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INVESTOR SOPHISTICATION, LEARNING AND THE DISPOSITION EFFECT

Boolell-Gunesh. S., Broihanne M-H., Merli M

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Université de Strasbourg
Pôle Européen de Gestion et d'Economie
61 avenue de la Forêt Noire
67085 Strasbourg Cedex
http://ifs.u-strasbg.fr/large

IFS
Institut de Finance
de Strasbourg

Investor Sophistication, Learning and the Disposition Effect

Boolell-Gunesh. S. [1] – Broihanne. M-H.– Merli. M[2]

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Abstract

This paper analyses the disposition effect at an individual level by studying the trading records of 20 379 investors over 1999-2006. As in previous studies, we confirm a huge heterogeneity among investors and we propose to explain these differences on the basis of financial sophistication and trading behavior proxies. Originally, we use direct sophistication variables: trading of foreign assets, derivative assets and bonds and trading on both tax-free and traditional accounts. We show that these variables reduce significantly the level of the disposition effect. Furthermore, based on a dynamic panel data analysis, we question the ability of investors to correct their bias over time. Results show that individual investor's disposition effect decreases over time and that our sophistication variables play a role in the decrease.

[1] LaRGE Research Center, EM Strasbourg Business School, Strasbourg University & IAF, University of Neuchâtel. E-mail: shaneera@unistra.fr.

[2] LaRGE Research Center, EM Strasbourg Business School, Strasbourg University, E-mail: mhb@unistra.fr / merli@unistra.fr (Corresponding author). We are grateful to M. Dubois, C. Godlewski, B. Koebel, L. Weill and P. Roger for helpful comments.

I. Introduction

Standard finance models assume that investors act with extreme rationality. In contrast, a number of recent studies demonstrate that investment behavior often departs from what rational theory predicts. For instance, individual portfolios are under-diversified (Goetzmann and Kumar, 2007), investors are overconfident (Barber and Odean, 2001) and net buyers of attention-grabbing stocks (Barber and Odean, 2008). These inconsistencies often lead to subsequent poor portfolio performance.

Starting with Shefrin and Statman (1985), a number of researchers have documented the presence of the disposition effect. This bias describes the tendency of investors to more readily sell winners than losers (winners and losers referring to assets that have appreciated or depreciated since purchase). The existence of the disposition effect for a representative investor (or a group of investors) is documented by Odean (1998) in the US, Shapira and Venezia (2001) in Israel, Grinblatt and Keloharju (2001) in Finland and Barber *et al.* (2007) in Taiwan[3].

Based on a different approach, Feng and Seasholes (2005) and Dhar and Zhu (2006) conduct an analysis of the disposition effect at an individual level. Dhar and Zhu (2006) show that even if on average, they observe a positive disposition effect, there is considerable heterogeneity among their sample investors. For instance, they demonstrate that about 20% of the investors they study exhibit the opposite behavior; they are more prone to sell their losing stocks. Individual differences in the disposition effect are significantly attributed to financial sophistication. Dhar and Zhu (2006) relate financial sophistication to professional occupation and income. Feng and Seasholes (2005) posit that initial portfolio diversification and number

[3] For other countries see, for instance, Brown *et al.* (2006) for Australia or Chen *et al.*, (2007) for China. Coval and Shumway (2005), Frino *et al.* (2005) and Locke and Mann (2005) obtain the same kind of results on professional futures markets. Weber and Camerer (1998) bring experimental evidence of this bias.

of trading rights are sophistication proxies and obtain similar results. Note that these authors further demonstrate that a combination of financial sophistication and trading experience can help investors to correct their behavioral mistakes.

Our work offers three main contributions. First, by analyzing 5.8 million trades, this work is the most comprehensive study of the individual level of the disposition effect in a European context.

Second, we analyze the impact of direct and never used measures of financial sophistication on the disposition effect. Actually, it is worth noting that direct measures of sophistication are very rarely used in the literature; Feng and Seasholes (2005) prove to be an exception. We consider investors to be sophisticated if they trade foreign assets, derivative assets, bonds and if they hold multiple accounts to place orders. We hypothesize that investors trading foreign assets and bonds are sophisticated because they are more likely to be conscious of diversification benefits. Furthermore, trading derivative assets requires familiarity with option-like payoffs, which may hint to enhanced financial sophistication. Finally, investors in our dataset have the opportunity to trade on traditional accounts and on tax-free accounts (French "PEA"). On these last accounts, capital gains are completely tax-free under some conditions; for instance, to benefit from tax exoneration, investors must hold the account for more than 5 years. In this respect, we consider investors trading the two types of accounts to be sophisticated because they take advantage of the traditional account flexibility and of the tax exoneration.

The third contribution of our paper is to give a comprehensive analysis of the dynamics of the disposition bias over time. We answer two main questions: Are investors able to correct their disposition bias over time? Does financial sophistication play a role in this correction?

The paper is organized as follows. Section II describes the data and the preliminary results. Sections III and IV present our empirical results based on a cross sectional analysis and on the dynamics of the disposition effect. Section V brings concluding remarks.

II. Data and Preliminary Results

The data used in our research is provided by a large French discount brokerage house and cover the period 1999-2006. First of all, note that measuring the disposition effect is not possible for investors holding portfolios with only purchases, portfolios with only one trade and portfolios containing sales for which no previous purchase could be identified (see below for a precise description of the methodology). According with this constraint, our initial database transactions were operated by 57 153 individual investors.

There are three data files: a trade file, an investors file and a fees file. The trade file contains information on the stocks each individual buys or sells, the price at which stocks are bought and sold, the time of such trades and the type of account used to place the orders (taxable versus tax-free accounts – French "PEA"). The investors file gathers some demographical information such as date of birth, sex and place of living. Finally, the fees file contains monthly fees paid by each investor.

It is well documented that on the average individual investors exhibit a low trading activity (Odean, 1998, Barber and Odean, 2001, Dhar and Zhu, 2006). In order to stress the learning of investors over time, we intentionally discard "less active traders". To do this, we select investors for whom we can compute the disposition effect for at least 4 years (consecutive or not) over our dataset period. Therefore, the analysis of the disposition effect at an individual level is conducted on 5.8 millions transactions operated by 20 379 investors.

We present descriptive statistics of our data in Table 1. As expected, our selection criteria lead to differences regarding trading behavior between the two samples. In table 1, the second column gathers descriptive statistics of the initial dataset while the third column presents statistics of the final sample.

[Table 1 about here]

Concerning trading behavior, on average, investors in our final sample have more trades (mean = 284 and median = 137) than the initial sample (mean = 144 and median = 52). On the whole period investors in our sample also trade higher amounts (mean = 1 037 870 EUR and median = 299 328 EUR) than those of the initial data base (mean = 558 429 EUR and median = 109 157 EUR). In the same vein and obviously, trading activity, where activity measures the number of year during which investors trade over our dataset period is higher in our sample (mean = 6.82 years and median = 7 years compared to mean = 4.98 years and median = 5 years in the entire data). Finally, demographic statistics show that in both datasets, the average investor is around 43 years old and that most traders are men.

The disposition effect at an individual level is computed following Odean (1998). The author defines the disposition effect as the difference between investors' propensity to realize winning stocks and losing stocks in their portfolios. By assuming that individual trades are independent, Odean (1998) shows the presence of the disposition effect at an aggregate level (representative investor). In this paper, we focus on *individual* disposition effect. We thus measure the disposition effect for *each* individual, which allows us to examine possible cross-sectional variation in the effect among investors with different characteristics.

Each day an investor sells securities, we determine whether the security is sold for a gain or for a loss by comparing its selling price to its average purchase price. Hence, each sale is counted as a Realized Gain (RG) or a Realized Loss (RL). Each stock in the portfolio at the beginning of the day that is not sold during that day is considered to be an unrealized gain, Paper Gain (PG) or an unrealized loss, Paper Loss (PL). Paper Gains and Paper Losses are defined by comparing the high and low price of the stock on that day to its average purchase price. If both the high and low price are above the average purchase price, we count a Paper Gain (PG). Otherwise, we count a Paper Loss (PL). If the average purchase price lies between the low price and the high price, neither a Paper Gain nor a Paper Loss is counted. All gains and losses are calculated after adjusting for splits.

The key values (RG, RL, PG and PL) allow to compute the Proportion of Realized Gains (PGR_i), the Proportion of Realized Losses (PLR_i) and the Disposition Effect (DE_i) for each individual investor *i* according to the following rules :

$$DE_i = PGR_i - PLR_i \quad (1)$$

$$PGR_i = \frac{N_{RG_i}}{N_{RG_i} + N_{PG_i}} \qquad PLR_i = \frac{N_{RL_i}}{N_{RL_i} + N_{PL_i}}$$

where $N_{RG_i}(N_{PG_i})$ and $N_{RL_i}(N_{PL_i})$ denote the Number of Realized (Paper) Gains and the Number of Realized (Paper) Losses of investor *i*. The disposition effect for individual *i* is defined as the difference between the Proportion of Realized Gains (PGR_i) and the Proportion of Realized Losses (PLR_i). When this difference is positive, it implies that investor *i* is more prone to realize his gains than his losses. It is important to point out that the computation of the disposition effect at an individual level implies that the PGR and PLR measured for a particular investor are independent from the PGR and PLR observed on all other accounts. We thus assume that individual accounts are independent[4].

[4] For a discussion on the limits of these measures, see for example Feng and Seasholes (2005).

Our first issue pertains to the computation of the disposition effect for each of the 20 379 individual investors of our sample. We measure PGR, PLR and DE for each investor and report average values of the different estimates. Table 2 presents the results.

[Table 2 about here]

We test the significance of the average DE using the following Z-statistic :

$$Z = \frac{\overline{PGR} - \overline{PLR}}{S_{DE} / \sqrt{n}}$$

Where $\overline{PGR}$ and $\overline{PLR}$ are the average values of PGR and PLR across our sample investors over the period 1999-2006. S_{DE} is the empirical standard deviation of the individual disposition effect and *n* is the number of investors. Results show that on our sample, the null hypothesis ($PGR \leq PLR$) is rejected with a high degree of statistical significance. The average value of DE is positive (0.099) and PGR / PLR equals 2.012. The ratio PGR to PLR is the rate at which the individual investors prefer to sell winning stocks rather than losing ones. On average, a stock that is up in value is more than 100% (2.012) more likely to be sold that a stock that is down.

We also present in Figure 1 the distribution of DE across our sample investors. We notice that even if we observe an average positive DE, there is a non-negligible heterogeneity among our investors. An interesting finding is that all investors do not exhibit the disposition bias (we call them "Non-positive DE investors"). More precisely, 13.7%[5] (2 781 investors) of the investors do not exhibit any disposition effect ($DE = 0$) or exhibit an opposite behavior ($DE < 0$). On the sub-sample of "Non-positive DE investors", PGR is 0.13, PLR is 0.18

[5] 0.10% of our sample investors do not exhibit any disposition bias and 13.6% of them have an opposite behavior.

and DE is – 0.05 ($Z-stat$ = - 46.094). All these results are consistent with previous research, for instance, Dhar and Zhu (2006) obtain an average DE of 0.21, a ratio PGR to PLR equal to 2.23 and about 20% of the investors exhibit a negative DE.

[Figure 1 about here]

In the following section we test our main assumptions on the determinants and the evolution of the DE at the individual level. First, we analyze if the disposition effect is lower for sophisticated investors (Section III). Second, we test if the disposition effect decreases over time and depends on the level of investor's sophistication (Section IV).

III. Cross-Sectional Analysis of the Disposition Effect

The obvious question which arises is to explain the observed heterogeneity among investors. Previous research (Feng and Seasholes, 2005, Dhar and Zhu, 2006 and Chen *et al.,* 2007) suggests that demographic variables, financial sophistication or trade experience can contribute to the fact that individual disposition effect varies across investors. Financial sophistication relates to accrued familiarity with financial markets and sophisticated investors are endowed with financial skills which may help them resist to the disposition effect. Typically, in the literature, the proxies used to financial sophistication are indirect measures and include professional occupation, income (Dhar and Zhu, 2006, Chen *et al.*, 2007) and living location (big cosmopolitan cities or not) (Chen *et al.*, 2007). Direct measures of sophistication are rarely used; Feng and Seasholes (2005) prove to be an exception. The authors use initial portfolio diversification (number of stocks) and number of trading rights[6] as sophistication proxies.

[6] The authors study investors in the PRC. Traders in the PRC cannot use different ways to place orders (computer terminals in branch office, internet, telephone, etc) if they are not granted the authorization to. They have to apply for the "right" to use each method. Hence, the authors hypothesize that sophisticated traders are

In the same lines, we propose that differences in individual disposition effect can be explained by investors' intrinsic characteristics described in Table 3. The chosen variables can be classified into three categories: demographics, trading behavior and financial sophistication.

[Table 3 about here]

Demographic variables include *Age* and *Gender*. Gender differences in investment behavior are now well-documented. For instance, Barber and Odean (2001) show that men are more overconfident than women, which leads them to trade 45% more than women. This behavior clearly hurts their portfolio performance, driving up their trading costs and reducing their net returns by 2.65 percentage points a year, compared to 1.72 percentage points for women. Gender differences may thus affect individual investment decisions. As shown in table 3, nearly 83% of our sample traders are men. Previous research also demonstrates the impact of age on investment choices (Goyal, 2004, Ang and Maddaloni, 2005). We thus expect traders in different age groups to vary in the disposition bias.

The *trading behavior* category includes *Trade Size* and *Delay*. *Trade Size* for a given investor is computed as the total amount traded (EUR) over 1999-2006 divided by the total number of trades he/she realizes over the same period. *Trade Size* is usually taken as a proxy to investors' wealth when this information is not available (Chen *et al.*, 2007). The common assumption is that investors trading high amounts can afford value-added services such as financial advices. Thereby, these investors have better financial literacy and are sophisticated agents. In the same vein, we suppose that *Trade size* can contribute to explain individual differences in the disposition bias. However, *Trade Size* being an indirect measure of wealth

more likely to have a higher number of trading rights to place orders. Hence, the authors hypothesize that traders who apply and obtain the right to use a higher number of trading rights to place orders are sophisticated.

and accordingly an imperfect proxy to sophistication, we choose not to classify this variable in the *financial sophistication* category. Finally, *Delay* captures two aspects of trading behavior: the total number of trades realized and the trade rhythm. *Delay*[7] for a given investor is defined as the average interval between two consecutive sales. Actually, we assume that a low delay may hint first to enhanced familiarity with financial markets and thus a lower disposition bias. Secondly, a low delay may hint to a higher frequency of adjustment of the reference point. Following Weber and Camerer (1998), the closer the reference point to the current price, the lower the disposition effect. Refering to Table 3, the average trade size on our sample is nearly equal to 3030 EUR and the average delay is nearly 3 months (86 days).

Differing from previous research, we are particularly concerned about finding direct measures of sophistication. We therefore choose the following variables: *Foreign Trade, Bonds, Warrants* and *Two Accounts*. *Foreign Trade* and *Bonds* pertain to portfolio diversification issues. We hypothesize that investors who trade foreign assets or bonds are sophisticated traders because they are better aware of diversification benefits. Furthermore, compared to “traditional” instruments, trading warrants is more complex or difficult to individual investors[8]. Indeed, trading warrants requires familiarity with option-like payoffs; investors trading warrants are thus likely to be sophisticated. Finally, the existence of tax-free accounts in the French system allows us to build a last original sophistication proxy. Actually, on the French market, investors can hold two types of accounts to manage their portofolio: traditional accounts and/or tax-free accounts named “PEA” (Plan d’Epargne en Actions). Capital gains are completely tax-free on PEA accounts. However, to compensate this advantage, PEA accounts have to be kept for more than 5 years and the investment universe is reduced. We thus assume that any investor holding both a PEA account and a traditional

[7] *Delay* is by construction negatively linked to the number of trades.
[8] A survey carried out by NYSE-Euronext in 2007 highlights that approximately 70% of investors think that trading warrants requires good financial training.

account is sophisticated because he takes advantage of the flexibility offered by the traditional accounts and simultaneously of the tax exoneration attached to PEA accounts. Column 3 of Table 3 shows that on our sub-sample of 20 379 traders, 86% of the investors trade foreign assets, 12% trade bonds, 24% trade warrants and 61% hold both a PEA and a traditional account to place orders.

A preliminary way to test the hypothesis that our variables can contribute to explain the observed heterogeneity in the individual disposition effect is to compare the magnitude of the bias across investors' characteristics. Focusing mainly on our *financial sophistication* proxies, we classify investors following whether they are sophisticated investors (sophistication =1) or unsophisticated investors (sophistication=0) and report in Table 4 the average PGR, PLR and DE for the different groups. We also include results concerning gender.

[Table 4 about here]

Results in Table 4 show that men, women and the 4 groups of sophisticated and unsophisticated investors are prone to the disposition bias. However, the magnitude of the bias seems to be lower for men and for financially sophisticated traders. For instance, the average individual disposition effect for investors trading foreign assets is 0.093 compared to 0.102 for investors trading only local assets. Though more investigation is clearly needed, this first result shows that sophistication appears to attenuate the magnitude of the disposition effect.

To better understand the impact of our variables on the bias, we model the following linear relationship:

$$DE_i = a + b_1 \ln Age_i + b_2 Gender_i + b_3 Foreign\ trade_i + b_4 Bonds_i + b_5 Warrants_i + b_6 Two\ Accounts_i + b_7 \ln Trade\ size_i + b_8 \ln Delay_i + e_i \quad (2)$$

The dependent variable is the individual disposition effect computed for each individual investor according to equation (1). Explanatory variables include demographic variables, financial sophistication proxies and variables related to trading behavior. A log transformation of some of the variables is needed because those exhibit an asymmetric distribution. Column 2 of Table 5 reports the regression results (Model 1). We also present in columns 3 to 6 (Models 2 to 5) regression results for each sophistication variable separately.

[Table 5 about here]

Focusing on the base model (Column 2), all of our variables have a significant impact on the individual disposition effect. The coefficients of the demographic variables and of the financial sophistication proxies are negative. Thereby, male investors trading foreign assets, bonds and warrants and placing orders on both their PEA and traditional accounts are less prone to the disposition effect. This supports our hypothesis that accrued familiarity with financial markets and financial skills help investors reduce their disposition bias. On the opposite, trading behavior variables impact positively the disposition effect. Consistent with our assumption, the lower the delay between successive sales, the lower the magnitude of the bias. In fact, it is expected that investors who trade frequently and regularly become more familiar with financial markets and adjust smoothly their reference point towards the current price, thereby reducing their disposition effect. The positive impact of *Trade Size* on the bias is surprising and not consistent with previous research. For instance, Chen *et al.* (2007) observe that the average amount traded by investors impacts negatively the bias. It is however noteworthy to point out that Chen *et al.* (2007) focus on the Chinese market where it is mandatory that investors hold at most one account. On the French market, investors have the opportunity to trade with multiple accounts, tax incentives often urging them to do so. Note that the results obtained on the base model (Model 1) are globally confirmed on the other models (models 2 to 5).

IV. Panel Data Analysis of the Disposition Effect

In the previous section, we have been dealing with the disposition effect at a static level and have ignored the fact that there may exist time patterns of the bias. In the next section, we extend our analysis of the disposition effect by integrating temporal characteristics in our study. The first sub-section mainly answers the following question: do the results obtained at a static level hold when we integrate temporal aspects in our analysis?

In the second sub-section, we investigate whether investors can correct their bias over time.

IV.1. Time-series Analyses of the Disposition Effect

We study the temporal characteristics of our 20 379 investors' trading behavior by focusing on a yearly length period. The average delay between consecutive sales over our sub-sample being approximately equal to 3 months (see Table 3), a lower time interval (for instance, monthly computation of the disposition effect) would have led to sharply reduce the number of investors and the heterogeneity between investors. The computation of yearly disposition effects for our 20 379 sample investors allows us to calculate a total of 114 747 DEs. We are able to compute a DE on each of the 8 years of our sample period for 14.97% of the investors (3 050 investors). Note that due to our data selection criteria (see section II) – only investors for whom we can compute a DE for at least 4 years (consecutive or not), our panel is unbalanced.

In a first step, we aim at describing the 114 747 yearly DEs. Figure 2 plots the density function of the disposition effect for our sample investors. The disposition effect is widely distributed between -1 and 1. An interesting finding is that the study of the bias over time puts to light the same kind of heterogeneity than the one observed in the analysis of the disposition effect across investors (section II). The extent of the bias varies greatly over time; standard deviation (0.236) is almost twice the mean (0.122). Furthermore, the median (0.091) is smaller than the mean, reflecting the asymmetric shape of the distribution.

[Figure 2 about here]

To better understand how the bias varies over time, we build a dummy variable taking the value of 1 if the yearly DE is strictly positive and 0 otherwise. This classification shows that nearly 80% of our observations with a strictly positive DE for one year remain with a strictly positive DE over the following year[9].

In a second step, we check whether the variables we found to have a significant impact on the disposition effect at the static level (*demographics*, *financial sophistication* and *trading behavior* proxies) still play the same role when DE is computed on a yearly basis. In this respect, we estimate the following equation[10]:

$$DE_{it} = \alpha_i + \beta_1 \ln Age_i + \beta_2 Gender_i + \beta_3 Foreign\ Trade_i + \beta_4 Bonds_i + \beta_5 Warrants_i + \beta_6 Two\ Accounts_i + \beta_7 \ln Trade\ Size_{it} + \beta_8 \ln Delay_{it} + \varepsilon_{it} \quad (3)$$

$$i = 1,...,20379 \quad t = 1999,...,2006$$

[9] In the same lines, 44% of observations with a $DE \leq 0$ follow the same trend over the next year.

[10] Note that the results of all the following sections are not modified if we focus the analyse on the sub-group of 17 006 traders who exhibit a positive first DE.

The dependent variable is the yearly disposition effect, α_i are individual-specific effects and ε_{it} the idiosyncratic error. Periodic values are computed for *Trade Size* and *Delay*. *Trade Size* (resp. *Delay*) for investor *i* in a specific year equals the total amount he/she traded (total delay between successive sales) during the year divided by the total number of trades (total number of sales minus one) realized in the same year. The average trade size over years is 2 827 EUR (standard deviation = 5 262 EUR) and the average delay is 126 days (standard deviation = 195 days). Table 6 presents the regression results with either fixed (Column 2) or random individual effects (Column 3). The Hausman test indicates that the fixed effect model should be used. The assumption underlying the use of the fixed-effect model in our study is as follows: if the determinants of the disposition effect are correlated with some unobserved investors' characteristics, they are only correlated with the time-invariant component of these characteristics. However, as the fixed effect model does not provide consistent estimators for the coefficients of the time-invariant regressors (*Age*, *Gender*, *Foreign Trade*, *Bonds*, *Warrants* and *Two Accounts*), we also present in Column 4 of Table 6 results for the Hausman-Taylor estimator[11].

[Table 6 about here]

Results show that in all estimations, our variables have a significant impact on the yearly DE. Coefficients are significant at the highest level and we obtain signs in accordance with those of the cross-sectional regressions; the coefficients of demographic variables and of financial sophistication proxies are negative. On the opposite, trading behavior variables impact positively the disposition effect. These results demonstrate that the variables we found

[11] The Hausman-Taylor estimator is an instrumental-variables estimator that additionally enables these coefficients to be estimated by making the stronger assumption that some specified regressors are uncorrelated with the fixed effect.

pertinent to explain the differences in the DE at the static level (section III) still play the same role when the yearly DE is analyzed.

IV.2. Dynamic Analyses of the Disposition Effect

In this last section, we question the ability of investors to reduce their disposition bias over time and the role played by financial sophistication. Then, we investigate the dynamics of DE over time, checking whether investors' DE for any period *t* may be explained by the DE of the preceding period (*t-1*). Formally, we consider that investor's i DE in period *t* can be modeled by the following dynamic equation with unobserved fixed individual effect[12]:

$$DE_{it} = \alpha DE_{it-1} + \beta_1 \ln Trade\ Size_{it} + \beta_2 \ln Delay_{it} + f_i + \varepsilon_{it} \qquad (4)$$

$$i = 1, ..., 20379 \quad t = 1999, ..., 2006$$

Note that the DEs in equation (4) are yearly DEs and that *Trade Size* and *Delay* are also computed on a yearly basis. Actually, if investors have the ability to correct their disposition bias over time, we expect to observe $\alpha < 1$. Given the dynamic nature of our model, we cannot refer to an OLS method for estimation[13]. We thus refer to Arellano and Bond (1991) who propose an estimation of the dynamic model with an extension of the Generalized Method of Moments[14] (Hansen, 1982). In the Arellano-Bond methodology, equation (4) is estimated in first differences, by using the lagged independent variables as instruments. This differentiation process removes the unobserved fixed effects. Under some assumptions[15], the differenced residuals satisfy orthogonality conditions and it can be shown that all lagged

[12] The variable f_i accounts for others unobserved investors' characteristics that do not vary with time.
[13] In fact, the presence of a lagged variable with fixed effects produces biased and non consistent OLS estimates This arises because the lagged dependent variable is correlated with the error term although there is no autocorrelation between terms ε_{it}.
[14] Arellano-Bond methodology is available in Stata. The poor performance of GMM for panel data is only documented for small samples (see Blundell and Bond, 1998).
[15] The later step in the estimation is to verify this assumption by checking if the average covariance in residuals of order 1 and 2 are zero.

variables DE_{it-k} for $k \geq 2$ are valid instruments[16]. Estimation results are reported in Table 7 for 114 747 yearly DEs over our 20 379 investors.

[Table 7 about here]

Results show that coefficients estimates are significant at the highest level. Most importantly, we observe $\alpha < 1$, which, in line with previous research (Feng and Seasholes, 2005), indicates that the disposition effect is a bias investors may learn to attenuate over time[17].

This first result brings us to investigate a last issue: does financial sophistication play any role in the correction of the disposition bias over time? In other words, is the decrease of the bias even stronger for investors we consider to be financially sophisticated? To answer this question, we estimate equation (4) separately for financially sophisticated and unsophisticated traders. We keep in mind that financial sophistication in this paper hints originally to trading foreign assets, bonds and warrants and to the use of two accounts (traditional accounts and tax-free PEA accounts) to place orders. Table 8 reports the results with respect to our 4 financial sophistication proxies. Results should be read as follows; for instance, concerning *Foreign Trade*, Column 2 of Table 8 (*Foreign Trade=0*) presents estimated coefficients for unsophisticated traders while Column 3 of the same table (*Foreign Trade=1*) reports estimations for sophisticated investors.

[Table 8 about here]

[16] DE_{t-2} values for t=2001 to 2006 and independent variables are used as instruments.

[17] Furthermore, the null hypothesis that the error terms are serially uncorrelated is, as expected, rejected at order 1 but not at order 2 at a level of 5%. Note that due to the fact that 9 instruments are used to estimate 5 parameters, we also perform a Sargan test of overidentifying restriction; unfortunately, the null hypothesis that the population moment conditions are correct is rejected at a level of 5%.

We notice that the coefficient estimates are in all cases significant at the highest level. Furthermore, whichever sophistication proxy we consider, we observe a lower α for sophisticated investors. For instance, as far as *Foreign Trade* is concerned, α equals 0.174 for sophisticated traders and 0.197 for unsophisticated investors. Then our financial sophistication proxies seem to play a role in the correction of the bias over time.

V. Conclusion

This paper studies the disposition effect at an individual level on the basis of trading records of 20 379 investors at a large discount brokerage house. We show that although we observe an average positive disposition effect, there is a huge disparity among investors. For instance, about 14% of our sample investors exhibit an opposite behavior. We propose to explain the cross-section of the bias using direct and original sophistication variables as well as trading behavior proxies. We define sophistication with regards to four dimensions: investors are sophisticated if they trade foreign assets, warrants and bonds and if they hold two types of accounts to place orders (tax-free account and traditional account). Results show that financially sophisticated investors are less prone to the disposition effect. In the same vein, trading behavior variables contribute to explain individual differences in the bias; investors trading more frequently are less subject to the disposition effect. Furthermore, a formal test conducted in a dynamic panel study shows that individual investors' disposition effect decreases over time. The impact of our direct sophistication proxies on this reduction gives us optimistic views about investors' ability to correct their behavioral mistakes over time and may be more deeply studied in futur papers.

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Table 1 Descriptive statistics on our entire dataset and on our sample

The second column of this table presents statistics on the whole dataset, i.e. 57 153 investors over the period 1999-2006. The third column presents statistics on the same period on the 20 379 investors studied in this paper. Panel 2 gives information about trading behavior; "Average number of trades" refers to the number of trades by investors computed over 1999-2006. "Average number of years of activity" is the number of years investors own active accounts: active accounts are those with at least one transaction over 1 year. "Average total trade amount" is the total amount (EUR) traded by investors over 1999-2006. Age (in years) is computed at the beginning of 1999. Medians are reported in parentheses.

	Entire data set	Data in this paper
Panel 1 : Sample size		
Number of investors	57 153	20 379
Panel 2 : Trading behavior		
Average number of trades	144 (52)	284 (137)
Average number of years of activity	4.98 (5)	6.82 (7)
Average total trade amount	558 429 (109 157)	1 037 869 (299 328)
- Buy	282 117 (56 559)	524 301 (153 765)
- Sell	276 312 (52 237)	513 568 (145 041)
Panel 3 : Investor demographics		
% of men	80.27	82.45
Average age in 1999	41.34 (39)	43.66 (42)

Table 2 Individual disposition effect

The Proportion of Gains Realized (PGR), the Proportion of Losses Realized (PLR) and the Disposition Effect (DE) are measured for each of our 20 379 sample investors over the period 1999-2006. This table reports descriptive statistics of the different estimates. *** means significant at the 1% level.

	Mean	**Std. Deviation**
PGR	0.197	0.116
PLR	0.098	0.075
PGR / PLR	2.012	4.630
DE	0.099	0.115
$Z-stat$	122.15***	

Table 3: Independent variables

This table contains the description of variables (column 2) and descriptive statistics on individual characteristics and trading patterns of the 20 379 investors in the sample (columns 3 and 4). Individual characteristics are mainly dummy variables for which frequencies are reported: *Gender*, *Foreign trade*, *Bonds*, *Warrants*, *Two Accounts*. Quantitative variables give information on trading pattern (with the exception of investors' *Age*) for which mean and standard deviation are reported.

Variables	Description	Frequency/Mean	Standard deviation
Panel 1 :Demographics			
Age	Computed in years on the 01/01/1999	43.66	13.48
Gender	= 1 if the investor is a man, 0 elsewhere	82.45%	
Panel 2 :Financial sophistication			
Foreign Trade	= 1 if the investor trades foreign assets during the 1999-2006 period, 0 elsewhere. Foreign assets' ISIN do not begin with "FR"	86.04%	
Bonds	= 1 if the investor trades bonds during the 1999-2006 period, 0 elsewhere.	11.88%	
Warrants	= 1 if the investor trades warrants during the 1999-2006 period, 0 elsewhere	24.68%	
Two Accounts	= 1 if the investor trades on a tax-free "PEA account" and a traditional account, 0 if the investor trades only on a traditional account	61.08%	
Panel 3 : Trading behavior			
Trade Size	Computed as the total amount traded (EUR) divided by the total number of trades for each investor	3029.078	4741.267
Delay	Average number of days between consecutive sales	85.18	93.69

Table 4: Disposition effect across investors' characteristics

This table contains results at the individual level for PGR, PLR and DE based on the transactions of 20 379 investors over 1999-2006. Results are reported for the different values of dummy variables pertaining to *financial sophistication*: Foreign Trade (=1 if the investor trades foreign assets), Bonds (=1 if the investor trades bonds), Warrants (=1 if the investor trades warrants), Two accounts (=1 if the investor trades on both a PEA account and a traditional account). We also include results relating to gender. Standard Deviations are given in parentheses. ***, ** and * indicate that the results are significant respectively at the 1% level, at the 5% level and at the 10% level.

	PGR	**PLR**	**DE**	**Z-stat**
Panel 1 :Gender				
Man	0.196 (0.116)	0.099 (0.075)	0.096 (0.1149)	108.65***
Woman	0.202 (0.117)	0.0910 (0.074)	0.111 (0.1183)	56.3***
Panel 2 : Sophisticated investors (sophistication = 1)				
Foreign Trade = 1	0.189 (0.112)	0.095 (0.073)	0.093 (0.11)	111.02***
Warrants = 1	0.177 (0.107)	0.096 (0.068)	0.081 (0.101)	56.99***
Two accounts = 1	0.181 (0.107)	0.0872 (0.068)	0.094 (0.105)	99.64***
Bonds = 1	0.148 (0.091)	0.076 (0.06)	0.072 (0.087)	40.69***
Panel 3 :Unsophisticated investors (sophistication = 0)				
Foreign Trade = 0	0.247 (0.124)	0.114 (0.076)	0.102 (0.118)	116.01***
Warrants = 0	0.203 (0.117)	0.098 (0.077)	0.104 (0.101)	108.65***
Two accounts = 0	0.221 (0.124)	0.115 (0.088)	0.106 (0.129)	73.64***
Bonds= 0	0.203 (0.117)	0.101 (0.076)	0.102 (0.118)	116.69***

Table 5: Determinants of the level of the disposition effect

This table contains results for the linear regression of the disposition effect for the transactions of 20 379 investors over 1999-2006. Model 1 gives the estimate of the coefficients of equation (2). Model 2 to 5 gives separately the results of equation (2) for each sophistication variable. Student *t* appears in parentheses. ***, ** and * indicate that the results are significant respectively at the 1% level, at the 5% level and at the 10% level.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	0.126*** (9.47)	0.118*** (8.95)	0.986*** (7.60)	0.108*** (8.28)	0.107*** (8.24)
Ln(Age)	-0.035*** (-14.26)	-0.036*** (-14.77)	-0.034*** (-14.02)	-0.037*** (-15.22)	-0.036*** (-14.63)
Gender	-0.009*** (-4.56)	-0.011*** (-5.41)	-0.011*** (-5.76)	-0.011*** (-5.63)	-0.011*** (-5.62)
Foreign Trade	-0.014*** (-6.32)	-0.016*** (-7.02)			
Bonds	-0.013*** (-5.36)		-0.016*** (-6.89)		
Warrants	-0.005*** (-3.09)			-0.008*** (-4.68)	
Two Accounts	-0.009*** (-6.25)				-0.011*** (-7.08)
Ln(Trade Size)	0.002* (1.91)	0.002** (2.12)	0.002** (2.01)	0.002** (2.33)	0.002* (1.90)
Ln(Delay)	0.030*** (38.84)	0.031*** (40.51)	0.032*** (42.43)	0.032*** (41.36)	0.032*** (43.27)
R^2	0.105	0.101	0.101	0.100	0.102
N	20379	20379	20379	20379	20379

Table 6: Regression results

This table contains results for the panel data regression of 114 747 yearly individual disposition effects. Column 2 gives the estimate of the coefficients of equation (3) for fixed effects. Column 3 gives the estimate of the coefficients of equation (3) for random effects. Robust standard errors of all coefficients are reported in parentheses. ***, ** and * indicate that the results are significant respectively at the 1% level, at the 5% level and at the 10% level.

Variables	**Fixed effects**	**Random effects**	**Hausman-Taylor estimator**
Intercept	-0.241*** (-17.08)	0.094*** (5.96)	0.094*** (4.84)
Ln(Age)		-0.050*** (-15.56)	-0.077*** (-18.88)
Gender		-0.014*** (-5.72)	-0.020*** (-7.71)
Foreign Trade		-0.019*** (-5.87)	-0.023*** (-7.93)
Warrants		-0.018*** (-8.67)	-0.021*** (-9.22)
Two Accounts		-0.012*** (-5.86)	-0.012*** (-6.17)
Bonds		-0.016*** (-6.89)	-0.013*** (-4.30)
Ln(Trade Size)	0.037*** (21.53)	0.021*** (18.49)	0.035*** (27.00)
Ln(Delay)	0.021*** (25.85)	0.025*** (35.08)	0.025*** (43.94)
R^2 *within*	0.016	0.013	
R^2 *between*	0.019	0.069	
R^2 *overall*	0.0174	0.034	
Hausman		546.00***	
Wald			3106.29***
N	114 747	114 747	114 747

Table 7: Dynamic panel data estimations

This table contains results for the dynamic panel data regression. It gives the estimate of the coefficients of equation (4) for the whole sample – 20 379 investors and 114 747 *DEs*. Robust standard errors of the coefficient for the preceding disposition effect are reported in parentheses. ***, ** and * indicate that the results are significant respectively at the 1% level, at the 5% level and at the 10% level.

	Dynamic panel data (114 747 investor-years)
Obs. Nber	60376
Grps. Nber	18895
DE_{t-1}	.177*** (.0053)
Ln(Trade Size)	.052*** (.0018)
Ln(Delay)	.013*** (.0008)
Intercept	-.377*** (.0149)
Wald	1927.5
Nber of instr.	9

Table 8: Dynamic panel estimations and sophistication

This table contains results for the dynamic panel data regression for the 20 379 investors, which sums up to 114 747 yearly *DEs*. Column 2 to 9 gives separately the results of equation (4) for each sophistication variable. Robust standard errors of the coefficient for the preceding disposition effect are reported in parentheses. . ***, ** and * indicate that the results are significant respectively at the 1% level, at the 5% level and at the 10% level.

	Foreign Trade=0	**Foreign Trade=1**	**Warrants=0**	**Warrants=1**
Obs. nber	6463	53913	43355	17021
Grps. nber	2478	16417	14118	4777
DE_{t-1}	.197*** (.017)	.174*** (.005)	.179*** (.006)	.166*** (.009)
Ln Trade Size	.09*** (.006)	.047*** (.002)	.06*** (.002)	.034*** (.003)
Ln Delay	.025*** (.030)	.012*** (.001)	.016*** (.001)	.007*** (.001)
Intercept	-.693*** (.055)	-.332*** (.15)	-.436*** (.018)	-.228*** (.024)
Wald	300.43	1622.46	1505.81	424.63
Nber of instr.	9	9	9	9

	Bonds=0	**Bonds=1**	**Two Accounts=0**	**Two Accounts=1**
Obs. nber	51405	8971	21319	39057
Grps. nber	16574	2321	7328	11567
DE_{t-1}	.178*** (.006)	.167*** (.012)	.178*** (.009)	.176*** (.006)
Ln Trade Size	.054*** (.002)	.044*** (.004)	.049*** (.003)	.055*** (.002)
Ln Delay	.014*** (.001)	.009*** (.002)	.011*** (.001)	.015*** (.001)
Intercept	-.385*** (.016)	-.314*** (.032)	-.336*** (.026)	-.402*** (.017)
Wald	1643.37	291.50	605.36	1368.46
Nber of instr.	9	9	9	9

Figure 1 Distribution of disposition effect of the 20 379 investors

This figure gives the distribution of the disposition effect across individual investors. The number of investors is given in thousands.

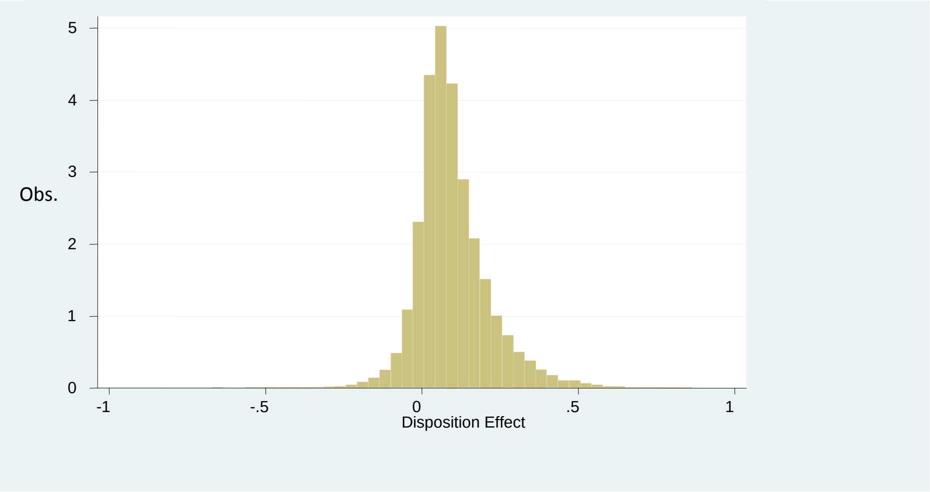
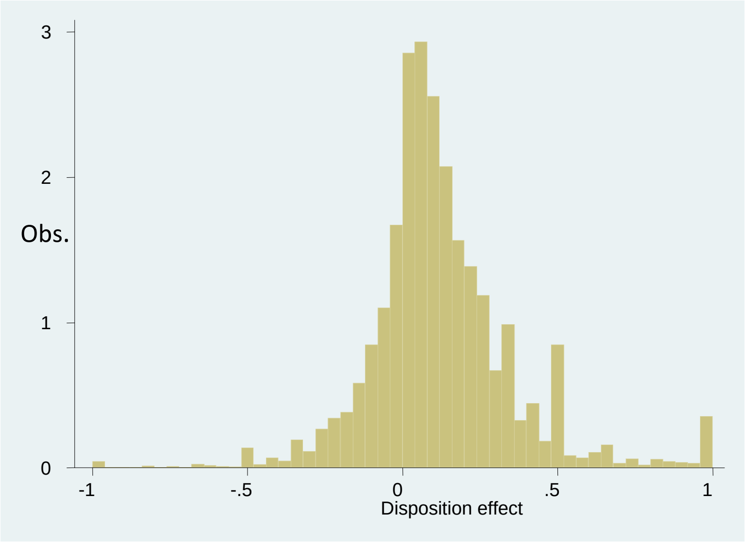


Figure 2: Distribution of the 114747 yearly disposition effect.

This figure gives the distribution of the yearly disposition effects across the 20 379 investors. The number of investors is given in thousands.



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