations. The line Obs. refers to the number of individuals used in each calculation. The p-values correspond to a Wilcoxon signed-rank test in which the null is that the corresponding DE is zero. We do not report p-values for PGR and PLR since all of them are below 0.0001.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The values we get for the DE range from 0.0177 (initial price) to 0.1205 (FIFO). With respect to the PGR, all reference prices but LIFO yield similar results. We get more variation with the PLR, where again the lowest value corresponds to LIFO.

Our findings are comparable to those obtained in others works. For instance, Odean (1998, Table 1) uses the average reference price and finds that 14.8 percent of the gains available for realization are actually realized, while only 9.8 percent of the losses are realized. This results in a DE of 0.05, a value close to 0.07, which is what we find when using the average reference price.

Results in Table 1 are average values. It is interesting to see how measures of the DE according to these different reference prices are correlated with each other. As Table 2 shows, all five measures are positively correlated. However, while the measures of the DE calculated using the average price, the initial price, FIFO, and the last price exhibit correlation coefficients well above 0.5 (the smallest one is 0.6626), the correlation between the DE using LIFO and the other four measures is always below 0.5.⁹

⁹ We find the same result with the other three treatments, and also if we compute correlation coefficients separately by gender.

Table 2. Correlation matrix of DE in the baseline treatment using different reference prices.

	Average	Initial	FIFO	LIFO	Last
Average	1				
Initial	0.7149	1			
FIFO	0.92	0.6746	1		
LIFO	0.482	0.3783	0.4477	1	
Last	0.8142	0.6626	0.868	0.3524	1

Note: p-values of all pairwise correlations < 0.0001

The results in Table 2 highlight that the choice of a reference price leads to substantially different measures of the DE. In particular, because of the low correlation of the measure of DE using LIFO with the other measures, results using this last measure can differ substantially from results using alternative measures.

As a guide to determining the adequacy of the different reference prices, we follow an approach similar to that of Kohsaka et al (2013). At the end of the experiment we present subjects with a hypothetical price path and transaction history and ask them to rate the degree to which they agree with various ways of computing gains or losses associated with the last sale in the example (subjects are presented with two scenarios, one involving gains and one involving losses).

The results of this survey are presented in Table 3. Consistently with Kohsaka et al (2013), the *weighted average* reference price received the highest average rating on average. The results are similar for the loss and gain scenarios and across genders.

Table 3. Subjective evaluation of reference prices.

	Mean score Loss domain	Mean score Gains domain
Initial Price	3.8021 (2.4306)	4.0729 (2.4804)
FIFO	3.5208 (1.9411)	3.875 (2.0378)
Average Price	4.1458 (1.9357)	4.2708 (1.9867)
LIFO	3.5938 (2.1155)	3.5521 (2.0358)
Last Price	3.3021 (2.1281)	3.1563 (2.1586)
Observations	96	96

Note: Each column corresponds to the mean score received by each reference price in the questionnaire for the loss domain and the gain domain respectively (from *completely disagree* = 1 to *completely agree* = 7).

Standard errors in parentheses. The number of observations is only 96 because we ask this question only in half of the sessions.

Based on this evidence, we will use the *weighted average price* in our analysis of individual heterogeneity and treatment effects (Sections 4.2, 4.3 and 4.4) leaving the rest to Appendix B. However, in Section 4.3 we also examine gender differences in baseline DE using all reference prices. We do so in order to compare our results to the previous experimental literature on gender and on the DE.

4.2 Treatment effects

Figure 1 displays average DE, PGR and PLR in each treatment, using the weighted average reference price. Considering the four treatments together, the DE is 0.078 (\pm 0.011 SE). Individuals, therefore, clearly display some degree of DE in all treatments. The DE is 0.069 (\pm 0.023 SE) in the baseline treatment, 0.070 (\pm 0.024 SE) in the competitive treatment, 0.105 (\pm 0.019 SE) in the tax treatment, and 0.068 (\pm 0.020 SE) in the competitive & tax treatment. Wilcoxon tests reject the null hypothesis of DE equal to zero, for each treatment ($p < 0.01$).

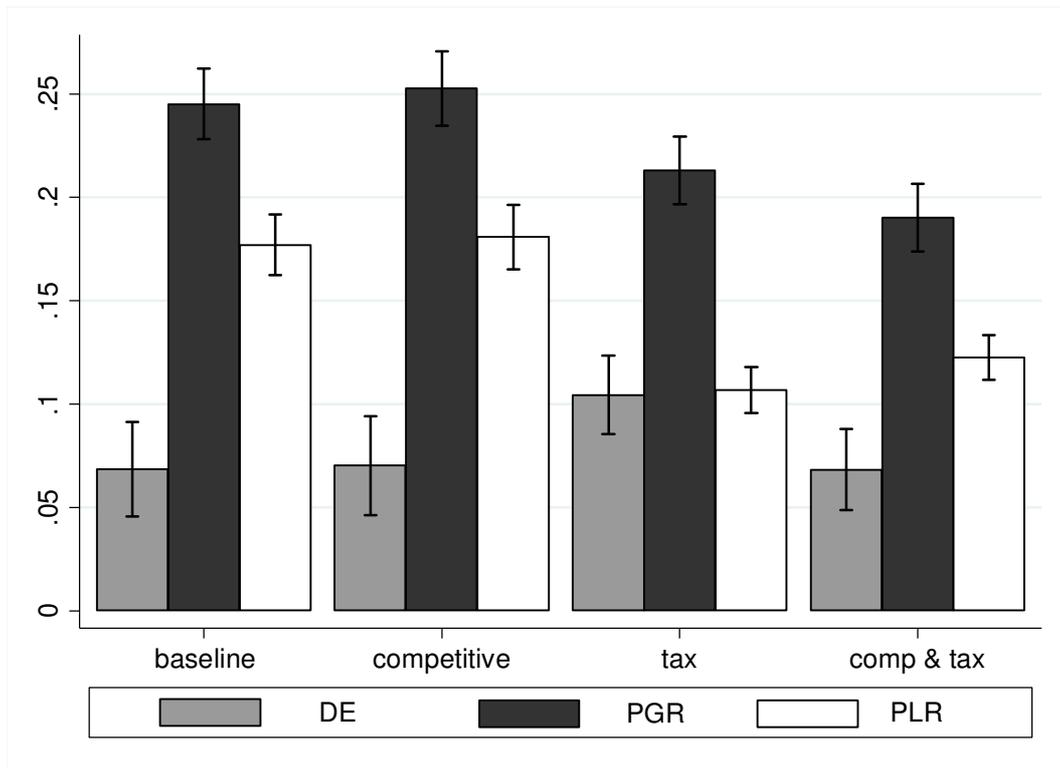


Figure 1. Mean DE, PGR and PLR by treatment with standard error bars. Weighted average reference price

Although the DE is higher in the tax treatment than in the baseline treatment, this difference is not significant (Wilcoxon test, $p = 0.391$). Using the Skillings-Mack (SM) test, (a generalization of the Friedman test that allows for missing observations) we also find no significant differences in DE across treatments ($p = 0.363$).

By contrast, PGR and PLR are significantly affected by our treatment conditions (SM tests, $p < 0.01$). In particular, in the tax and in the competitive & tax treatment both PGR and PLR decrease significantly (Wilcoxon tests, $p < 0.01$). Finally, we do not find any effect of competition on PGR and PLR.

In the Appendix (Table B2) we show the results corresponding to the four other reference prices. To summarize, we find that DE is significantly different from zero for most treatments and reference prices. The DE tends to be higher in the tax treatment although, as before, this difference is not significant.

4.3 Gender effects

In Table 1 we saw that different reference prices produce quite different values of

DE, PGR, and PLR. In Table 4 we calculate these three measures for the five different reference prices in our baseline treatment. We also report p-values corresponding to a test in which the null hypothesis is that there are no gender differences.

Table 4. DE, PGR, and PLR in the baseline treatment by gender

		Reference Prices					N*
		Average	Initial	FIFO	LIFO	Last	
DE	male	0.0488 (0.0364)	-0.0160 (0.0378)	0.1011 (0.0297)	0.0256 (0.0229)	0.0818 (0.028)	74 - 83
	female	0.0885 (0.0275)	0.0514 (0.0305)	0.1404 (0.0245)	0.0231 (0.0255)	0.1173 (0.0212)	71 - 82
	p-value	0.4734	0.2712	0.4328	0.8850	0.4794	
PGR	male	0.2548 (0.024)	0.2251 (0.0201)	0.2479 (0.0226)	0.0859 (0.0142)	0.2218 (0.0214)	74 - 83
	female	0.2353 (0.0243)	0.2193 (0.0226)	0.2322 (0.0235)	0.0945 (0.0182)	0.2029 (0.0205)	71 - 82
	p-value	0.5537	0.4653	0.5537	0.4491	0.5817	
PLR	male	0.2090 (0.0247)	0.2491 (0.0312)	0.1468 (0.0189)	0.0558 (0.0146)	0.1400 (0.0174)	77 - 83
	female	0.1451 (0.0153)	0.1733 (0.0221)	0.0897 (0.0095)	0.0659 (0.0156)	0.0847 (0.0094)	77 - 83
	p-value	0.2492	0.1989	0.0418	0.5115	0.0644	

Note: Standard errors in parentheses, p-values from Mann-Whitney U-test, where the null is no gender effect.

*Range of subjects used for the calculation of DE, PLR and PGR using each reference price. Out of a total of 96 men and 96 women, each reference price generated some missing observations.

With all reference prices but LIFO we find that the average value of the DE is lower for men than for women. However, these differences are never statistically significant. This result differs from previous findings in the literature. In particular, Da Costa et al (2008) find that only men fall into the DE when using the last price as the reference. On the other hand, Rau (2014) reports values of the DE using the LIFO rule and finds significant gender differences. In particular, he finds a negative average DE for men and a positive one for women.

We get very similar values for the PGR of men and women, and again the LIFO rule differs significantly from the other reference prices. We find some gender differences with respect to PLR. This happens with the FIFO rule and with the last price. In both cases women tend to have a lower PLR than men. This is in line with previous results obtained by Feng and Seasholes (2005) and Rau (2014).

There are a number of differences between our experimental set-up and that of Da

Costa et al (2008) and Rau (2014) which might explain the discrepancy between our results. First, in their studies all participants face the same market, which corresponds exactly to the price path in Weber and Camerer (1998). In our experiment, each group of four subjects face a different market, with randomly generated price paths for each group. In this sense our results might be considered more general. Second, our sample size is larger. We have 192 subjects, half of each gender. Rau's sample is 55 subjects, of which 28 are female. Da Costa et al have 96 subjects, of which 52 are female.¹⁰ Finally, our experiment is incentivized, whereas Da Costa et al (2008) use hypothetical payoffs.

We now investigate gender differences in each treatment, controlling for various individual characteristics. Table 5 presents the marginal effect of the variable *female* for each treatment. We have to compute these marginal effects because our model has the dummy variable *female* interacted with the treatment dummies.¹¹ In the first line of Table 5 we calculate the overall marginal effect. In lines 2-5 we report the marginal effects computed for each treatment. The full regression model on which these marginal effects are based is presented in Table 6. The estimated marginal effects confirm our previous results. Although women have a higher DE than men on average, the difference is not statistically significant in any treatment. In turn, women exhibit a significantly lower PLR in the baseline treatment, but this difference completely disappears in the presence of transaction costs.

¹⁰ This refers to the deliberate selling treatment, which is the case comparable to ours.

¹¹ Suppose we estimate a simple OLS model with interactions in which there are only two treatments (treatment 1 and treatment 2). The estimated model is: $Y = b_0 + b_1F + b_2T_2 + b_3FT_2$, where F and T_2 are dummy variables that take value 1 for women and treatment 2, respectively. The marginal effect of the dummy F in treatment 1 is b_1 , and it is $b_1 + b_3$ in treatment 2. Finally, the overall effect of F is just a weighted average of b_1 and $b_1 + b_3$.

Table 5. Marginal effects

VARIABLES	Average Price Reference		
	DE	PGR	PLR
(overall) female = 1	0.0203 (0.0356)	-0.00115 (0.0288)	-0.0221 (0.0208)
(baseline) female = 1	0.00473 (0.0407)	-0.0432 (0.0331)	-0.0508** (0.0221)
(competitive) female = 1	0.0216 (0.0448)	-0.0226 (0.0359)	-0.0431 (0.0280)
(tax) female = 1	0.0335 (0.0433)	0.0178 (0.0341)	-0.00669 (0.0266)
(comp & tax) female = 1	0.0202 (0.0478)	0.0375 (0.0360)	0.00989 (0.0287)
Observations	706	720	710

Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1

4.4 Individual heterogeneity

The questionnaire administered at the end of the experiment allows us to carry out a more in depth analysis of individual heterogeneity. Summary statistics of the individual measures can be found in Table B1 in the Appendix. We estimate three regression models with DE, PLR and PGR as dependent variables and the measures gathered from the questionnaire as regressors. A similar analysis with the alternative reference prices is left to the Appendix (see Tables B3 to B5).

Individual measures are standardized for the regression when appropriate (0 mean, unit std. dev.). The variable *experience* takes values {1, 2, 3, 4} according to the order of the corresponding treatment within a session¹² We also include four dummy variables measuring ability and confidence: *high financial literacy*, *high grades*, *>1 switches* and *high confidence before*.¹³ Finally, since our experimental subjects are students from all

¹² For example, in the first session, the treatment order was *baseline, competitive, tax, competitive & tax*. The variable *experience* would then take value 1 in the *baseline*, 2 in the *competitive* treatment and so on. On the other hand, in the eighth session, the treatment order was *competitive & tax, tax, competitive, baseline*. So here *experience* would take value 1 in the *competitive & tax*, 2 in the *tax* treatment and so on.

¹³ *High financial literacy* = 1 if a subject answers the three questions of the Financial Literacy Test (Lusardi and Mitchell, 2011, 2014) correctly; *high grade* = 1 if a subject reports an average grade of 7 or higher (out of 10) in their studies; *>1 switches* = 1 if a subject switches more than once in a Holt and Laury (2002) type lottery task, reflecting inconsistent behavior; and *high confidence before* = 1 if a subject guesses that she will be the best in her group of 4 before a given treatment. To avoid reducing the sample size significantly, we do not include the measure of risk aversion gathered in the lottery task, since we would have to exclude 42 subjects who switched more than once. This variable was nevertheless insignificant when included in the regression.

fields (Social Sciences, Art and Literature, Health, Sciences, and Engineering),¹⁴ we control for the field of studies with four dummy variables, with students from Social Sciences as the reference group.

Table 6. DE, PGR and PLR with average reference price. Random effects regression.

VARIABLES	DE	PGR	PLR
Female	0.00473 (0.0407)	-0.0432 (0.0331)	-0.0508** (0.0221)
Competitive	0.00237 (0.0314)	0.00362 (0.0234)	-0.00279 (0.0205)
Tax	0.0209 (0.0419)	-0.0572** (0.0291)	-0.0900*** (0.0231)
Competitive & Tax	-0.000554 (0.0349)	-0.0896*** (0.0254)	-0.0888*** (0.0209)
Female*Competitive	0.0168 (0.0366)	0.0205 (0.0289)	0.00769 (0.0290)
Female*Tax	0.0288 (0.0483)	0.0610* (0.0349)	0.0441* (0.0253)
Female*(Comp & Tax)	0.0155 (0.0346)	0.0807*** (0.0294)	0.0607*** (0.0198)
Experience	-0.0205** (0.00870)	-0.0152*** (0.00524)	0.00431 (0.00572)
Optimism	0.0191 (0.0176)	-0.00285 (0.0180)	-0.0230** (0.00929)
Risk	-0.00853 (0.0177)	-0.000421 (0.0157)	0.0107 (0.0107)
Confidence	-0.00468 (0.0194)	0.0177 (0.0162)	0.0192 (0.0117)
Not Recognize Errors	0.0301* (0.0164)	0.00583 (0.0152)	-0.0262*** (0.00793)
Competitiveness	0.00521 (0.0199)	-0.00550 (0.0142)	-0.00801 (0.0117)
Enjoys Winning	-0.00909 (0.0130)	-0.0117 (0.0137)	-0.00139 (0.0135)
Decisiveness	-0.0149 (0.0185)	-0.0200 (0.0185)	-0.00377 (0.00939)
Self-control	0.0433** (0.0207)	0.0345* (0.0176)	-0.0127 (0.00867)
High Confidence	-0.00655 (0.00984)	-0.00775 (0.00841)	-0.000558 (0.00614)
High Financial Literacy	-0.0157	-0.00786	0.00675

¹⁴ These are the five official categories of fields of studies in Spanish universities.

	(0.0195)	(0.0158)	(0.0116)
High Grades	-0.00402	-0.00560	-0.00137
	(0.0185)	(0.0165)	(0.0101)
>1 Switches	0.00234	0.0000	-0.00281
	(0.0152)	(0.0122)	(0.00914)
Neuroticism	0.0237	0.0296*	0.00325
	(0.0173)	(0.0172)	(0.0129)
Extraversion	0.0178	0.0105	-0.00808
	(0.0159)	(0.0157)	(0.0109)
Agreeableness	-0.0182	-0.0214	0.00122
	(0.0178)	(0.0160)	(0.00922)
Openness	0.0214	0.0186	-0.00481
	(0.0141)	(0.0135)	(0.00943)
Conscientiousness	-0.0165	-0.0167	0.00121
	(0.0216)	(0.0175)	(0.0113)
Art	-0.0196	-0.0530	-0.0345
	(0.0475)	(0.0490)	(0.0334)
Health	0.0179	-0.0264	-0.0435**
	(0.0444)	(0.0393)	(0.0209)
Science	0.0204	-0.0573	-0.0777***
	(0.0508)	(0.0428)	(0.0277)
Engineering	-0.0940*	-0.0993***	-0.00770
	(0.0489)	(0.0356)	(0.0374)
Constant	0.123***	0.339***	0.220***
	(0.0403)	(0.0344)	(0.0266)
Observations	706	720	710
Number of id	192	192	192

Note: All variables except Female, Treatment and Experience standardized to zero mean and unit standard deviation. Standard errors in parentheses. Robust standard errors clustered by group and session in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6 presents the estimated coefficients of three regressions. The results confirm our previous findings and offer some additional evidence. The tax treatment increases subjects' DE, although not significantly. This is because the drop in PLR provoked by the tax is partly offset by a drop in PGR. The variable *experience* has a negative and significant effect on DE. This provides further support to previous empirical evidence that trading frequency and experience helps to attenuate the DE (Feng and Seasholes, 2005; Dhar and Zhu, 2006; Weber and Welfens, 2007).

Among individual characteristics, the most significant one is *not recognize errors*. This variable measures the extent to which an individual finds it hard to recognize her mistakes. It has a significant positive effect on the DE that operates via a decrease in the sale of losing assets, while having no effect on the sale of winning assets. This result is

robust to all reference price specifications: *not recognize errors* has a highly significant negative effect on PLR computed according to the average reference price, FIFO, last price ($p < 0.01$) and initial price ($p < 0.05$, see Table B5 in the appendix). This result confirms the hypothesis of Shefrin and Statman (1985) regarding one possible cause of the DE. Namely, that investors find selling losing assets difficult because they are reluctant to admit their past mistakes. Earlier studies point towards this interpretation of the DE, for instance, by showing that the DE disappears when losing stocks are inherited from a previous fund manager (Jin and Scherbina, 2010), or when previous investment decisions were delegated (Chang et al, 2015). However, the significant and robust negative correlation between PLR and the degree to which subjects agree with the statement “*I find it hard to recognize my mistakes*” presented here constitutes the first direct evidence in support of this view.

Surprisingly, we find a positive correlation between *self-control* and the DE. The effect is driven by a positive correlation between *self-control* and PGR. This result contrasts with the notion that poor self-control is an important ingredient of the DE (Shefrin and Statman, 1985). Intuitively, our evidence suggests that the tendency to sell winners too early might be the result of an excessive adherence to the principle of “knowing when to stop”. However, in contrast with the effect of *not recognize errors*, the effect of *self-control* is not robust to different reference prices (see Appendix B).

Among the Big Five personality traits, we only find a moderate effect of *neuroticism*. As with *self-control*, subjects scoring high in *neuroticism* have a more pronounced tendency to sell winning assets. Finally, an interesting result is that students from Engineering exhibit a lower DE and PGR for all reference prices. One possible interpretation is that Engineering students are better able to understand the price process in the experiment and this discourages them from selling winners too early. This result fits well with field evidence that sophisticated investors tend to exhibit a lower DE (Odean, 1998, Grinblatt and Keloharju, 2001; Shapira and Venezia, 2001; Dhar and Zhu, 2006, Brown et al, 2006).

5. Conclusion

This paper studies the DE under various experimental conditions. Our results show that the DE is robust to an environment with transaction costs and with highly competitive payment schemes. Contrary to earlier experimental findings (DaCosta et al 2008; Rau, 2014), we do not find significant gender differences in the DE. Our findings

rely on a comparatively larger sample and are robust to various specifications of the reference price. In this regard, we show that the choice of reference price has a large impact on the magnitude of the DE. This could easily influence statistical comparisons, especially in small sample studies. A questionnaire administered to the participants after the investment task suggests that the weighted average price is the most psychologically plausible reference price, both in the gain and in the loss domain.

Using questionnaire data to control for individual heterogeneity, regression results indicate a significant gender effect on PLR. Confirming earlier field evidence by Feng and Seasholes (2005) and laboratory findings by Rau (2014), women appeared significantly more reluctant to realize their losses than men in our baseline treatment. However, this difference disappeared in the presence of transaction costs.

To gain further insight into the possible psychological causes of the DE, the questionnaire includes various individual measures such as self-control, decisiveness, optimism, difficulty in admitting errors, as well as financial literacy and a reduced version of the big five personality questionnaire. From all these measures *difficulty recognizing errors* turns out to be the most significant individual predictor of an individual's PLR. To our knowledge, this provides the first direct evidence in support of Shefrin and Statman's (1985) hypothesis that the DE is partly caused by the fact that:

*“Investors are also reluctant to accept and realize losses because the very act of doing so proves that their first judgment was wrong”.*¹⁵

This simple idea can explain why the DE is greatly reduced when shares are sold automatically after every period (Weber and Camerer, 1998); why mutual funds investors exhibit a lower DE (Calvet et al 2009; Ivković and Weisbenner, 2009; Chang et al 2015); and why the DE disappears when the assets are inherited from a previous fund manager (Jin and Scherbina, 2011).

¹⁵ This is taken from an original quote in Shefrin and Statman (1985) of a manual on investment strategy by Gross (1982, p. 150).

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Appendix A.

Questionnaire (translated from Spanish)

- Are you an optimistic or a pessimistic person?
- Are you a person willing to take risks or do you try to avoid risks?
- Are you a confident person?
- I find it hard to recognize my mistakes
- I am a very competitive person
- I enjoy very much winning in a game
- After making a decision, I do not worry about it or regret it

Appendix B. Additional tables.

Table B1. Summary statistics of the individual measures

VARIABLES	Mean	Std. Dev.	Min	Max	Obs
DE	0.0797	0.2228	-0.6282	0.7134	192
PGR	0.2279	0.1884	0	0.8472	192
PLR	0.1470	0.1349	0	0.7843	192
Female	0.5052	0.5013	0	1	192
Experience	2.5	0	2.5	2.5	192
Optimism	4.8229	1.3420	1	7	192
Risk	4.6615	1.5536	1	7	192
Confidence	4.7604	1.5195	1	7	192
Not Recognize Errors	3.9479	1.6681	1	7	192
Competitiveness	4.9740	1.5933	1	7	192
Enjoys Winning	5.9010	1.3047	2	7	192
Decisiveness	3.2708	1.7183	1	7	192
Self-control	42.1719	9.3443	20	67	192
High Confidence	0.3372	0.3204	0	1	192
High Financial Literacy	0.3802	0.4867	0	1	192
High Grades	0.6198	0.4867	0	1	192
>1 Switches	0.2188	0.4145	0	1	192
Neuroticism	4.1128	1.1998	1.5	7	192
Extraversion	4.3896	1.3874	1	7	192
Agreeableness	4.7969	0.7378	2.4	7	192
Openness	5.2314	0.9016	2.8571	7	192
Conscientiousness	5.0490	0.9537	2.4	7	192
Art	0.1042	0.3063	0	1	192
Health	0.3177	0.4668	0	1	192
Science	0.0990	0.2994	0	1	192
Engineering	0.1771	0.3827	0	1	192
Social Sciences	0.3021	0.4604	0	1	192

Note: DE, PGR, and PLR are calculated with weighted average reference price.

Table B2. DE for all treatments with different reference prices

Treatment		Reference prices				
		Average	Initial	FIFO	LIFO	Last
Baseline	Mean	0.0685***	0.0177*	0.1205***	0.0243**	0.0994***
	St. Error	(0.0228)	(0.0244)	(0.0193)	(0.0171)	(0.0176)
	Obs.	163	154	164	145	165
	p-value	0.0021	0.0685	0.0000	0.0294	0.0000
Competitive	Mean	0.0703***	-0.0099	0.1031***	0.0275***	0.0678***
	St. Error	(0.0228)	(0.0228)	(0.0196)	(0.0097)	(0.0180)
	Obs.	182	172	182	166	183
	p-value	0.0017	0.4125	0.0000	0.0003	0.0001
Tax	Mean	0.1045***	0.0321***	0.1422***	0.0950***	0.0865***
	St. Error	(0.0189)	(0.0196)	(0.0163)	(0.0135)	(0.0140)
	Obs.	179	171	186	153	188
	p-value	0.0000	0.0076	0.0000	0.0000	0.0000
Comp. & tax	Mean	0.0684***	0.0127	0.0968***	0.0459***	0.0585***
	St. Error	(0.0195)	(0.0225)	(0.0167)	(0.0122)	(0.0136)
	Obs.	182	171	187	148	187
	p-value	0.0011	0.2482	0.0000	0.001	0.0007

Note: Standard errors in parentheses. From a total of 192 individuals, each reference price generated some missing observations. The line Obs. refers to the number of individuals used in each calculation. The p-values correspond to a Wilcoxon signed-rank test in which the null is that the corresponding DE is zero. We do not report p-values for PGR and PLR since all of them are below 0.0001.

*** p<0.01, ** p<0.05, * p<0.1.

Table B3. Disposition Effect according to each reference price

VARIABLES	Average Price	Initial Price	FIFO	LIFO	Last Price
Female	0.00473 (0.0407)	0.0506 (0.0508)	0.000867 (0.0368)	-0.00832 (0.0278)	0.00636 (0.0337)
Competitive	0.00237 (0.0314)	-0.0326 (0.0384)	-0.0198 (0.0270)	0.0140 (0.0262)	-0.0374 (0.0317)
Tax	0.0209 (0.0419)	0.00525 (0.0409)	0.0271 (0.0351)	0.0547* (0.0298)	-0.0167 (0.0304)
Competitive & Tax	-0.000554 (0.0349)	-0.00950 (0.0495)	-0.0228 (0.0310)	0.00823 (0.0335)	-0.0534* (0.0274)
Female*Competitive	0.0168 (0.0366)	0.0262 (0.0555)	0.0211 (0.0325)	-0.00572 (0.0318)	0.0242 (0.0371)
Female*Tax	0.0288 (0.0483)	0.0258 (0.0527)	-0.000170 (0.0398)	0.0334 (0.0339)	0.0234 (0.0322)
Female*(Comp & Tax)	0.0155 (0.0346)	0.0236 (0.0552)	0.0158 (0.0327)	0.0337 (0.0403)	0.0402 (0.0285)
Experience	-0.0205** (0.00870)	-0.0221** (0.00906)	-0.0189*** (0.00723)	-0.0128* (0.00667)	-0.0271*** (0.00704)
Optimism	0.0191 (0.0176)	0.0242 (0.0179)	0.0135 (0.0160)	-0.000451 (0.00982)	0.00884 (0.0136)
Risk	-0.00853 (0.0177)	-0.00721 (0.0180)	-0.00358 (0.0155)	-0.00197 (0.00804)	-0.00402 (0.0134)
Confidence	-0.00468 (0.0194)	-0.00217 (0.0216)	0.00222 (0.0160)	0.00484 (0.0103)	0.00448 (0.0118)
Not Recognize Errors	0.0301* (0.0164)	0.0297* (0.0174)	0.0215 (0.0136)	0.0131* (0.00712)	0.0183* (0.0102)
Competitiveness	0.00521 (0.0199)	0.00396 (0.0186)	0.00561 (0.0167)	-0.00276 (0.00919)	-0.000309 (0.0134)
Enjoys Winning	-0.00909 (0.0130)	-0.0172 (0.0160)	-0.0104 (0.0117)	-0.00457 (0.00781)	-0.0143 (0.00947)
Decisiveness	-0.0149 (0.0185)	-0.00420 (0.0176)	-0.0120 (0.0162)	-0.00906 (0.00859)	-0.0226* (0.0134)
Self-control	0.0433** (0.0207)	0.0299 (0.0201)	-0.0372* (0.0191)	-0.0103 (0.0120)	0.0278 (0.0180)
High Confidence	-0.00655 (0.00984)	0.00570 (0.0122)	-0.00526 (0.00927)	-0.00353 (0.00813)	0.00153 (0.00823)
High Financial Literacy	-0.0157 (0.0195)	-0.0160 (0.0170)	-0.0127 (0.0163)	0.00620 (0.0104)	-0.00563 (0.0123)
High Grades	-0.00402 (0.0185)	0.0115 (0.0187)	-0.00551 (0.0164)	-0.00638 (0.00935)	-0.00705 (0.0135)
>1 Switches	0.00234 (0.0152)	0.00246 (0.0147)	-0.00309 (0.0127)	0.00499 (0.00727)	0.00230 (0.0118)
Neuroticism	0.0237	0.0281	0.0311*	0.00242	0.0267**

	(0.0173)	(0.0191)	(0.0169)	(0.0106)	(0.0133)
Extraversion	0.0178	-0.000450	0.0186	0.0113	0.0166
	(0.0159)	(0.0154)	(0.0142)	(0.00875)	(0.0115)
Agreeableness	-0.0182	-0.0176	-0.0210	-0.0126*	-0.0112
	(0.0178)	(0.0171)	(0.0143)	(0.00755)	(0.0125)
Openness	0.0214	0.0252*	0.0201*	0.00197	0.00885
	(0.0141)	(0.0137)	(0.0116)	(0.00767)	(0.0100)
Conscientiousness	-0.0165	-0.00595	-0.0135	-0.00555	-0.0125
	(0.0216)	(0.0191)	(0.0179)	(0.00848)	(0.0163)
Art	-0.0196	0.0319	-0.0209	-0.0134	-0.0141
	(0.0475)	(0.0458)	(0.0401)	(0.0211)	(0.0416)
Health	0.0179	-0.0115	0.00693	-0.0198	-0.00162
	(0.0444)	(0.0399)	(0.0369)	(0.0219)	(0.0308)
Science	0.0204	-0.00952	0.0141	-0.0312*	0.00239
	(0.0508)	(0.0476)	(0.0462)	(0.0176)	(0.0398)
Engineering	-0.0940*	-0.0972**	-0.0798**	-0.0319	-0.0629**
	(0.0489)	(0.0464)	(0.0331)	(0.0237)	(0.0312)
Constant	0.123***	0.0542	0.176***	0.0705**	0.171***
	(0.0403)	(0.0404)	(0.0339)	(0.0324)	(0.0345)
Observations	706	668	719	612	723
Number of id	192	192	192	191	192

Note: All variables except Female, Treatment and Experience standardized to zero mean and unit standard deviation. Standard errors in parentheses. Robust standard errors clustered by group and session in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table B4. Proportion of Gains Realized (PGR) according to each reference price

VARIABLES	Average Price	Initial Price	FIFO	LIFO	Last Price
Female	-0.0432 (0.0331)	-0.0229 (0.0326)	-0.0420 (0.0326)	0.00746 (0.0228)	-0.0393 (0.0309)
Competitive	0.00362 (0.0234)	-0.0223 (0.0206)	-0.00913 (0.0224)	0.0230 (0.0181)	-0.0169 (0.0225)
Tax	-0.0572** (0.0291)	-0.0632*** (0.0226)	-0.0492* (0.0289)	0.0179 (0.0237)	-0.0773*** (0.0232)
Competitive & Tax	-0.0896*** (0.0254)	-0.0700*** (0.0221)	-0.0858*** (0.0249)	-0.00921 (0.0228)	-0.0980*** (0.0202)
Female*Competitive	0.0205 (0.0289)	0.0262 (0.0290)	0.0331 (0.0265)	-0.0319 (0.0234)	0.0282 (0.0280)
Female*Tax	0.0610* (0.0349)	0.0564* (0.0291)	0.0537 (0.0336)	0.0273 (0.0265)	0.0695** (0.0280)
Female*(Comp & Tax)	0.0807*** (0.0294)	0.0502 (0.0309)	0.0786*** (0.0285)	0.0102 (0.0290)	0.0834*** (0.0263)
Experience	-0.0152*** (0.00524)	-0.0110*** (0.00412)	-0.0154*** (0.00521)	-0.00747 (0.00524)	-0.0202*** (0.00462)
Optimism	-0.00285 (0.0180)	0.000995 (0.0158)	-0.00381 (0.0178)	-0.00388 (0.00819)	-0.00638 (0.0149)
Risk	-0.000421 (0.0157)	-0.000963 (0.0141)	0.00253 (0.0155)	0.00620 (0.00752)	0.00387 (0.0132)
Confidence	0.0177 (0.0162)	0.0207 (0.0161)	0.0184 (0.0160)	0.0123 (0.00781)	0.0195 (0.0127)
Not Recognize Errors	0.00583 (0.0152)	0.00484 (0.0142)	0.00361 (0.0148)	0.00936 (0.00578)	-0.000904 (0.0115)
Competitiveness	-0.00550 (0.0142)	-0.0178 (0.0137)	-0.00383 (0.0140)	-0.00876 (0.00691)	-0.00819 (0.0113)
Enjoys Winning	-0.0117 (0.0137)	-0.0102 (0.0136)	-0.0126 (0.0142)	-0.00458 (0.00639)	-0.0156 (0.0115)
Decisiveness	-0.0200 (0.0185)	-0.00938 (0.0171)	-0.0163 (0.0184)	-0.00971 (0.00798)	-0.0223 (0.0151)
Self-control	0.0345* (0.0176)	0.0303* (0.0161)	-0.0283 (0.0183)	-0.00622 (0.00934)	0.0198 (0.0147)
High Confidence	-0.00775 (0.00841)	0.00553 (0.00679)	-0.00430 (0.00810)	-0.00734 (0.00691)	-0.00500 (0.00640)
High Financial Literacy	-0.00786 (0.0158)	-0.0132 (0.0126)	-0.0101 (0.0151)	0.00530 (0.00827)	-0.00763 (0.0115)
High Grades	-0.00560 (0.0165)	0.00209 (0.0139)	-0.00540 (0.0161)	-0.00797 (0.00844)	-0.00737 (0.0130)
>1 Switches	1.77e-05 (0.0122)	0.00314 (0.0106)	-0.00369 (0.0118)	0.00254 (0.00606)	0.000763 (0.0106)
Neuroticism	0.0296* (0.0122)	0.0292* (0.0106)	0.0297* (0.0118)	0.00211 (0.00606)	0.0256* (0.0106)

	(0.0172)	(0.0165)	(0.0174)	(0.00820)	(0.0139)
Extraversion	0.0105	-0.00106	0.00989	-0.00345	0.00582
	(0.0157)	(0.0137)	(0.0152)	(0.00673)	(0.0126)
Agreeableness	-0.0214	-0.0142	-0.0212	-0.00631	-0.0117
	(0.0160)	(0.0150)	(0.0154)	(0.00665)	(0.0129)
Openness	0.0186	0.0177	0.0174	0.00357	0.0114
	(0.0135)	(0.0124)	(0.0128)	(0.00535)	(0.0119)
Conscientiousness	-0.0167	-0.0128	-0.0127	-0.00561	-0.0108
	(0.0175)	(0.0138)	(0.0158)	(0.00780)	(0.0141)
Art	-0.0530	-0.0330	-0.0605	-0.0296	-0.0547
	(0.0490)	(0.0380)	(0.0471)	(0.0191)	(0.0411)
Health	-0.0264	-0.0191	-0.0305	-0.0205	-0.0431
	(0.0393)	(0.0301)	(0.0369)	(0.0177)	(0.0296)
Science	-0.0573	-0.0612*	-0.0556	-0.0561***	-0.0665*
	(0.0428)	(0.0354)	(0.0419)	(0.0162)	(0.0357)
Engineering	-0.0993***	-0.0813**	-0.0977***	-0.0314*	-0.0887***
	(0.0356)	(0.0378)	(0.0348)	(0.0164)	(0.0318)
Constant	0.339***	0.291***	0.336***	0.121***	0.320***
	(0.0344)	(0.0305)	(0.0340)	(0.0247)	(0.0315)
Observations	720	719	720	612	727
Number of id	192	192	192	191	192

Note: All variables except Female, Treatment and Experience standardized to zero mean and unit standard deviation. Standard errors in parentheses. Robust standard errors clustered by group and session in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table B5. Proportion of Losses Realized (PLR) according to each reference price

VARIABLES	Average Price	Initial Price	FIFO	LIFO	Last Price
Female	-0.0508** (0.0221)	-0.0760** (0.0312)	-0.0487*** (0.0189)	0.0131 (0.0195)	-0.0507*** (0.0187)
Competitive	-0.00279 (0.0205)	0.00376 (0.0339)	0.00867 (0.0189)	0.0114 (0.0164)	0.0175 (0.0193)
Tax	-0.0900*** (0.0231)	-0.0782** (0.0340)	-0.0799*** (0.0196)	-0.0333** (0.0147)	-0.0644*** (0.0185)
Competitive & Tax	-0.0888*** (0.0209)	-0.0613 (0.0396)	-0.0645*** (0.0176)	-0.0187 (0.0177)	-0.0446** (0.0176)
Female*Competitive	0.00769 (0.0290)	0.00245 (0.0415)	0.0163 (0.0268)	-0.0207 (0.0244)	0.0142 (0.0277)
Female*Tax	0.0441* (0.0253)	0.0383 (0.0370)	0.0588*** (0.0215)	-0.00718 (0.0230)	0.0514** (0.0205)
Female*(Comp & Tax)	0.0607*** (0.0198)	0.0278 (0.0432)	0.0629*** (0.0219)	-0.0160 (0.0271)	0.0406* (0.0223)
Experience	0.00431 (0.00572)	0.0102 (0.00850)	0.00114 (0.00400)	0.00376 (0.00257)	0.00441 (0.00454)
Optimism	-0.0230** (0.00929)	-0.0233* (0.0124)	-0.0143** (0.00684)	-0.00374 (0.00376)	-0.0117 (0.00739)
Risk	0.0107 (0.0107)	0.00920 (0.0141)	0.00374 (0.00733)	0.00614 (0.00409)	0.00495 (0.00719)
Confidence	0.0192 (0.0117)	0.0196 (0.0145)	0.0130 (0.00831)	0.00474 (0.00503)	0.0108 (0.00772)
Not Recognize Errors	-0.0262*** (0.00793)	-0.0259** (0.0114)	-0.0191*** (0.00563)	-0.00327 (0.00478)	-0.0194*** (0.00601)
Competitiveness	-0.00801 (0.0117)	-0.0215* (0.0129)	-0.00912 (0.00750)	-0.00609 (0.00414)	-0.00705 (0.00715)
Enjoys Winning	-0.00139 (0.0135)	0.00761 (0.0132)	0.00112 (0.00851)	0.00151 (0.00408)	0.00244 (0.00899)
Decisiveness	-0.00377 (0.00939)	-0.00836 (0.0111)	-0.00242 (0.00675)	-0.000122 (0.00440)	0.00466 (0.00641)
Self-control	-0.0127 (0.00867)	-0.00178 (0.0140)	0.0110 (0.00807)	0.00382 (0.00610)	-0.00974 (0.00746)
High Confidence	-0.000558 (0.00614)	0.000907 (0.0113)	0.00276 (0.00454)	-0.00394 (0.00380)	-0.00192 (0.00509)
High Financial Literacy	0.00675 (0.0116)	0.00189 (0.0135)	0.00248 (0.00745)	-0.000238 (0.00558)	-0.00286 (0.00717)
High Grades	-0.00137 (0.0101)	-0.0108 (0.0119)	-0.000674 (0.00731)	-0.00124 (0.00371)	-0.000887 (0.00732)
>1 Switches	-0.00281 (0.00914)	-0.00117 (0.0109)	0.00202 (0.00583)	-0.000383 (0.00358)	0.000579 (0.00596)
Neuroticism	0.00325	-0.000639	-0.00121	-0.00247	-0.00107

	(0.0129)	(0.0160)	(0.00904)	(0.00554)	(0.00895)
Extraversion	-0.00808	-0.00195	-0.00859	-0.0123***	-0.0107
	(0.0109)	(0.0136)	(0.00807)	(0.00458)	(0.00796)
Agreeableness	0.00122	0.00272	0.00265	0.00560	0.00232
	(0.00922)	(0.0131)	(0.00699)	(0.00423)	(0.00767)
Openness	-0.00481	-0.00817	-0.00294	0.00207	0.00136
	(0.00943)	(0.0123)	(0.00624)	(0.00457)	(0.00602)
Conscientiousness	0.00121	-0.00509	0.00120	-0.000674	0.00136
	(0.0113)	(0.0121)	(0.00699)	(0.00370)	(0.00838)
Art	-0.0345	-0.0643*	-0.0371*	-0.0153	-0.0370
	(0.0334)	(0.0360)	(0.0218)	(0.0125)	(0.0233)
Health	-0.0435**	-0.00588	-0.0363**	-0.00423	-0.0357**
	(0.0209)	(0.0283)	(0.0154)	(0.00980)	(0.0155)
Science	-0.0777***	-0.0508*	-0.0681***	-0.0275***	-0.0666***
	(0.0277)	(0.0286)	(0.0186)	(0.00990)	(0.0210)
Engineering	-0.00770	0.0128	-0.0258	-0.00335	-0.0338
	(0.0374)	(0.0442)	(0.0218)	(0.0156)	(0.0222)
Constant	0.220***	0.244***	0.168***	0.0513***	0.156***
	(0.0266)	(0.0334)	(0.0212)	(0.0167)	(0.0221)
Observations	710	673	732	660	729
Number of id	192	192	192	191	192

Note: All variables except Female, Treatment and Experience standardized to zero mean and unit standard deviation. Standard errors in parentheses. Robust standard errors clustered by group and session in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Experimental instructions (translated to English) – intended for online publication

Welcome to the experiment. This is an experiment to study how individuals take decisions. We are only interested in what individuals do on average. Do not think that any particular behavior is expected from you.

Please read these instructions carefully. Throughout the experiment you will be able to buy and sell assets using experimental money. To simplify the presentation, we will use *pesetas* as experimental money. The amount of pesetas you can earn depends on the decisions you make and, in some cases, the decisions made by other participants. At the end of the experiment you will be asked to fill in a short questionnaire.

Once you finish the experiment you will be paid privately and in cash the earnings you have obtained in the experiment.

The exchange rate is 1000 pesetas = 1 €

Please, it is important that you take all decisions privately. So do not talk to other participants during the experiment. You cannot use mobile phones during the experiment. If you need help, raise your hand and remain silent. We will answer your question as soon as possible.

The experiment lasts approximately 2 hours and consists of four rounds and a warm-up round. Each round consists of 14 periods (from -3 to 10). In periods -3 to 0 you will receive information on the prices of 6 assets (A, B, C, D, E and F), although you will not be able to buy or sell. In period 1 of each round you will receive an endowment of 5000 pesetas that you can use to buy and sell units of the 6 assets for the next 9 periods (period 1 to 9).

LOTTERY ROUND

You have 21 decisions between a fixed payment and a lottery. The lottery is always the same: there is a 50 % chance of winning 5000 pesetas and a 50 % chance of winning nothing. At the end of the experiment we will randomly select one of the 21 decisions. If in that decision you chose the safe payment, you will be paid that amount. If you

chose the lottery, the computer will “flip a coin”: if heads you will get 5000 pesetas and if tails you will get nothing.

ANY QUESTIONS?

FIRST ROUND

In this round, you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. The 4 members in the group participate in a small financial market consisting of 6 assets. All assets have the same initial price (in period -3) of 100 pesetas. From there, the price of each asset will change: it will raise a 6% or it will decrease a 5%. The probability of a price increase may be different for each asset but is constant for the same asset over each round. At the beginning of each round, the computer randomly chooses new probabilities of up or down for each asset, which will remain constant for that round. That means that the same asset can have a very high probability of rising in a round, and very low in another.

Suppose, for example, that an asset has a probability of price increase of 0.55 (i.e. 55%). This means that in each period, the current price can go up a 6% with a probability of 55%, or down a 5% with a probability of 45% (= 100% -55%).

This means that, if in a given period the price of an asset is 113.9 pesetas, its price in the next period will rise by 6% to 120.7 pesetas (= $113.9 \times (1 + 0.06)$) with probability 0.55 or will fall 5% to 108.2 pesetas (= $113.9 \times (1 - 0.05)$) with probability $1 - 0.55 = 0.45$.

These probabilities will be unknown for you. However, remember that they will not change within each round. In addition, price changes are independent of each other and independent of your trading decisions. They are also independent of the decisions of others.

In each of the periods from period 1 to period 9 you can buy or sell assets. In the figure below you can see the computer screen. At the top you can see the prices of assets A-F throughout the round. In this case we only show prices up to period 5.

Periodo		5 de 10										Tiempo restante [sec]: 9	
		Per. -3	Per. -2	Per. -1	Per. 0	Per. 1	Per. 2	Per. 3	Per. 4	Per. 5			
Activo A	Precio: Comp./Vend. (+/-)	100 ---	96 ---	92 ---	98 ---	104 3	110 -2	116 0	122 0	116 0			
Activo B	Precio: Comp./Vend. (+/-)	100 ---	106 ---	100 ---	96 ---	102 4	96 0	92 -2	88 0	84 0			
Activo C	Precio: Comp./Vend. (+/-)	100 ---	96 ---	92 ---	98 ---	94 6	100 0	96 8	92 0	98 0			
Activo D	Precio: Comp./Vend. (+/-)	100 ---	106 ---	100 ---	96 ---	102 8	108 -2	102 -2	96 0	102 0			
Activo E	Precio: Comp./Vend. (+/-)	100 ---	106 ---	112 ---	118 ---	126 4	134 0	142 -1	150 0	160 0			
Activo F	Precio: Comp./Vend. (+/-)	100 ---	96 ---	92 ---	98 ---	94 7	90 7	86 -1	82 0	78 0			

En mi cartera		Precio Actual			
Activo A	1	116		Compra 1	Vende 1
Activo B	2	84		Compra 1	Vende 1
Activo C	14	98		Compra 1	Vende 1
Activo D	4	102		Compra 1	Vende 1
Activo E	3	160		Compra 1	Vende 1
Activo F	13	78		Compra 1	Vende 1
SALDO:	392				

The top of the screen shows the evolution of the prices of the six assets A-F from period -3, and all the transactions you have already made. As in periods -3, -2, -1 and 0 you cannot buy or sell, the number of transactions for these periods is always 0. Purchases from period 1 onwards are represented by positive numbers and sales by negative numbers.

The bottom of the screen contains your transactions. Here you can decide whether to buy or sell one or more units of assets A-F. The column "En mi cartera" indicates the number of units of each asset you own. The column "Precio actual" means the price you pay for each additional unit you want to buy and also the price you receive for each unit you want to sell. You can also see how much pesetas you still have available under "SALDO".

If you want to buy an asset you have to pay for each unit the current price of the asset. You can never spend more money than you have available (your "SALDO"). To purchase an asset, you have to click the "Compra 1" button. If you want to buy more than one unit, you simply have to click as many times as you want to buy units.

Example: As in the figure above, suppose we are in period 5 and Asset A has a price of 116 pesetas. If you decide to buy 3 units of A, you will have to click three times on the "Compra 1" button. In this operation you are going to spend $3 \times 116 = 348$ pesetas. This amount is subtracted from your SALDO.

If you own units of an asset, then you have the option to sell those units. For each unit you sell you will receive the current price of the asset. The number of units you sell cannot exceed the number of units you own.

Example: As in the figure above, suppose we are in period 5 and Asset C has a price of 98 pesetas. You have 14 units of C and you want to sell 3 of them. To do this you have to click 3 times on the “Vende 1” button. You will receive $3 \times 98 = 294$ pesetas that will be added to your SALDO.

In each period you have a limited time to take your purchase decisions. This time will be one minute. You will see the remaining time in red on the top right of the screen.

The round ends in period 10. In period 10 you will not be able to buy or sell assets. The prices of period 10 will determine the final value of your portfolio. The value of the portfolio will be added automatically to your “SALDO” and will be part of your earnings.

At the beginning and end of the round we will ask you to tell us what position you believe you will be in terms of profits within the group of 4 people to which you belong. Every time you guess correctly, you will be paid 100 pesetas.

Also, before periods 1, 6 and 10 we will ask you to guess, which one of the 6 assets is the best (i.e., the one whose probability of price increase is highest), which one is the second best, which one is the worst (the one whose probability of price increase is the lowest) and which one is the second worst. In each of the three times, if you guess correctly the four, you will receive an additional 100 pesetas. For these two decisions there is no time limit. However, we ask you not to take too much time because until you do not take your decision the round cannot continue.

In short, your gains in this first round are:

Your SALDO

- + The value of the assets in your portfolio
- + What you have earned guessing your position
- + What you have earned guessing the assets

To get you familiar with the mechanics of the experiment, we will start with a small trial

practice.

ANY QUESTIONS?

SECOND ROUND

This second round is similar to the first, with a variation. As in the first round you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. Again you will have an initial endowment of 5000 pesetas to participate. The difference with the previous round has to do with the profits you can get. Specifically, your earnings in this round are:

If you are the winner in your group of 4 (i.e., if at the end of the round the value of your assets plus your “SALDO” is greater than those of the other 3 members of your group), you will receive:

(The value of the assets in your portfolio + your “SALDO”) × 2
+ What you have earned guessing your position
+ What you have earned guessing the assets

If you are not the winner in your group of 4, then you will receive:

+ What you have earned guessing your position
+ What you have earned guessing the assets

ANY QUESTIONS?

THIRD ROUND

This third round is similar to the first round, with a variation. As in the first round you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. Again you will have an initial endowment of 5000 pesetas to

participate. The difference is that each time you buy or sell an asset, you will have to pay a fee that is a percentage of the value of the asset. The fee is the same for all members of each group, although it can vary across groups. At the bottom of the screen you will see the amount of the fee.

Example: We are in period 3 and asset A has a price of 130 pesetas. The fee applied to transactions is 1%. If you want to buy 4 units of A you have to pay $4 \times 130 = 520$ pesetas plus $4 \times 130 \times 0.01 = 5.2$ pesetas in fees. In total this operation has a cost of $520 + 5.2 = 525.2$ pesetas. This amount is subtracted from your “SALDO”.

Example: We are in period 8 and asset E has a price of 90 pesetas. The fee is 4%. Suppose you own 5 units of E and you decide to sell 3 of them. By selling those 3 units you receive $3 \times 90 = 270$ pesetas, but you have to pay fees of $3 \times 90 \times 0.04 = 10.8$ pesetas, so your net revenue will be $270 - 10.8 = 259.2$ pesetas that will be added to your “SALDO”.

IMPORTANT: The fee will be charged automatically each time you press the “Compra 1” or “Vende 1” button. You must be careful because if you buy a unit of an asset and sell it within the same period, you pay the fee twice.

Your earnings in this round are:

Your SALDO

- + The value of the assets in your portfolio
- + What you have earned guessing your position
- + What you have earned guessing the assets

ANY QUESTIONS?

FOURTH ROUND

This fourth and final round is similar to the second round, but also as in the third round each time you buy or sell an asset, you will have to pay a fee that is a percentage of the

value of the asset. The fee is the same for all members of each group, although it can vary across groups. At the bottom of the screen you will see the amount of the fee. As in previous rounds you will be in a group of 4 randomly selected participants. You will never know who is in your group, and no one will know if you are in his/her group, neither during nor after the experiment. Again you will have an initial endowment of 5000 pesetas to participate.

Your earnings in this round are:

If you are the winner in your group of 4 (i.e., if at the end of the round the value of your assets plus your “SALDO” is greater than those of the other 3 members of your group), you will receive:

(The value of the assets in your portfolio + your “SALDO”) × 2
+ What you have earned guessing your position
+ What you have earned guessing the assets

If you are not the winner in your group of 4, then you will receive:

+ What you have earned guessing your position
+ What you have earned guessing the assets

Once you finish the four rounds, your total earnings will be the sum of the earnings of the four rounds plus the result of the lottery round.

ANY QUESTIONS?

To finish we ask you to answer a short questionnaire. Once you finish you can leave the room and wait outside. Do not forget to pick up your number. We will call you to come in to collect your earnings.

Thank you all!



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