Erasmus University Rotterdam
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MSc Financial Economics
Master Thesis

# Are Short Sellers Subject to the Disposition Effect?
# Evidence from Short Sale Disclosures in the United Kingdom

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## Abstract

This study investigates whether the disposition effect is prevalent among short sellers, who are regarded as rational, well-informed traders. Using 10 years of disclosures of short positions larger than 0.50% from the United Kingdom, I show that short positions with a capital gain are 24%-30% more likely to be closed than short positions with a capital loss. Furthermore, a regression analysis shows that capital gains have a positive effect on the closing propensity. However, there is no conclusive evidence that this behaviour is caused by a behavioural bias or that this is merely the result of short sellers acting as informed traders. Finally, I demonstrate that the closing propensity curve follows a hump shape.

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Keywords: Disposition Effect, Short Seller, Behavioural Bias, Short Position Disclosure, Closing Propensity Curve

# Table of Contents

## 1. Introduction

The disposition effect refers to the tendency of investors to hold on to losing investments for too long, and sell winning investments too early (e.g., Odean, 1998; Shefrin & Statman, 1985). This tendency can result in suboptimal investment outcomes, as investors miss out on opportunities to sell at a profit and incur additional losses by holding on to losing investments too long. The disposition effect is one of the most robust behavioural biases documented in the literature, and it has been extensively researched in different financial markets and for different types of investors. The most research has been done on retail investors, investors that are not qualified and informed enough to trade profitably, and are subject to the disposition effect (e.g., Dhar & Zhu, 2006; Grinblatt & Keloharju, 2001; Odean, 1998). The disposition effect is, in addition to stock investments, also prevalent in housing markets (Genesove & Mayer, 2001; Hong et al., 2022). Moreover, the literature shows that not only retail investors, but also more sophisticated investors are subject to the disposition effect. Actually, the more sophisticated an investor is, the less prone he is to the disposition effect, although not immune (Barber & Odean, 1999, 2000; Frazzini, 2006; Shapira & Venezia, 2001). A few studies exist that provide evidence on the absence of the disposition effect in some cases. For example, O'Connell and Teo (2009) discover that the disposition effect has no effect on institutional investors in the currency market. Thus, the evidence on professional investors is both mixed and limited.

Most literature so far focuses on investors who are either non-professional, uniformed, who focus on intraday-trading, or some combination thereof. Short sellers, on the other hand, are sophisticated rational investors, who trade on long-term information. Because short sellers are informed (eg., Engelberg et al., 2012; Kecskés et al., 2013) and tend to trade away mispricings (Chen, Da & Huang, 2022; Lee, 2016), any form of behavioural bias they are subject to has a direct implication on the stock market, increasing the limits to arbitrage.

To the best of my knowledge, Von Beschwitz and Massa (2020) is the only paper to

specifically focus on the disposition effect among short sellers. They find that short sellers in the United States (U.S.) are more likely to close positions with a gain than positions with a loss. Furthermore, they show that this disposition effect behaviour is associated with less profitable closing decisions, and therefore not caused by any rational explanation. Thus, they conclude that short sellers in the U.S. are subject to the disposition effect. The study has one major drawback though, which is the lack of investor-level data. Instead, they use stock-level data, and have to estimate average purchase price of positions entered. Furthermore, they can only estimate the total amount of short positions closed per stock in a week, and cannot distinguish between investors. To accurately measure the disposition effect, one needs investor-level stock data.

In this study, I research the disposition effect among short sellers in the United Kingdom (U.K.), using investor-level stock data. This data comes from a regulation adopted by the European Union (EU) in 2012, that obliges investors who have a net short position of minimal 0.50% to disclose this position to their national authority. This means the dataset contains investor-level data with all short positions larger than 0.50% in the U.K. over the last 10 years. Because the data tracks which investors enters and closes which position on which date, it is exceptionally well suited to research the disposition effect among short sellers. In this study, I specifically focus on the U.K. Therefore, I propose the following research question:

*"Are investors with short positions of minimal 0.50% in the U.K. subject to the disposition effect?"*

I find that, on average, short positions with a gain are more likely to be closed than short position with a loss. The percentage of gains realized is 7.3%, while the percentage of losses realized is only 5.6%. This effect is approximately 3 times weaker than the effect retail investors exhibit (Odean, 1998). Then, I analyze the effect of capital gains of the closing decision. I obtain a significant negative regression coefficient for closing, which is in line with the disposition

effect. A 1 percentage point increase in the capital gains on an outstanding short position, increases the probability that the investor closes this position on a day, by 0.00237 percentage points.

When plotting closing propensity as a function of capital gains, the function follows a hump shape. Von Beschwitz and Massa (2020) find a similar shape. They argue that this shape is caused by liquidity concerns from short sellers. I do, however, not find enough supporting evidence to conclude the same.

The disposition effect in a short sellers' market could be explained by rational short sellers trading on private information. A short seller that shorts a stock he believes is overvalued, will close the position once the stock goes down and he has positive capital gains, but will hold on to the position if the stock price goes up and he has negative capital gains. To control for this possible cause of the disposition effect, I examine whether disposition effect behaviour leads to more profitable closing decisions. I find no supporting evidence for this explanation. I do find some evidence that investors who are more likely to close positions with large positive capital gains than positions with small positive capital gains, make less profitable closing decisions. This result is in line with a disposition effect that is caused by some sort of bias.

This study aims to better understand the disposition effect among short sellers. It is important to better understand behavioural biases in short selling behaviour, as short sellers impact financial markets. Irrational trading behaviour from short sellers would imply less efficient markets, which is not only undesirable for short sellers themselves, but for the market as a whole. Moreover, this paper contributes to the existing literature in a few ways. First, it contributes to the literature about the disposition effect and behavioural biases, using a new dataset and a type of investor that has received limited attention with regards to behavioural biases, particularly the disposition effect. Second, it contributes to literature about short selling

behaviour. Short sellers are regarded as rational informed traders. Studying whether short sellers are subject to a behavioural bias such as the disposition effect, provides further insight into how short sellers behave. This is important as it can further solidify or change our understanding of the impact short sellers have on the market.

The rest of the paper is structured as follows: Section 2 provides an overview of the relevant literature, and introduces the hypotheses. Section 3 describes the data and provides summary statistics. Section 4 examines whether positions with a capital gain have a higher chance to be closed than positions with a loss. Section 5 tests whether the effect could be explained by rational trading behaviour. Section 6 discusses the results. Section 7 concludes.

## 2. Literature

### 2.1 Disposition Effect

The disposition effect is a phenomenon observed in financial markets that refers to the tendency of investors to hold on to losing investments for too long and sell winning investments too quickly. It was introduced to the literature by Shefrin and Statman in 1985. Since then, it has been studied extensively and has turned out to be one of the most robust behavioural regularities documented in studies of trading behaviour.

The disposition effect imposes costs on investors. First of all, investors that suffer from the bias, pay higher capital gains taxes than necessary (Kaustia, 2010a). When investors need to sell stock for cash but lack information on which stocks will perform poorly in the future, they should liquidate stocks such that it minimizes taxes the most. This typically involves realizing either losses or a combination of gains and losses. When investors fail to minimize taxes, wealth is transferred from them to the rest of society. Besides, focusing on the purchase price of an investment can impede rational decision making based on future prospects, potentially leading to suboptimal investment performance.

Apart from investor suffering from the disposition effect, the market as a whole could be affected. Investors systemically acting irrationally, could impact trading volume and lead to a divergence between fundamental values and market prices (Kaustia, 2004; Birru, 2015).

### 2.2 Disposition Effect among Retail Investors

The disposition effect has extensively been researched in different financial markets and for different types of investors. The most research has been done on retail investors. After the disposition effect was first discovered in 1985, it gained little traction for some time. This changed in 1998, when Odean published the most influential paper on the disposition effect till date. Odean (1998) shows, using stock market investments from 10.000 US brokerage accounts, that the percentage of positions being sold is significantly higher for gains than for losses. Barber and Odean (1999) confirm these results for different accounts from the same broker. Shapira and Venezia (2001) show that Israeli investors hold losers two to three times longer than winners. Furthermore, Grinblatt and Kelohjaru (2001) find that the disposition effect is also prevalent in the Finnish stock market for household investors, non-financial corporations, insurance companies, and government and non-profit institutions. The literature is full of evidence showing that the disposition effect is prevalent across many countries for retail investors (e.g., Australia – Brown et. Al, 2006; China – Feng & Seasholes, 2005; Sweden – Calvett et al., 2009; Taiwan - Barbet et al. 2007). The disposition effect is also prevalent in housing markets (Genesove & Mayer, 2001; Hong et al., 2022). Besides, Heath et al. (1999) show evidence for the disposition effect in the exercise of stock options. Weber and Camerer (1998) conduct a controlled laboratory experiment on the disposition effect, finding that participants are 50% more likely to sell and realize gains compared to losses, validating the presence of the disposition effect in a controlled experimental setting.

### 2.3 Disposition Effect among Professional Investors

The existing literature shows that greater investor sophistication is associated with less susceptibility to the disposition effect. Nonetheless, professional traders are far from immune to it. Frazzini (2006) demonstrates that mutual fund managers sell equities held for a gain at a higher rate than those held for a loss. Coval and Shumway (2005), studying trading behaviour on the Chicago Board of Trade, find that the disposition effect, among professional market makers, is most prevalent in traders that perform the worst. Dhar and Zhu (2006) further show that among individual investors in the US, the disposition effect is weaker among the wealthy and those employed as professionals. With the use of Chinese data, Feng and Seasholes (2005), report evidence that trading experience helps weaken the disposition effect, but does not eliminate it entirely. This finding is backed by Chen et al. (2007).

Locke and Mann (2005) study the trading behaviour of professional futures traders. While they do find that they are subject to the disposition effect, they do not find evidence that this imposes costs on the investors. Finally, in a few cases, the non-existence of the disposition effect is reported. Cici (2012) reports that investing experience can fully mitigate the disposition effect among institutional investors in the equity market. Furthermore, O'Connell and Teo (2009) show that institutional investors in the currency market are not affected by the disposition effect. To conclude, while empirical evidence generally indicates that professional traders are susceptible to the disposition effect, there are some instances where this may not be the case.

### 2.4 Disposition Effect in the Short Sellers' Market

Most research is done on investors that are either non-professional (individual household investors), uniformed (mutual fund managers), or focus on intraday-trading. In contrast, short sellers are professional investors, who trade on long-term information. Furthermore, short sellers are assumed to be informed (eg.,Engelberg et al., 2012; Kecskés et al., 2013).

To the best of my knowledge, the disposition effect among short seller has been studied twice in the literature. Barber et al. (2007) use 5 years of data from the Taiwan Stock Exchange to research the disposition effect for the typical investor and the aggregate investor. To test the robustness of their results, the researchers perform the same analysis on the short sales in the dataset. Of the short sellers, 330.000 are individuals and 1.100 are corporations. The findings confirm that short sellers are also subject to the disposition effect, with 71% of individuals and 50% of corporations closing winning positions faster than losing positions.

Von Beschwitz and Massa (2020) specifically focus on short sellers. They use data from the U.S. equity lending market to study the disposition effect. The results are in line with the rest of the literature. Short sellers are also subject to the disposition effect, but to a lesser extent than household investors. The difference between proportion of gains realized and proportion of losses realized for short sellers is 9-17% of the magnitude retail investors exhibit (Odean, 1998). Since both papers on the disposition effect in the short selling market show its existence, my hypotheses will follow these results.

**H1**. Short positions with an unrealized gain are more likely to be closed than short positions with an unrealized loss.

**H2**. The closing activity of short positions is positively related to the amount of capital gains.

These hypotheses lie close together, but both make use of a different methodology. The first hypothesis uses Odean's (1998) method, a wide-spread approach, which makes it easily comparable to other findings in similar studies. The second hypothesis offers more insight into the direct effect of capital gains on the closing propensity, and is tested by running a linear regression.

### 2.5 Possible Explanations for the Disposition Effect

One well-known and widely used explanation for the disposition effect is prospect theory, first introduced by Kahneman and Tversky in 1979 and further developed by the same researchers

in 1991. Prospect theory is a concept that describes how individuals make decisions under uncertainty, particularly in situations involving potential gains or losses. According to the theory, individuals tend to evaluate outcomes relative to a reference point, which is usually equal to the initial purchase price. They experience gains and losses asymmetrically, with losses being perceived as more significant than equivalent gains. This phenomenon is known as loss aversion, and it suggests that individuals are more sensitive to avoiding losses than acquiring gains. Furthermore, the relative impact of a gain or loss decreases as the gain or loss gets bigger. This, the reference point, and loss aversion make that the value function is S-shaped; normally concave for gains, commonly convex for losses, and steeper for losses than for gains.

However, Kaustia (2010b) and Barberis and Xiong (2009) both find empirical evidence suggesting that prospect theory does not accurately explain the disposition effect. In 2012, Barberis and Xiong come up with their own explanation: realization utility. According to realization utility, the disposition effect arises because investors experience utility from selling a gain, and negative utility from selling a loss. This leads people to prefer selling a profitable position rather than a loss-making position. According to the researchers, this effect increases as gains become larger, but flattens out for losses. The reason for this, is that investors hold on to losses for as long as possible until they are forced to sell their position due to a liquidity shock. Hence, the size of the loss has no effect on the willingness to sell. Hong et Al. (2022) find that the disposition effect seen in apartment transactions in Singapore, could best be explained by realization utility. Moreover, other research provides supporting evidence for this explanation, with an experimental study (Frydman et al., 2014) and trading data from company insiders (Kelly, 2018).

Nonetheless, other explanations for the disposition effect have been proposed. Ben-David and Hirschleifer (2012) find that, for short-term stock investments, the probability of selling increases for extreme values, both positive and negative. They therefore conclude that

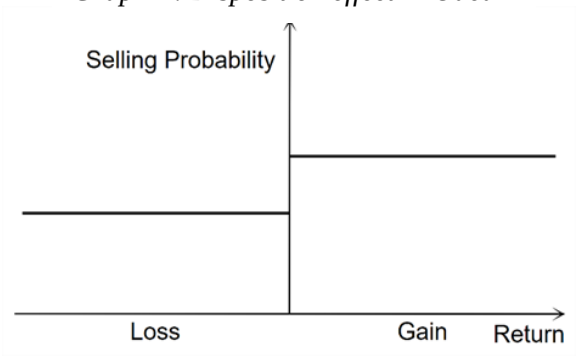
both prospect theory and realization utility do not explain their findings. Instead, they propose that the disposition effect is caused by belief revision: when an asset's value increases or decreases heavily, investors are more likely to revisit their original valuation and therefore sell the asset. This leads to a V-shaped selling propensity function. Furthermore, Ingersoll and Jin (2013) show that this pattern is also consistent with realization utility theory that considers reference dependent preferences.

All in all, research puts forward four relevant selling propensity curves, or in this case closing propensities, to consider. The first is based on Odean (1998), when the study only differentiates between gains and losses, but not the amount of the gains/losses. Then, the curve will be flat both for losses and for gains, but makes a jump at exactly zero profit. Second, the realization utility by Barberis and Xiong (2012). Realization utility predicts a curve that is flat over losses, but increasing over gains. Third, Ben-David and Hirschleifer find a V-shape, which they explain with belief revision. A V-shape indicates a selling propensity that is increasing both for gains and losses. Last, the shape found by Von Beschwitz and Massa (2020) is considered, as they study short sellers as well. They find a hump shape, which is the exact opposite of a V-shape: decreasing both for gains and losses. They argue that this shape is caused by liquidity concerns, as short positions with high absolute gains, are often in less liquid stocks.

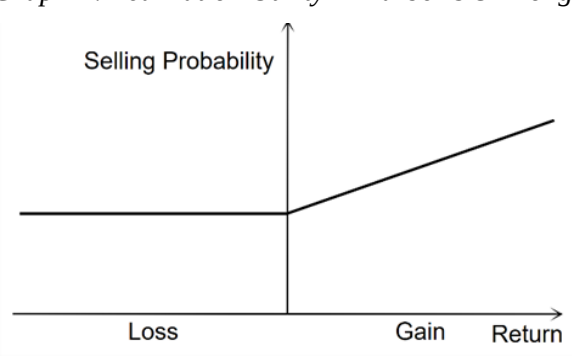
As this research most closely resembles the research by Von Beschwitz and Massa, and it is the only closing propensity curve studied in the literature, the hypothesis is stated that the closing propensity curve follows a similar shape. An overview of the selling and closing propensity curves is displayed in Figure 1.

**H3**. The closing propensity curve is hump shaped.

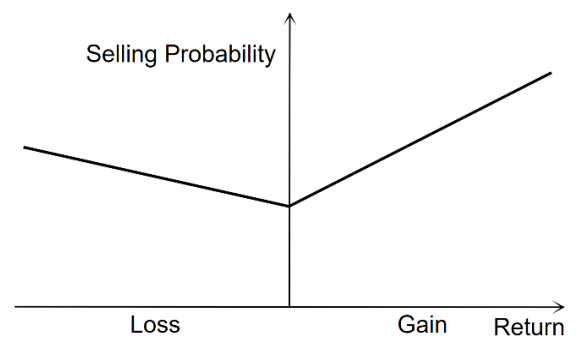
*Graph A. Disposition effect in Odean*




*Graph B. Realization Utility in Barberis & Xiong*




*Graph C. Belief Revision in Ben-David & Hirschleifer*




*Graph D. Closing Propensity in Von Beschwitz & Massa*

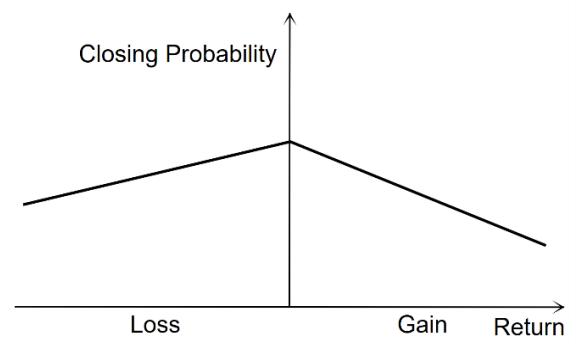



**Figure 1. Selling and Closing Propensities.** This figure illustrates the selling propensities based on the disposition effect in Odean (1998) (Graph A), realization utility in Barberis & Xiong (2012) (Graph B), belief revision in Ben-David & Hirschleifer (2012) (Graph C), and the closing propensity curve in Von Beschwitz & Massa (2020) (Graph D).

### 2.6 Short sellers' Rational Explanation for the Disposition Effect

One possible explanation for observing the disposition effect in the short sellers' market, is investors trading on private information. An informed short seller, who shorts a stock that is overvalued will hold on to a position that goes up in price, as it only gets more overvalued. However, when the stock price drops to the perceived fair value, he will close the position. Thus, this investors holds on to his losses but closes his gains, and therefore acts in line with the disposition effect. Nonetheless, the investor does not have to be subject to the disposition effect bias. To control for this, Von Beschwitz and Massa (2020) test whether keep-losers-close-winners behaviour is associated with more profitable closing decisions. If the effect is explained by informed trading, keep-losers-close-winners behaviour should be more profitable. They find that this is not the case, and conclude that short sellers are indeed subject to the

disposition effect. The last hypothesis will follow their result that the more an investor exhibits disposition effect behaviour, the less profitable the closing decisions are.

**H4**. The closing of short positions is less profitable when the investor exhibits more disposition effect behaviour.

## 3. Data and Descriptive Statistics

### 3.1 Data Background

In 2012, the EU adopted a regulation that obliges investors who have a net short position of minimal 0.50% to disclose this position to their national authority. Additionally, there are extra thresholds for each next 0.10%. Thus, when the short position reaches 0.60% (and 0.70%, 0.80% etc.), the exact position has to be disclosed again. The rule applies for all stocks traded on European Exchanges and for all market participants, except market makers. As the focus of this paper is specifically on informed traders, rather than liquidity providers, this exception only brings benefits. Furthermore, this regulation was converted to U.K. domestic law in 2018, three years before Brexit. This means that when the U.K. left the EU, it did not affect this short disclosure regulation. The Financial Conduct Authority provides information on the name of the investor (short seller), name of share issuer, ISIN code of the security, disclosure date and the magnitude of the net short position as a percentage of shares outstanding. An example of a short position in the dataset is illustrated in Figure 2.

The example illustrates a total of 11 short disclosures by Melvin Capital Management LP. On August 24, 2018, the investor crossed the 0.50% threshold with their net short position in Burberry. Since then, they reported their net short position every time they crossed a threshold, which exists for every next 0.10% on top of 0.50%. On October 25, 2018, they reached their highest net short position of 1.02%. The last disclosure is dated January 10, 2019, when they reported a position of 0.45% and thereby dropping below the minimum disclosure threshold.

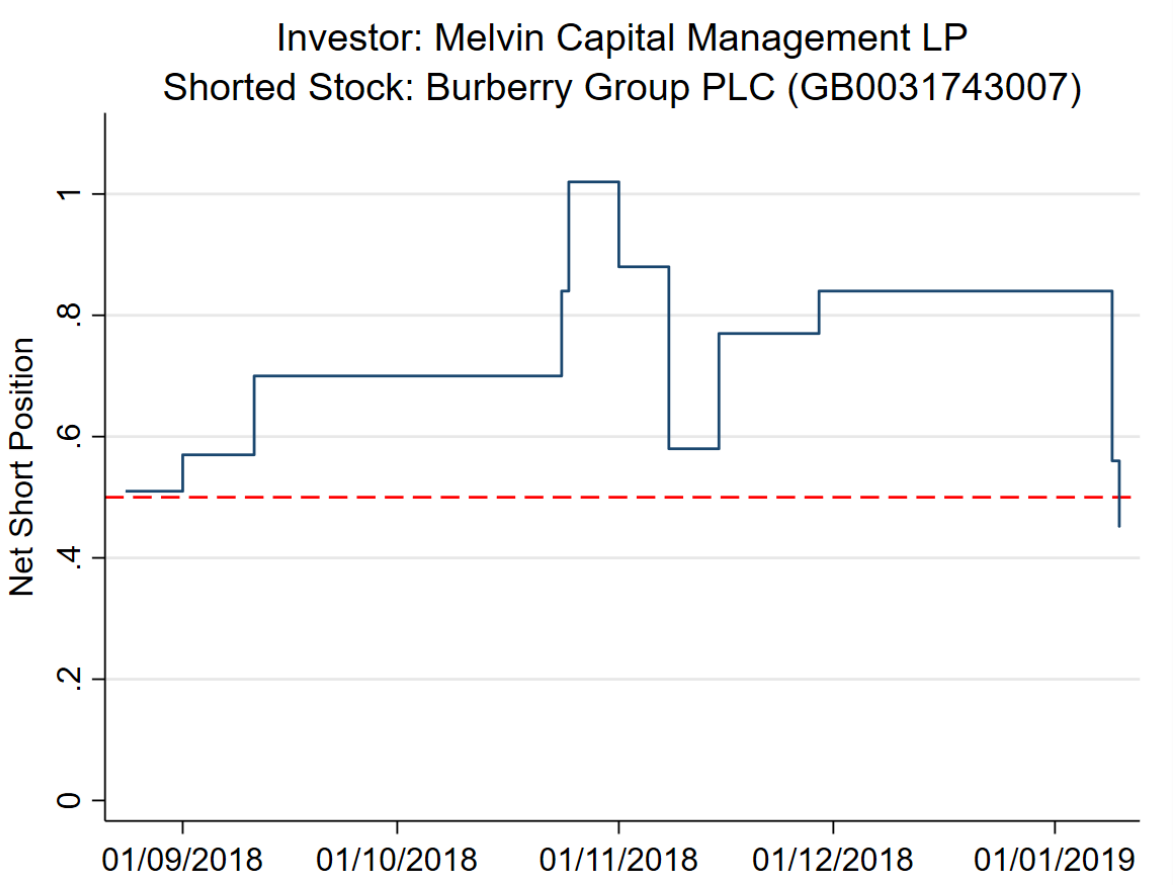



**Figure 2. Example of a short position disclosure in the dataset.** This figure shows the course of the net short position disclosed by Melvin Capital Management LP for their short position in Burberry Group PLC. The red line indicates the threshold of 0.50% above which investors are obliged to report net short positions.

The characteristics of the dataset has several advantages, since it provides comprehensive details on the entry, size, changes, and exit of all net short positions larger than 0.50% in the U.K. From now on, a net short position larger than 0.50% will be referred to as a Significant Short Position, or SSP.

One limitation of the dataset, is that not every change in the position is disclosed, but only when a threshold is crossed. To illustrate why this could be concerning, consider the following (hypothetical) example: The dataset records a short position where a hedge fund is short 0.89% in a company. Then, the hedge fund closes 0.08 percent points, and one day later closes an additional 0.02 percent points. The first day no new information has to be disclosed as the short position reaches 0.81%, and no threshold is crossed. However, the next day, the net

short position reaches 0.79%, crossing the 0.80% threshold, and therefore does get disclosed. This is important to note, as *Closing* is defined as a dummy that is 1 for every day a position is partially closed, as recorded in the dataset. In the previous example, day 2 would be considered as a partial close but day 1 would not, whilst on day 1 a larger part of the position was closed . Furthermore, given the rules of the regulations, the dataset does not contain net short position lower than 0.50%. Hence, this study specially focuses on Significant Short Positions.

### 3.2 Data Collection

The public short position disclosures for the U.K. are collected through Wharton Research Data Services (WRDS), for November 1, 2012, until January 1, 2023. During this period, 79,999 short positions have been disclosed. The dataset is expanded by merging them with data collected from Thomson Reuters Datastream. This source is used to gather stock prices and return data of the shorted stocks, as well as other company characteristics, like market value and price to book ratio. The datasets are merged on the ISIN code of the shorted stocks.

Next, for every trading day a SSP is open, the size of the net short position is kept track of, and updated every time a new disclosure is observed. Moreover, the investors' capital gains are calculated for each position on each trading day the position is open. As a result, the dataset expands from 79,999 disclosures to a total of 1,639,306 observations (trading days).

### 3.3 Constructing Variables

A key part of studying the disposition effect is assessing the capital gains of investors. All capital gains, as well as past and future returns used in this paper are calculated using Thomson Reuters' total return index. This index represents the stock price changes, but also accounts for stock splits and dividends, making it very much suitable for calculating returns and capital gains. From now on, when I mention stock price, I actually will be talking about this total return index.

The capital gains of short sellers are computed by using the average shorting price as a reference point. The average shorting price is calculated for each position, and is a weighted average of all past stock prices for which a short seller entered that part of the position. This gets updated every time the investor increases his short position in a stock. When a position is partially closed, the average shorting price does not change. This method is in line with Odean (1998) and Grinblatt and Keloharju (2001). Other studies that test for robustness in different mental accounting methods, such as FIFO and LIFO, find that this does not alter the findings (e.g. Frazzini, 2006; Weber & Camerer, 1998). Finally, *Capital Gains* is computed as the percentage decrease between the average shorting price and the current stock price. If the average shorting price is £10, and the current stock price is £9, *Capital Gains* will be 10%. This makes sense, as short sellers benefit when the stock price goes down. In the case that the current stock price is higher than the average shorting price, *Capital Gains* will be negative.

Furthermore, I construct past and future return variables by taking the percentage increase of the stock price for the specified periods. Unlike Capital Gains, these past and future returns are stock returns, and not investor returns. For example, if today the stock price is £12 and one year ago the stock price was £10, *Past Return 1 Year* will be 20%.

The variable *Closing* is constructed as a dummy variable. Every disclosure where part of the position gets closed, is recorded as a 1. All other days, when there are no disclosures, or when a net short position increases, are recorded as a 0. Thus, *Closing* does not distinguish between the amount of the position that gets closed. 2.3% of all days in the dataset are recorded as a close. For an overview of all variables, see Appendix A.

### 3.4 Descriptive Statistics

On average, there are 618 Significant Short Positions open on any given day in the sample period. The mean of the outstanding positions is 1.01%. In the case an investor has significantly shorted a stock, the chance is more than half (54%) that the same stock is also significantly

shorted by other investors. Moreover, the average number of short sellers per shorted stock, at any point in time, is 2.72. The duration of the significant short positions are skewed, with a mean of 305 trading days and a median of 124. When considering periods between each partial close, the mean is 44 trading days and the median 10. Table 1 provides summary statistics.

**Table 1. Summary statistics**. Panel A presents different characteristics of the Significant Short Positions in the dataset. Panel B contains the variables that are used in this study. 'N' is the number of observations, and 'SD' is the standard deviation. For 'Number of investors', a stock that is shorted by multiple investors on a single day, is considered as 1 observation. The investor sensitivity variables are multiplied by 1000.

| | | | | Percentiles | | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | N | Mean | SD | $10^{th}$ | $25^{th}$ | $50^{th}$ | $75^{th}$ | $90^{th}$ |
| **Panel A: SSP Characteristics** | | | | | | | | |
| Net short position (%) | 1,639,306 | 01.01 | 0.73 | 0.52 | 0.6 | 0.79 | 1.12 | 1.7 |
| Amount of SSPs | 1,639,306 | 698.17 | 207.33 | 400 | 517 | 740 | 868 | 959 |
| SSP Duration | 5,376 | 304.86 | 431.83 | 8 | 31 | 124 | 391 | 882 |
| Duration Partial Closes | 37,618 | 44.07 | 118.99 | 1 | 3 | 10 | 33 | 98 |
| Number of investors | 603,045 | 2.72 | 2.57 | 1 | 1 | 2 | 3 | 6 |
| **Panel B: Variables** | | | | | | | | |
| Closing | 1,639,306 | 0.02 | 0.15 | 0 | 0 | 0 | 0 | 0 |
| Capital Gains (%) | 1,563,524 | -0.87 | 32.94 | -30.73 | -12.38 | 0.02 | 13.03 | 32.15 |
| Ln(Market Value) | 1,599,754 | 7.37 | 1.29 | 5.83 | 6.64 | 7.44 | 8.32 | 8.75 |
| Ln(Revenue) | 1,482,801 | 14.06 | 1.62 | 12.03 | 13.13 | 14.12 | 15.12 | 16.13 |
| Price to Book Value | 1,432,149 | 4.89 | 10.8 | 0.6 | 1.12 | 2.08 | 4.26 | 8.92 |
| Amihud Illiquidity | 1,624,281 | 50.43 | 28.84 | 10 | 25 | 50 | 75 | 90 |
| Days Outstanding | 1,639,306 | 458.66 | 453.04 | 37 | 112 | 309 | 669 | 1116 |
| Past Return 1 Month (%) | 1,609,208 | -0.00 | 0.13 | -0.13 | -0.06 | .00 | 0.06 | 1.13 |
| Past Return 1 Year (%) | 1,595,756 | 0.01 | 0.46 | -0.46 | -0.24 | 0.03 | 0.19 | 0.44 |
| Past Return 3 Years (%) | 1,519,950 | 0.19 | 0.97 | -0.61 | -00.31 | 0.02 | 0.45 | 1.01 |
| Capital Gains Positive | 1,639,306 | 9.22 | 16.82 | 0 | 0 | 0 | 11.76 | 32.31 |
| Capital Gains Negative | 1,639,306 | -17.05 | 40.00 | -47.98 | -18.66 | -0.71 | 0 | 0 |
| Capital Gains Absolute | 1,639,306 | 27.54 | 40.11 | 2.30 | 6.51 | 16.23 | 34.48 | 61.66 |
| Dummy Amihud | 1,639,306 | 0.50 | 0.50 | 0 | 0 | 1 | 1 | 1 |
| Dummy Market Value | 1,639,306 | 0.51 | 0.50 | 0 | 0 | 1 | 1 | 1 |
| Investor Sensitivity (x1000) | 1,624,492 | -0.11 | 2.84 | -2.44 | -0.92 | 0 | 0.64 | 2.15 |
| Investor Gain Sensitivity (x1000) | 1,635,568 | -0.21 | 10.94 | -4.96 | -01.32 | 0 | 0.67 | 4.13 |
| Investor Loss Sensitivity (x1000) | 1,635,568 | -0.80 | 11.65 | -5.89 | -1.24 | 0 | 0.90 | 4.24 |
| Future 1 Week Return (%) | 1,609,520 | 0.06 | 7.27 | -5.97 | -2.59 | 0.05 | 2.67 | 5.89 |
| Future 2 Week Return (%) | 1,609,308 | 0.12 | 10.47 | -8,63 | -3,79 | 0.11 | 3,94 | 8,67 |
| Future 3 Week Return (%) | 1,608,830 | 0.18 | 12.74 | -10.66 | -4.77 | 0.14 | 4.98 | 10.86 |
| Future 4 Week Return (%) | 1,607,992 | 0.26 | 17.14 | -12.82 | -5.73 | 0.19 | 6.05 | 13.03 |

## 4. Do Short Sellers Exhibit the Disposition Effect?

This section examines whether short positions with a gain have a higher chance to be closed than short positions with a loss. Then, a regression is performed to further analyze the effect of *Capital Gains* on *Closing.* Third, the closing propensity curve is plotted. Lastly, a potential explanation for the shape of the closing propensity curve is explored.

### 4.1 Are Winners Closed More Often than Losers?

To test whether the closing propensity is higher for short positions with a gain than for short positions with a loss, the same method used by Odean (1998) is employed. This method consists of calculating a Proportion of Gains Realized (PGR) and a Proportion of Losses Realized (PLR).

$$PGR = \frac{Realized\ Gains}{Realized\ Gains + Paper\ Gains}$$

$$PLR = \frac{Realized\ Losses}{Realized\ Losses + Paper\ Losses}$$

Short sellers make profit when the price of a shorted stock goes down. Hence, a gain is defined as a position that currently has a lower stock price than the average shorting price. When the current price is higher than the average shorting price, it is recorded as a loss. On a given day, a gain can either be a paper gain or a realized gain. When the position is closed, either partially or fully, it is considered to be a realized gain. When the position is not closed, it is a paper gain. The exact same holds for losses. The stock prices used are actually Thomson Reuters' return index, which accounts for dividends and stock splits.

Now, although it seems like a pretty straightforward calculation, there are multiple ways to determine which days are considered in this calculation. Odean (1998), who studies household investor in the stock market, constructs stock portfolios at the investor level. Then, each day a sale takes place, realized and paper gains/losses are recorded. The idea behind this

is that only on days that household investors sell a stock, they also decide whether they want to sell stocks in their current portfolio. This is the most common way, and Odean's results are often used as a benchmark. Therefore I start with this method.

First, I construct short portfolios for every investor present in the dataset. Short portfolios are updated every time new information is disclosed. Then, each day an investor discloses new information, i.e. crosses a threshold for any stock in their portfolio, paper and realized gains/losses are computed for each stock in their portfolio. The disposition effect predicts that the proportion of gains realized is bigger than the proportion of losses realized. The results are shown in Table 2.

**Table 2. PGR and PLR compared to Odean (1998) and Von Beschwitz & Massa (2020).** This table compares the aggregate PGR and PLR for the entire dataset with the results from Odean (1998) and Von Beschwitz & Massa (2020). Von Beschwitz & Massa do not have data on the investor level and cannot calculate PGR and PLR. Instead, they estimate the difference between PGR and PLR using their regression results. In total, there are 20,133 realized gains, 253,994 paper gains, 17,395 realized losses and 291,159 paper losses. The t-statistics test the null hypotheses that the differences in proportions are equal to zero assuming that all realized gains, paper gains, realized losses, and paper losses result from independent decisions.

| | My Results | Results from Odean (1998) | Results from Von Beschwitz & Massa (2020) |
|---|---|---|---|
| PGR | 7.3% | 14.8% | - |
| PLR | 5.6% | 9.8% | - |
| PGR - PLR | 1.7% | 5.0% | 0.47% - 0.86% |
| T-statistic | 26.3 | 35 | - |

Short positions with a gain are 30% more likely to be closed than short positions with a loss. The difference between PGR and PLR is approximately three times weaker than the effect found by Odean (1998). This result indicates that short sellers might be less prone to the disposition effect than retail investors. Another thing to notice, is the difference in magnitude when the results are compared to Von Beschwitz and Massa (2020). The difference in PGR and PLR that I find is 2 till 3.6 times stronger than the difference they obtain, while we both research short sellers. It is possible that the difference could (partially) be explained by the difference in the calculation, since they could not calculate PGR and PLR in the same way. It might be that

their estimation is not fully accurate. Otherwise the difference has to lie in the difference in datasets we study, for example the difference in countries studied (U.K. vs U.S.).

There is also another method to calculate PGR and PLR. Short sellers are perceived as the most professional investors that rebalance the efficiency in financial markets the most (Boehmer & Wu, 2013). Hence, a good assumption would be that short sellers decide each trading day whether they want to sell their positions or not (in line with Barber et al. (2007)). To compute PGR and PLR this way, there is no need to construct portfolios at the investor level. As explained in the data section, the dataset has already been expanded with all trading days between two disclosures. Each observation, which is a distinct combination of position holder, issuer and date represents a paper gain, realized gain, paper loss or realized loss. Since Barber et al. (2007) is the only other study researching the disposition effect among short sellers and using this exact same method of calculating PGR and PLR, I compare my results with theirs. This is presented in Table 3.

**Table 3. PGR and PLR calculated each trading day, compared to Barber et al (2007).** This table compares the aggregate PGR and PLR, now based on each trading day the position is open (above the 0.50% threshold). In total, there are 20,133 realized gains, 768,875 paper gains, 17,395 realized losses and 826,366 paper losses. Barber et al. differentiate between individual short sellers and corporations. The t-statistic tests the null hypotheses that the differences in proportions are equal to zero assuming that all realized gains, paper gains, realized losses, and paper losses result from independent decisions. Barber et al. do not provide the T-statistic but their results are significant at the 0.05-level.

| | My Results | Results from Barber et al. (2007) | |
|---|---|---|---|
| | | All investors | Corporations |
| PGR | 2.55% | 7.68% | 5.47% |
| PLR | 2.06% | 3.67% | 2.01% |
| PGR - PLR | 0.49% | 4.01% | 3.47% |
| T-statistic | 20.9 | - | - |

As Table 3 demonstrates, when paper and realized gains/losses are recorded every trading day, PGR – PLR is still positive, which is in line with the disposition effect. This time, the PGR is 24% higher than the PLR. The PGR and PLR are smaller using this approach, which makes sense since the number of gains and losses realized are the same but the number of paper gains and losses are higher. These results have a smaller magnitude than the results of Barber

et al. (2007). This is partly due to the fact that their sample also includes individual short sellers who are more prone to behavioural biases. However, the difference is still large when compared to corporations.

As explained in Section 3, the closing decisions are only recorded when a threshold is passed, meaning that sometimes observations that are recorded as a close might actually have a smaller proportion closed than days which are not recorded as a close. This is a downside of the dataset, and might bias the results I find for both ways of calculation PGR and PLR. However, it is not clear in what way this biases the results, as this happens both for gains and losses.

### 4.2 Regression Analysis of the Disposition Effect

To gain further insight into the effect of capital gains on closing propensity, a regression analysis is run. There are multiple ways to do so. On first glance, it seems likely to use a logit or probit model, as the dependent variable is dichotomous. However, there are fixed effects that should be included in the model. This poses a problem, because when using a probit or logit model with fixed effects, you run into the 'incidental parameter problem' (Lancaster, 2000). Therefore I use a linear regression with fixed effects. This may seem odd, as a linear regression assumes that the dependent variable is continuous, which it is not in this case. It is, however, common in the literature to use this approach. Gomilla (2021) shows that when estimating causal effects on a binary outcome variable it is safer to use a linear regression when interaction effects or fixed effects are included.

First, *Closing* is regressed on *Capital Gains*. If short sellers in the dataset are subject to the disposition effect, we expect a positive beta coefficient for *Capital Gains*. Namely, when short sellers have made a gain on their position, the disposition effect expects that they will be more likely to close or 'cover' their position. This is equivalent to a long position that gets sold.

Since *Closing* is 1 on a day a position is partially closed, and 0 otherwise, we expect a positive relation between *Capital Gains* and *Closing*.

I control for past return, since the decision to cover a position might be driven by past stock return. Again, note that this variable is the stock return and not the return a short seller would have made on this stock. Just like Grinblatt and Han (2005), I use the 1 month, 1 year and 3 years horizons. Furthermore, I add *Market Value* and *Revenue* to control for size, *Price to Book Value* to capture the value factor, and *Amihud illiquidity* to control for liquidity concerns (Amihud, 2002). *Amihud illiquidity* is calculated as the quarterly mean of absolute daily return divided by daily dollar volume. Then, the quarterly means are ranked as percentiles instead of a continuous variable, given that it often has large outliers. Moreover, as older positions might have a higher chance to be closed, *Days Outstanding* is included to control for this.

Besides these control variables, time, stock, and investor fixed effects are included in the model. This approach acknowledges that short positions may be closed more frequently in certain years or with respect to certain stocks, and that such decisions may also vary across investors. Including fixed effects is important because it helps to account for unobserved heterogeneity that exists between the units (years, stocks, investors). Including fixed effects is the main reason a linear regression is preferred over a logit or probit in this situation, since using fixed effects in those binary regressions gives inaccurate results.

The standard errors in the model so far might be biased, since the standard errors may be correlated within each year, stock or investor. By clustering standard errors, I adjust for the correlation within clusters by estimating the variability of the coefficients within each cluster. This method provides more accurate estimates of the standard errors. I cluster the standard errors such that it gives the most cautious results, which turns out to be clustering by year, stock and investor. To put it into perspective, the standard error for *Capital Gains* (Table 4, regression

6) would be roughly 4 times smaller without clustering. The model, including all variables and all fixed effects can be described as the following:

$$\begin{aligned} Closing \; = \beta_0 + \; \beta_1 * Capital\ Gains + \; \beta_2 \; * \ln(Market\ Value) + \; \beta_3 * \ln(Revenue) \\ + \; \beta_4 * Price\ to\ Book\ Value + \; \beta_5 * Amihud\ Illiquidity + \; \beta_6 \\ * Days\ Outstanding + \; \beta_7 * Past\ Return\ 1\ Month + \; \beta_8 \\ * Past\ Return\ 1\ Year + \; \beta_9 * Past\ Return\ 3\ Years + Time\ Fixed\ Effects \\ + Stock\ Fixed\ Effects + Investor\ Fixed\ Effets + \; \varepsilon \end{aligned}$$

Given that only 2.3% of all days observed are days when a partial close is disclosed, *Closing* takes on the value 0 often. This results in very small beta coefficients. To avoid much scientific notation, all regression coefficients are multiplied by 1000 in this paper, when *Closing* is used as the dependent variable. The sign of the coefficients and their relative size don't change when all coefficients are multiplied by 1000. The results are presented in Table 4.

Indeed, there exists a positive effect of capital gains on the closing of short positions. The corresponding coefficient is highest when no fixed effects and no control variables are added in the model. However, the effect is persistent in all regressions. As the control variables and fixed effects get added, the coefficient becomes smaller, but stays significant and positive. In the last regression the significance drops from the 1% to the 5% level.

When considering the last regression, the coefficient for *Capital Gains* has to be interpreted the following way: a 1 percentage point increase in the capital gains on an outstanding short position, increases the probability that the investor closes this position on a day, by 0.00237[1] percentage points, which is only 0.1 percent of its mean. Economically, this seems to be a small impact. Furthermore, it is notable that the fixed effects provide the most explanatory power in this model, as the models without fixed effects have a smaller $R^2$. A low $R^2$ is not problematic given that the goal of this paper is not to most accurately predict closing, but study the effect capital gains has on the closing decision. All in all, these results suggest

[1] Note that the coefficient presented in the table is multiplied by 1000, and that *Closing* is reported as a proportion, and not as a percentage: 0.00237 percentage point = 0.0237 / 1000 * 100.

that short sellers have a tendency to close positions with a gain faster than positions with a loss, which is consistent with the disposition effect.

**Table 4. The effect of capital gains on closing propensity**. This table contains the results of linear regressions where *Closing* is regressed on *Capital Gains* and several control variables. Regression (1) and (2) do not include control variables. From regression (3) to (6), the fixed effects are added step-by-step. All coefficients are multiplied by 1000 for reading clarity purposes. The standard errors are clustered by year, stock and investor. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Closing | (2) Closing | (3) Closing | (4) Closing | (5) Closing | (6) Closing |
|---|---|---|---|---|---|---|
| Capital Gains (%) | 0.0779*** | 0.0480*** | 0.0480*** | 0.0459*** | 0.0349** | 0.0237** |
| | (0.0189) | (0.0122) | (0.0157) | (0.0157) | (0.0139) | (0.0113) |
| Ln(Market Value) | | | -1.132* | -1.169** | -2.827** | -3.211** |
| | | | (0.613) | (0.592) | (1.328) | (1.550) |
| Ln(Revenue) | | | 0.790*** | 0.670** | -0.169 | -0.171 |
| | | | (0.278) | (0.308) | (1.489) | (1.562) |
| Price to Book Value | | | -5.83e-05 | 0.000132** | 0.000194*** | -0.000151** |
| | | | (4.81e-05) | (5.51e-05) | (4.15e-05) | (6.28e-05) |
| Amihud Illiquidity | | | -0.00461 | -0.0165 | 5.21e-05 | 0.0617** |
| | | | (0.0314) | (0.0282) | (0.0339) | (0.0252) |
| Days Outstanding | | | 0.00595*** | 0.00634*** | -0.00516*** | -0.00637*** |
| | | | (0.00159) | (0.00160) | (0.00163) | (0.00135) |
| Past Return 1 Month (%) | | | 14.14*** | 25.07*** | 25.21*** | 25.86*** |
| | | | (4.624) | (3.961) | (3.888) | (3.976) |
| Past Return 1 Year (%) | | | -1.351 | -0.497 | 0.134 | -0.755 |
| | | | (1.390) | (1.410) | (1.387) | (1.253) |
| Past Return 3 Years (%) | | | -1.355** | -1.316** | -1.303* | -1.661** |
| | | | (0.637) | (0.615) | (0.702) | (0.781) |
| Constant | 23.25*** | 23.00*** | 22.66*** | 25.33*** | 48.12** | 48.57** |
| | (1.234) | (0.0665) | (5.197) | (5.078) | (19.15) | (19.62) |
| Observations | 1,563,524 | 1,563,508 | 1,277,924 | 1,277,924 | 1,277,918 | 1,277,918 |
| R-squared | 0.001 | 0.015 | 0.001 | 0.007 | 0.010 | 0.014 |
| Time fixed effects | No | Yes | No | Yes | Yes | Yes |
| Stock fixed effects | No | Yes | No | No | Yes | Yes |
| Investor fixed effects | No | Yes | No | No | No | Yes |

### 4.3 Decomposing the Disposition Effect

According to the disposition effect, investors tend to sell/close winners quicker than losers. Up till now, it has been demonstrated that this is indeed the case for short sellers in the U.K. This could be because losing positions are relatively not closed often, or winning positions are closed relatively often, or some combination of both. To examine this, *Closing* is plotted

against *Capital Gains*. This is standard in the literature and lot of different selling propensity curves have been found. In the case of short sellers, it is not selling propensity but closing propensity, although the concept is the same. *Capital Gains* is grouped into deciles. The corresponding graph is reported in Figure 3.

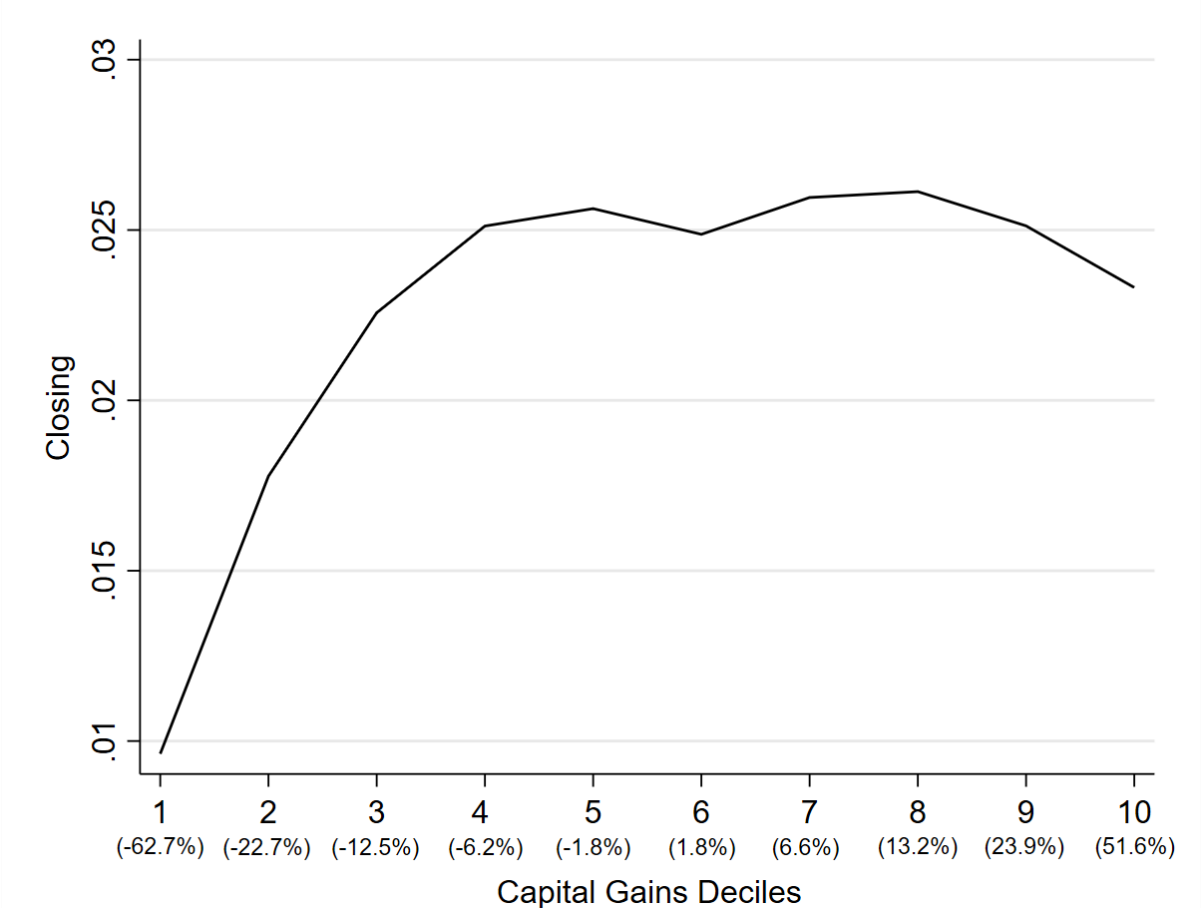



**Figure 3. Closing propensity as a function of Capital Gains**. This figure shows the average closing propensity for every decile of *Capital Gains*. The function is hump shaped.

The closing propensity decreases as the absolute value of capital gains increases. The curve has a 'inverted V', or hump shape. This is interesting to see, as Von Beschwitz and Massa (2020) find a similar shape. Remarkably, theirs and this paper are the only two papers researching disposition effect among short sellers and no other study has found this shape. This is evidence pointing in the direction that short sellers might behave differently, or at least are effected differently by the disposition effect bias.

To test whether the shape is statistically significant, two regressions are performed. First, *Closing* is regressed on *Capital Gains Positive* and *Capital Gains Negative*, to isolate both effects from the *Capital Gains* variable, just like Ben-David and Hirschleifer (2012) do. Based on Figure 3, we expect a negative coefficient for *Capital Gains Positive*, and a positive coefficient for *Capital Gains Negative.* Another way to test it is by regressing *Closing* on the absolute value of capital gains. In this case we expect a negative coefficient for *Capital Gains Absolute*, as seemingly, the closing probability gets lower as the absolute value of capital gains gets higher.

To do so, three new variables are constructed. The capital gains get split up into positive capital gains and negative capital gains. Also, the absolute value of the capital gains is generated as a variable. First, Closing is regressed on *Capital Gains Positive* and *Capital Gains Negative*. Then, Closing is regressed on *Capital Gains Absolute*. The regressions include the same control variables and fixed effects as before. The results of the regressions can be found in Table 5.

$$\textit{Capital Gains Positive} = \textit{Max(Capital Gains, 0)}$$
$$\textit{Capital Gains Negative} = \textit{Min(Capital Gains, 0)}$$
$$\textit{Capital Gains Absolute} = \textit{Abs(Capital Gains)}$$

The table shows negative coefficients for *Capital Gains Positive* and positive coefficients for *Capital Gains Negative* . In other words, the larger a gain or loss a short seller incurs, the lower the chance that the short seller closes his position. This is the same as saying that there exists a negative relation between *Closing* and *Capital Gains Absolute*. And indeed, the coefficients for *Capital Gains Absolute* are negative. Since the coefficients are also significant, it can be concluded that the closing propensity curve is hump shaped. When considering the last regression, which includes all fixed effects and control variables, we see that when an investor's absolute capital gains increase by 1 percentage point, we observe a decrease of 0.00645 percentage points in the likelihood that a position will be closed on a day.

**Table 5. The shape of the closing propensity function.** This table shows the regressions that test whether the hump shape found in the closing propensity curve is statistically significant. The dependent variable is *Closing*. The explanatory variables of interest are *Capital gains Positive* and *Capital gains Negative* in the first three regressions, and *Capital Gains Absolute* in the fourth, fifth and sixth regression. All regressions include time, stock and investor fixed effects. The standard errors are clustered by year, stock and investor and are reported between brackets. All coefficients are multiplied by 1000 for clarity's sake. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Closing | (2) Closing | (3) Closing | (4) Closing | (5) Closing | (6) Closing |
|---|---|---|---|---|---|---|
| Capital Gains Positive | -0.0166** | -0.0926*** | -0.193*** | | | |
| | (0.0354) | (0.0332) | (0.0575) | | | |
| Capital Gains Negative | 0.103*** | 0.0799*** | 0.0539*** | | | |
| | (0.0299) | (0.0212) | (0.0168) | | | |
| Capital Gains Absolute | | | | -0.093*** | -0.077*** | -0.0645*** |
| | | | | (0.0268) | (0.0212) | (0.0198) |
| Ln(Market Value) | | | -4.630* | | | -3.581** |
| | | | (2.359) | | | (1.620) |
| Ln(Revenue) | | | -0.347 | | | 0.0203 |
| | | | (1.764) | | | (1.618) |
| Price to Book Value | | | -0.000134* | | | -0.000145** |
| | | | (7.76e-05) | | | (6.64e-05) |
| Amihud Illiquidity | | | 0.0556** | | | 0.0600** |
| | | | (0.0255) | | | (0.0253) |
| Days Outstanding | | | -0.00458*** | | | -0.00502*** |
| | | | (0.00122) | | | (0.00121) |
| Past Return 1Month | | | 22.12*** | | | 24.74*** |
| | | | (4.296) | | | (4.061) |
| PastReturn 1 Year | | | -1.365 | | | -0.399 |
| | | | (1.326) | | | (1.181) |
| PastReturn 3 Years | | | -1.731** | | | -1.295 |
| | | | (0.771) | | | (0.788) |
| Constant | 24.82*** | 25.13*** | 63.66*** | 25.17*** | 26.04*** | 49.53** |
| | (1.404) | (0.525) | (20.70) | (1.549) | (5.073) | (19.39) |
| Observations | 1,639,306 | 1,639,304 | 1,310,776 | 1,563,524 | 1,563,508 | 1,310,776 |
| R-squared | 0.001 | 0.016 | 0.015 | 0.001 | 0.015 | 0.011 |
| Fixed effects | No | Yes | Yes | No | Yes | Yes |

As expected from Figure 3, the coefficients of *Capital Gains Positive* and *Capital Gains Negative* suggests a steeper line for negative capital gains than for positive capital gains. It is worth noting that, by adding fixed effects to the first regression, the magnitude of the coefficient of *Capital Gains Positive* reaches a similar level as that of *Capital Gains Negative.*

The closing propensity curve follows hump shape, or inverted V-shape, which is the exact opposite of the findings from Ben-David and Hirschleifer (2012), who find a V-shape. They argue that the shape comes from belief revision: when an asset's value increases or decreases heavily, investors are more likely to revisit their original valuation and therefore sell the asset. Since I find the exact opposite, this indicates that short sellers are not affected by belief revision when deciding when to close a position.

### 4.4 Why is the Closing Propensity Curve Hump Shaped?

Von Beschwitz and Massa (2020) propose that the hump shape could best be explained by liquidity constraints. During volatile times, short sellers are likely to have large absolute (either positive or negative) capital gains. Literature shows that markets are less liquid during volatiles times (e.g., Bedowska & Kliber, 2019; Kim & Verrechia, 1994). Large professional investors, unlike most retail investors, are incentivized to close their positions when markets are most liquid. This could therefore explain why the closing propensity curve follows a hump shape.

To test this, I start by testing the underlying assumption, which is that positions with large absolute gains are in stocks that are less liquid. Therefore, I plot *Amihud Illiquidity* as a function of *Capital Gains*. The higher the measure for *Amihud Illiquidity,* the less liquid a stock is. If the assumption holds, we expect a U-shape or V-shape. The result is presented in Figure 4. However, as shown, this function does not have a U-shape or V-shape. Instead, the function can best be described as a J-shape. *Amihud Illiquidity* is especially large for positive extreme capital gains, and only slightly larger for negative extreme capital gains. While there seems be some truth to it, the underlying assumption seems weak.

A regression of *Amihud Illiquidity* on *Capital Gains Absolute* is run to further investigate the assumption. If the assumption holds, we expect a positive coefficient for *Capital Gains Absolute.* The results of this regression are included in Appendix B. As expected, I find a positive coefficient for *Capital Gains Absolute*. This result does provide some evidence in

favour of the underlying assumption that positions with large absolute gains are in stocks that are less liquid. All in all, the underlying assumption, while not perfect, seems to hold.

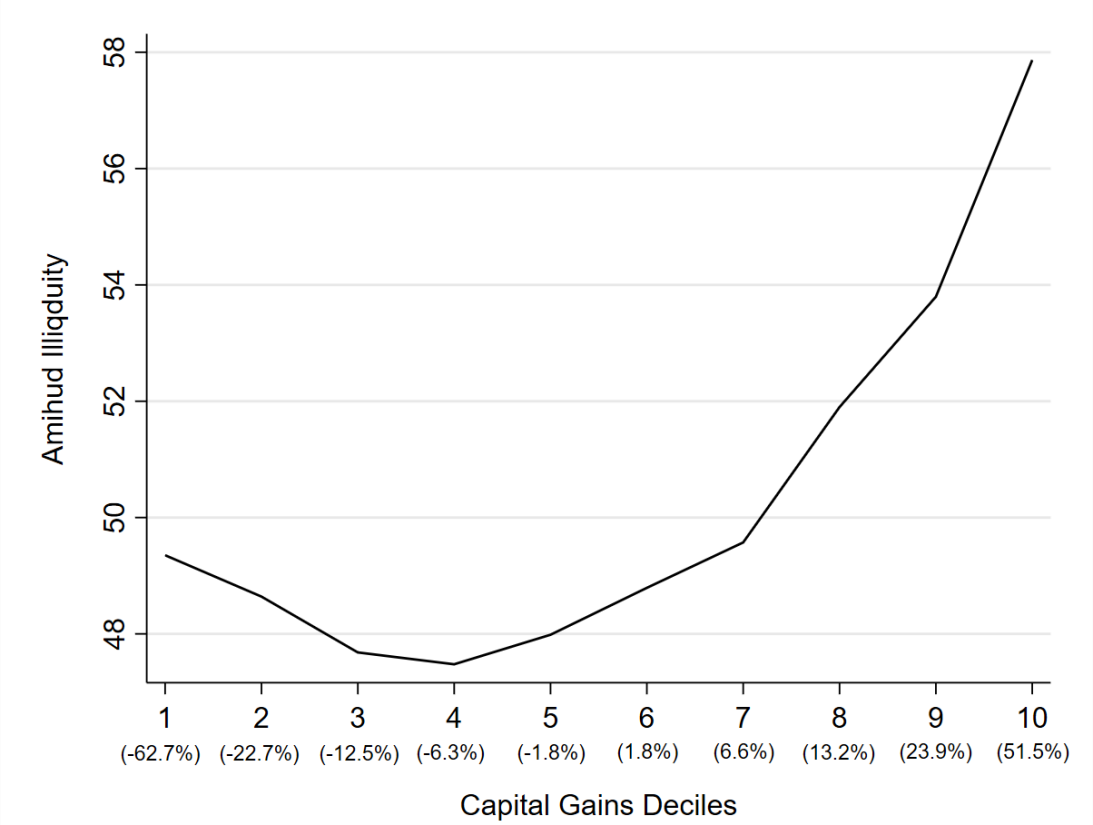



**Figure 4. Amihud Illiquidity as a function of Capital Gains.** In this figure, the average *Amihud Illiquidity* for every decile of *Capital Gains* is shown. *Amihud Illiquidity* is a ranked variable between 1 and 100; the higher the ranking, the less liquid a stock.

If liquidity problems explain the hump shape of the closing propensity curve, it is expected that this shape is stronger for stocks that are less liquid. Two firm characteristics that are often associated with less liquid stocks are *Market Value,* as smaller firms often are less liquid (Stoll & Whaley, 1983), and *Amihud Illiquidity*. I create a dummy which is 1 if *Market Value* is lower than its median, and 0 otherwise. Also, a dummy is constructed for *Amihud Illiquidity*: a 1 if *Amihud Illiquidity* is higher than its median, and 0 otherwise. Note that by constructing the dummies this way, they both take on the value 1 for stocks that are less liquid.

The dummies for *Amihud Illiquidity* and *Market Value* are interacted with *Capital Gains Absolute*. Then, *Closing* is regressed on these interaction variables. This way, it becomes clear

whether less liquid stocks exhibit a stronger hump shape, which would be the case if I find negative coefficients for the interaction variables. The results are presented in Table 6. As can be seen, all coefficients for the interaction variables are non-significant. Furthermore, they are not all negative. Therefore, it seems unlikely that the hump shape of closing propensity can be explained by illiquidity concerns from the short sellers.

**Table 6. Do less liquid positions exhibit a stronger hump shape?** Two illiquidity measures, *Dummy Amihud Illiquidity* and *Dummy Market Value*, are interacted with *Capital Gains Absolute* and then used to predict *Closing* to see whether the hump shape is more pronounced for illiquid stocks. Regression 2 and 4 include time, stock and investor fixed effects, as well as *Ln(Revenue), Price to Book Value, Days Outstanding, Past Return 1 Month, Past Return 1 Year, Past Return 3 years* as control variables, which are excluded for brevity. All coefficients are multiplied by 1000. Standard errors are clustered by year, stock and investor, and are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1)<br>Closing | (2)<br>Closing | (3)<br>Closing | (4)<br>Closing |
|---|---|---|---|---|
| Dummy Amihud Illiquidity * Capital Gains Absolute | 0.00590<br>(0.0157) | -0.00849<br>(0.0185) | | |
| Dummy Market Value * Capital Gains Absolute | | | -0.0588<br>(0.0365) | -0.0155<br>(0.0323) |
| Dummy Amihud Illiquidity | -1.246<br>(1.6457) | 0.275<br>(1.1770) | | |
| Dummy Market Value | | | 0.825<br>(1.6956) | -0.0939<br>(1.7787) |
| Capital Gains Absolute | 0.0957***<br>(0.0307) | -0.0600***<br>(0.0190) | -0.0534**<br>(0.0229) | -0.0546**<br>(0.0252) |
| Constant | 25.78***<br>(1.406) | 53.30***<br>(19.02) | 24.51***<br>(1.753) | 49.61**<br>(20.25) |
| Observations | 1,563,524 | 1,277,920 | 1,563,524 | 1,277,920 |
| R-squared | 0.001 | 0.015 | 0.001 | 0.014 |
| Control Variables | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |

## 5. Disposition Effect or Trading on Private Information?

Up till now I have shown that, on average, short sellers in the U.K. are more likely to close a short position with a gain than a short position with a loss. Also, it has become clear that the closing propensity function follows a hump shape. It seems likely that short sellers suffer from

the disposition effect, but this observed behaviour could also be explained by short sellers trading on private information. Consider the following example, of a short seller that trades on private information and is convinced that he has shorted a stock which is currently overvalued. If the stock price goes down to the perceived fair value – the short seller has an unrealized gain – he will then close the position. If the price goes up instead of down – the short seller has an unrealized loss – he perceives the stock as even more overvalued and holds on to the short position i.e. not close. He will only close once the stock goes down in price and he has made a gain. Therefore, one can expect to see keep-losers-close-winners behaviour in markets where short sellers mostly are informed and trade on private information. In this section, I will examine whether this is the case or the findings are a consequence of the disposition effect. To do so, I examine whether *Closing* predicts future returns more profitably when investors exhibit more disposition effect behaviour. Lastly, the capital gains will also be split up in gains and losses, to further examine the impact of gains and losses.

### 5.1 Is Disposition Effect Behaviour Associated with More Profitable Closing Decisions?

To distinguish between the effect that is caused by the disposition effect and the effect that is caused by rational informed investors, I examine whether the profits are higher for investors that follow this keep-losers-close-winners pattern more. If the effect comes from short sellers that trade on private information, the closing of positions should generally be more profitable. If it comes from the disposition effect bias, the trades should be less profitable.

A large advantage of the dataset used in this study, in that it is has data on the investor level. This means that it is possible to determine how investors' closing decisions are affected by their capital gains. Then, we will find out how the level of disposition effect exhibited by investors influences how *Closing* predicts future returns. By looking at future returns, it becomes clear whether ex post it was a good moment to close a position or not. In other words, whether this trade was profitable or not.

To start, I compute how much disposition effect behaviour investors exhibit. For this purpose, I use a rolling regression to estimate how *Capital Gains* influences the closing decision of investors. In these regressions, *Closing* is the dependent variable and *Capital Gains* the independent variable. The window size used is 50, which is small enough to get estimates in the smaller holding periods, but also large enough to capture the effect for larger periods when there are no closings for a longer time. The regressions yield regression coefficients. A higher coefficient means that an investor is more likely to close larger capital gains, and less likely to close larger capital losses, and thus exhibits more disposition effect behaviour. Then, I construct a new variable, *Investor Sensitivity*, which is the mean of the regression coefficients for each investor on each date. To get rid of outliers, *Investor Sensitivity* is winsorized at the 1% cutoff. This variable, *Investor Sensitivity*, represents how much keep-losers-close-winners behaviour an investor exhibits.

Then, a regression is run to see how *Closing* predicts *Future One Week future Stock Return*. The closing of a position is profitable for short sellers if it is followed by a positive stock return, since it prevents losses that the investor would have incurred if he had hold on to the position. On the other hand, closing is not profitable if it is followed by a negative stock return, as the investor misses out on gains by closing too early. In the regression, the main variable of interest will be an interaction variable between *Investor Sensitivity* and *Closing*. The regression coefficient of this interaction term will show how closing behaviour, depending on how much disposition effect the investor exhibits, predicts future returns. If the coefficient is positive, keep-losers-close-winners behaviour makes *Closing* predict future returns more profitably, which means the effect is most likely caused by informed trading. If it is negative on the other hand, keep-losers-close-winners behaviour leads to less profitable closing decisions, which would indicate that the behaviour is caused by the disposition effect bias. The results of the regression are presented in Table 7.

**Table 7. How does closing predict one week future returns?** This table presents the regressions that test how well closing predicts one week future returns. Furthermore, it examines how this effect is impacted by the amount of disposition effect behaviour the investor exhibits. Regression 2, 4 and 6 include time, stock and investor fixed effects. The standard errors are clustered by year, stock and investor and are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Future 1 week return (%) | (2) Future 1 week return (%) | (3) Future 1 week return (%) | (4) Future 1 week return (%) | (5) Future 1 week return (%) | (6) Future 1 week return (%) |
|---|---|---|---|---|---|---|
| Closing | 0.0385 | 0.0506 | 0.0285 | 0.0435 | 0.0162 | 0.0290 |
| | (0.0953) | (0.0579) | (0.0989) | (0.0605) | (0.106) | (0.0584) |
| Investor Sensitivity | | | -10.83 | 3.157 | -13.07 | 1.325 |
| | | | (8.793) | (3.586) | (10.13) | (3.774) |
| Closing*Investor Sensitivity | | | -19.92 | -6.646 | -18.47 | -10.63 |
| | | | (15.93) | (12.63) | (17.58) | (13.59) |
| Capital Gains | | | | | 0.000966 | 0.00178 |
| | | | | | (0.000615) | (0.00116) |
| Ln(Market Value) | | | | | -0.0683 | -0.651* |
| | | | | | (0.0703) | (0.368) |
| Ln(Revenue) | | | | | 0.0308 | 0.157 |
| | | | | | (0.0312) | (0.186) |
| Price to Book Value | | | | | -1.03e-05 | -1.58e-05 |
| | | | | | (1.19e-05) | (9.64e-06) |
| Amihud Illiquidity | | | | | -0.00342*** | -0.000313 |
| | | | | | (0.000777) | (0.000678) |
| Days Ooutstanding | | | | | -3.53e-06 | 9.87e-05* |
| | | | | | (6.00e-05) | (5.04e-05) |
| Past Return 1 Month (%) | | | | | -1.026 | -1.412*** |
| | | | | | (0.924) | (0.465) |
| Past Return 1 Year (%) | | | | | 0.0152 | 0.133 |
| | | | | | (0.119) | (0.108) |
| Past Return 3 Years (%) | | | | | -0.0216 | -0.0590 |
| | | | | | (0.0338) | (0.0577) |
| Constant | 0.0574 | 0.0572*** | 0.0569 | 0.0581*** | 0.360 | 2.743 |
| | (0.0639) | (0.000657) | (0.0642) | (0.000920) | (0.264) | (1.715) |
| Observations | 1,609,520 | 1,609,519 | 1,599,831 | 1,599,822 | 1,276,507 | 1,276,496 |
| R-squared | 0.000 | 0.179 | 0.000 | 0.179 | 0.001 | 0.228 |
| Time fixed effects | No | Yes | No | Yes | No | Yes |
| Stock fixed effects | No | Yes | No | Yes | No | Yes |
| Investor fixed effects | No | Yes | No | Yes | No | Yes |

First of all, most coefficients found are not significant. This makes it hard to draw conclusions based on this regression. The coefficients for closing are positive in all regressions, which would suggest that, on average, short sellers show skill in their decision making concerning closing short positions, although none of the coefficients is significant. Now, to see if the disposition effect found in the previous sections can be explained by a behavioural bias

or is caused by investors trading on private information, I examine the coefficients belonging to *Closing* Investor Sensitivity*. Again, these coefficients are insignificant. However, they are all negative, which would indicate that observed keep-losers-close-winners behaviour, leads to less profitable closing decisions. These results would point in the direction that short sellers in the U.K. are subject to the disposition effect, but the results are non-significant. I obtain similar results when C*losing* and *Closing* Investor Sensitivity* are used to predict future two week, three week, and four week returns. These results can be found in Appendix C.

### 5.2 Effect of Gains and Losses on Profitability of Closing Decisions

In Section 4.3, I decompose the disposition effect into positive and negative capital gains. I will do the same in this section, by dividing capital gains into positive and negative capital gains. Using the same methodology as for *Investor Sensitivity*, rolling regression coefficients for both *Capital Gains Positive* and *Capital Gains Negative* are computed. This is done by regressing *Closing* on *Capital Gains Positive* and *Capital Gains Negative*, with a rolling window of 50 days. Again, I take the mean of the regression coefficients for each investor on each day, and winsorize them at the 1% cut-off. This gives *Investor Gain Sensitivity* and *Investor Loss Sensitivity*. *Investor Gain Sensitivity* captures whether investors are more likely to close higher positive capital gains than lower positive capital gains. *Investor Loss Sensitivity* captures whether investors are more likely to keep bigger losses than smaller losses. A higher sensitivity indicates more disposition effect behaviour. Now, the keep-losers-close-winners behaviour, is split up in keep-losers and close-winners. Both investor sensitivities are interacted with *Closing*, to see how this behaviour impacts how *Closing* predicts future stock return. *Future One Week Return* is regressed on *Closing* and these interaction terms. If disposition effect behaviour leads to less profitable closing decisions, we expect negative regression coefficients for *Closing * Investor Gain Sensitivity* and *Closing * Investor Loss Sensitivity*. The results are reported in

table 8. Also, the base effect of *Closing* on *One Week Future Return*, as well as the economic magnitude of the *Closing * Investor Gain Sensitivity* interaction effect, are included.

**Table 8. Is keep-losers-close-winners behaviour associated with more profitable closing decisions, when capital gains are split up in positive and negative gains?** This table contains the results of the regressions where *Future One Week Return* is regressed on, inter alia, the interaction terms *Closing * Investor Gain Sensitivity* and *Closing * Investor Loss Sensitivity*. Regression 1, 4 and 5 include *Ln(Market Value), Ln(Revenue), Price to Book Value, Amihud Illiquidity, Days Outstanding, Past Return 1 Month, Past Return 1 Year, Past Return 3 years* as control variables. They are omitted for brevity. Regression 1, 3 and 5 include time, stock and investor fixed effects. Standard errors are clustered by year, stock and investor. They are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively. Panel B provides an overview of the base effect *Closing* has on *One Week Future Return*, as well as the economic magnitude of the interaction effect of *Closing * Investor Sensitivity Positive.*

**Panel A: Regression Results**

| VARIABLES | (1) Future One Week Return (%) | (2) Future one week return (%) | (3) Future one week return (%) | (4) Future one week return (%) | (5) Future one week return (%) |
|---|---|---|---|---|---|
| Closing | 0.0404 | 0.0415 | 0.0551 | 0.0494 | 0.0514 |
| | (0.0559) | (0.0961) | (0.0589) | (0.105) | (0.0570) |
| Investor Gain Sensitivity | | 0.930 | 0.0462 | 0.209 | -0.312 |
| | | (2.581) | (0.895) | (2.986) | (0.818) |
| Investor Loss Sensitivity | | 1.182 | 0.169 | 0.301 | 0.00379 |
| | | (1.428) | (0.833) | (1.306) | (0.798) |
| Closing * Investor Gain Sensitivity | | -9.280** | -8.112** | -7.260* | -5.945* |
| | | (4.286) | (3.452) | (4.221) | (3.254) |
| Closing * Investor Loss Sensitivity | | 0.460 | 1.066 | 1.832 | 2.034 |
| | | (3.147) | (2.712) | (3.509) | (3.071) |
| Constant | 3.199* | 0.0603 | 0.0591*** | 0.408 | 3.218* |
| | (1.686) | (0.0638) | (0.000624) | (0.258) | (1.688) |
| Observations | 1,310,776 | 1,605,968 | 1,605,958 | 1,308,754 | 1,308,747 |
| R-squared | 0.228 | 0.000 | 0.179 | 0.001 | 0.228 |
| Control Variables | Yes | No | No | Yes | Yes |
| Fixed effects | Yes | No | Yes | No | Yes |

**Panel B: Base effect and Economic Magnitude of the Interaction Effect**

| | |
|---|---|
| Base effect of *Closing* on *One Week Future Return* (Regression 1) | 0.0404 |
| Std. dev. of *Investor Gain Sensitivity* | 0. 0109 |
| Regression Coefficient of *Closing * Investor Gain Sensitivity* | -5.945 |
| Effect of 1 std. dev. on base effect | -0.0648 |
| As percentage of base effect | -160% |

Unlike Table 7, the regressions yield significant coefficients for one of the interaction terms. This significance is persistent in all four regressions, and concerns the interaction variable *Closing * Investor Gain Sensitivity.* The coefficient is negative, which means that *Closing* predicts future returns less profitably, when the investor exhibits more 'closing-the-winners' behaviour (i.e. has a higher *Investor Gain Sensitivity).*

The base effect of *Closing* on *Future One Week Return* is 0.0404. Although not significant, this positive effect indicates that short sellers seem to show skill in their closing decisions, as, on average, the one week stock return increases with 0.0404 percentage points if a position is closed. Then, I estimate how much this effect is moderated by the amount of 'closing-the-winners' behaviour (measured by the *Investor Gain Sensitivity*). The effect is economically large. A one standard deviation increase in *Investor Gain Sensitivity* reduces how well *Closing* predicts future returns by 160%.

This result provides some supporting evidence for of the existence of the disposition effect. It has been shown that short sellers have a tendency to keep losers and close winners. Now it has been demonstrated that, at least for the 'close-the-winners' part, that this behaviour leads to less profitable decision making. Therefore it seems likely that this is the result of a disposition effect bias and not caused by informed trading. However, the existence of the disposition effect among short sellers in the U.K. has not been definitively proven by these results alone, as the coefficient for *Investor Loss Sensitivity*, and the results of Table 7 are insignificant. As a robustness check, the 2, 3, and 4 week future returns are regressed on the same explanatory variables. The significance of the *Closing*Investor Gain Sensitivity* coefficient disappears but comes back in the regression with future 4 week return. All regressions, as well as Table 8 including all control variables, are included in Appendix D.

## 6. Discussion

The proportion of paper and realized gains and losses obtained in Section 4, are in line with the rest of the literature and therefore as expected. Short sellers, who are regarded as more sophisticated investors, also seem to have a tendency to close winners more often than losers. But, also as expected, the effect I find is less strong than the typical empirical findings for retail investors (e.g., Barber et al, 2007; Frazzini, 2006; Odean, 1998). Thus, the result is in line with hypothesis 1. Hypothesis 2 holds as well, as the regression shows that *Capital Gains* has a positive significant effect on *Closing*. Hypothesis 3, which states that the closing propensity curve follows a hump shape, is also in line with the results I obtain. It is a similar shape as Von Beschwitz and Massa (2020) find. This is remarkable, as to the best of my knowledge, this shape has never been found in selling propensity curves. However, Von Beschwitz and Massa (2020) and I, who both study short sellers, find a hump shape. This indicates that the shape might be caused by some underlying rational that is specific to short sellers. While Von Beschwitz and Massa argue that the shape comes from liquidity concerns, they do not rule out the possibility that it could be caused by something different. Furthermore, I do not find evidence which supports that the shape is caused by liquidity concerns. This makes it more likely that there might be some other explanation for it. One such explanation could be shorting costs. Short positions, contrary to long positions, are expensive to keep open, since short sellers have to pay a lending fee to the owner of the shares they borrow while they are sold short. In quiet markets, with position with little capital gains (positive or negative), it might not be worth it to keep these positions open for long because of the lending fee they pay. This might incentivize short sellers to close positions if they have not moved a lot since entering the position. This incentive would diminish as absolute capital gains increase, and could therefore explain the hump shape. This might be interesting for further research to examine.

Besides finding out about the cause of the hump shape, it is interesting to examine what the hump shape actually tells us about the cause of the observed behaviour. As often, selling propensity curves are used to support proposed explanations of the disposition effect. The hump shape, however, is not in line with any of the proposed explanations in the literature (Barberis & Xiong, 2012; Ben-David & Hirschleifer, 2012; Ingersoll & Jin, 2013; Kahneman & Tversky, 1991; Odean, 1998; Stein, 1995). Since the hump shape that I find is more steep over losses than over gains, it seems to suggest that the cause of keep-losers-close-winners behaviour, might primarily stem from the effect of negative capital gains. Nonetheless, a hump shape does not provide an obvious explanation as to why investors are more likely to close their winning positions than losing positions. Especially, since no explanation in the literature predicts a negative relation between *Closing* and *Capital Gains Positive*. Therefore, the hump shape requires more attention and has to be researched in greater depth as it could potentially provide a better understanding of short sellers' trading behaviour.

Hypothesis 4 states that the closing of short positions is less profitable when investors exhibit more disposition effect behaviour. I do, however, not obtain conclusive evidence to support this hypothesis. The only significance result from this section indicates that *Closing* predicts future return less profitably, for investors who close positions with high capital gains quicker than positions with low capital gains. This finding on its own is not enough to conclude that the hypothesis is true. Furthermore, it makes drawing conclusions about the disposition effect in the short sellers' market complex, as it is not clear what the reason for the observed keep-losers-close-winners behaviour is. Hence, a recommendation for future research would be to examine this cause further.

Moreover, the data used in this study, based on the short disclosures in the U.K., is also available for the 27 EU member states[2]. By utilising this data, it is possible to research the

[2] Although some countries do not have any short positions disclosed as of April 25, 2023.

disposition effect among short sellers over a wide variety of European countries. The last recommendation for future research I put forward, is to categorise the investors. For example, the short sellers could be categorised into: hedge funds, mutual funds, banks, other investment advisers, brokers and individuals. This leads to extra insights, as it shows which type of investor is more, less or not susceptible to the disposition effect. Again, providing a deeper knowledge of the mechanics of this behavioural bias.

The present study has, as any other study, some limitations. First of all, the dataset contains only short positions that are larger than 0.50%. Consequently, all findings are based on those large short positions. This study provides no insight into the disposition effect among short positions that are smaller than 0.50%. If you were to be interested in the disposition effect among short sellers overall, this could bias the results, but it is not clear in what way. Second, this study regards every partial close equally, and does not differentiate between the amount of the positions that gets closed. Furthermore, positions are only disclosed when a threshold is crossed. For these two reasons, the variable *Closing* does not capture the actual closing decision fully accurate. Besides, closing a small part of your position may be done for portfolio rebalancing purposes, which is not the type of closing decision the disposition effect refers to.

## 7. Conclusion

An abundance of literature shows that retail investors and uninformed professional investors are subject to the disposition effect. I study whether the disposition effect is also prevalent among short sellers, who are regarded as rational, well-informed traders. Data is collected on the short disclosures of positions larger than 0.50% from the U.K. between 1 November 2012, and 1 January 2023. I show that short positions with a capital gain are more likely to be closed than short positions with a capital loss. On average, the percentage of gains realized is 7.3% while the percentage of losses realized is 5.6%. This difference is smaller than the typical

difference retail investors exhibit, indicating that the disposition effect is weaker for more sophisticated investors. Furthermore, a regression analysis shows that capital gains indeed have a significant positive effect on the closing propensity, although economically, this effect seems to be small. I also examine the closing propensity curve, which follows a hump shape. The shape could possibly be explained by liquidity concerns, as generally higher absolute capital gains are in stock which are less liquid. Nonetheless, I do not find supporting evidence to support this explanation.

The observed keep-losers-close-winners behaviour, could also be explained by rational short sellers who trade on private information. Therefore, I examine how closing predicts future one week returns, depending on the amount of disposition effect behaviour an investor exhibits. However, the results do not indicate whether this behaviour is associated with more or less profitable closing decisions, as the results are not significant. Although, there is some significant evidence pointing in the direction that close-winners behaviour leads to less profitable closing decisions. Because of the non-significant results overall, it is hard to draw conclusions about the reason for the keep-losers-close-winners behaviour I observe. All in all, if short sellers in the U.K. are subject to the disposition effect, this seems to be to a limited extent.

The main limitation of this study is that by using short disclosures, it is hard to accurately measure closing, as positions only get disclosed once they pass a threshold. Recommendations for future research include to further examine the hump shape, categorise the investors, and use short sale disclosure data over a wide variety of countries in the European Union.

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# Appendix A

**Table A1. An overview of all variables.** All variables, except the date variables, used in this study are presented here. When 'stock price' is mentioned, it refers to the total return index from Thomson Reuters Datastream, which takes into account stock splits and dividends. Note that when calculating returns, only trading days are considered.

| Variable Name | Definition |
|---|---|
| Closing | Dummy variable, which takes on the value 1 for days when a short position is partially closed, and 0 otherwise. |
| Capital Gains (%) | $\frac{\text{Average Shorting Price - Current Stock Price}}{\text{Current Stock Price}} * 100\%$. |
| Ln(Market Value) | Natural logarithm of the Market Value of the shorted stock. |
| Ln(Revenue) | Natural logarithm of the Revenue in the previous book year of the shorted stock. |
| Price to Book Value | $(Market\ Capitalization)/(Book\ Value\ of\ Equity)$ . |
| Amihud Illiquidity | Percentage rank of quarterly means of Amihud Illiquidity. Amihud Illiquidity is calculated as $\frac{\lvert Daily\ Return \rvert}{Daily\ Dollar\ Volume}$. |
| Days Outstanding | Amount of days a SSP is open. |
| Past Return 1 Month (%) | $\frac{\text{Stock Price}_t - \text{Stock Price}_{t-22}}{\text{Stock Price}_{t-22}} * 100\%$. |
| Past Return 1 Year (%) | $\frac{\text{Stock Price}_t - \text{Stock Price}_{t-252}}{\text{Stock Price}_{t-252}} * 100\%$. |
| Past Return 3 Years (%) | $\frac{\text{Stock Price}_t - \text{Stock Price}_{t-756}}{\text{Stock Price}_{t-756}} * 100\%$. |
| Capital Gains Positive | Max(Capital Gains, 0). |
| Capital Gains Negative | Min(Capital Gains, 0). |
| Capital Gains Absolute | Abs(Capital Gains). |
| Dummy Amihud | Dummy variable, which is 1 if *Amihud Illiquidity* is higher than its median, and 0 otherwise. |
| Dummy Market Value | Dummy variable, which is 1 if *Market Value* is lower than its median, and 0 otherwise. |
| Investor Sensitivity | The daily mean, for each investor, of the regression coefficients for *Capital Gains*, when *Closing* is regressed on *Capital Gains* with a rolling window of 50 days. It aims to capture the amount of disposition effect behaviour an investors exhibits. |
| Investor Gain Sensitivity | The daily mean, for each investor, of the regression coefficients for *Capital Gains Positive*, when *Closing* is regressed on *Capital Gains Positive* with a rolling window of 50 days. |
| Investor Loss Sensitivity | The daily mean, for each investor, of the regression coefficients for *Capital Gains Negative*, when *Closing* is regressed on *Capital Gains Negative* with a rolling window of 50 days. |
| Future 1 Week Return (%) | $\frac{\text{Stock Price}_{t+5} - \text{Stock Price}_t}{\text{Stock Price}_t} * 100\%$. |
| Future 2 Week Return (%) | $\frac{\text{Stock Price}_{t+10} - \text{Stock Price}_t}{\text{Stock Price}_t} * 100\%$. |
| Future 3 Week Return (%) | $\frac{\text{Stock Price}_{t+15} - \text{Stock Price}_t}{\text{Stock Price}_t} * 100\%$. |
| Future 4 Week Return (%) | $\frac{\text{Stock Price}_{t+20} - \text{Stock Price}_t}{\text{Stock Price}_t} *100\%$. |

# Appendix B

**Table B1. Amihud Illiquidity regressed on the absolute value of capital gains**. This table shows the results of the linear regressions where *Amihud Illiquidity* is regressed on the absolute value of capital gains. Control variables are included in regression 4 and 5. Time, stock and investor effects are included in regression 3 and 5. In the first regression, the standard errors are not clustered, which explains the significance. In regression 2, 3, 4 and 5 the standard errors are clustered by year, stock and investor. The standard errors are shown between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Amihud Illiquidity | (2) Amihud Illiquidity | (3) Amihud Illiquidity | (4) Amihud Illiquidity | (5) Amihud Illiquidity |
|---|---|---|---|---|---|
| Capital Gains Absolute | 0.0240*** | 0.0240 | -0.00885** | 0.0160 | -0.00489 |
| | (0.000574) | (0.0159) | (0.00344) | (0.0133) | (0.00390) |
| Ln(Market Value) | | | | -7.056*** | -0.382 |
| | | | | (2.006) | (0.355) |
| Ln(Revenue) | | | | -1.704* | -0.575 |
| | | | | (1.007) | (0.660) |
| Price to Book Value | | | | -0.000420*** | -0.000185*** |
| | | | | (0.000105) | (4.59e-05) |
| Days Outstanding | | | | 0.00321 | -0.00134** |
| | | | | (0.00197) | (0.000612) |
| Past Return 1 Month (%) | | | | 0.0578 | -0.460 |
| | | | | (1.233) | (0.511) |
| Past Return 1 Years (%) | | | | -1.210 | 0.102 |
| | | | | (1.269) | (0.313) |
| Past Return 3 Years (%) | | | | 0.309 | -0.336 |
| | | | | (0.759) | (0.218) |
| Constant | 49.65*** | 49.65*** | 50.56*** | 123.6*** | 60.55*** |
| | (0.0280) | (3.995) | (0.0445) | (11.62) | (9.136) |
| Observations | 1,551,809 | 1,552,809 | 1,552,794 | 1,277,924 | 1,277,918 |
| R-squared | 0.001 | 0.001 | 0.697 | 0.136 | 0.702 |
| Fixed Effects | No | No | Yes | No | Yes |
| Clustered Standard Errors | No | Yes | Yes | Yes | Yes |

# Appendix C

**Table C1. How does closing predict two week future returns?** This table presents the regressions that test how well closing predicts stocks returns two weeks after closing. Furthermore, it examines how this effect is impacted by the amount of disposition effect behaviour the investor exhibits. Regression 2, 4 and 6 include time, stock and investor fixed effects. The standard errors are clustered by year, stock and investor and are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Future two week return (%) | (2) Future two week return (%) | (3) Future two week return (%) | (4) Future two week return (%) | (5) Future two week return (%) | (6) Future two week return (%) |
|---|---|---|---|---|---|---|
| Closing | 0.0299 | 0.0577 | 0.0218 | 0.0529 | -0.0104 | 0.0178 |
| | (0.117) | (0.0761) | (0.121) | (0.0768) | (0.137) | (0.0807) |
| Investor Sensitivity | | | -13.73 | 4.019 | -17.92 | 0.744 |
| | | | (14.42) | (6.431) | (16.89) | (6.539) |
| Close*Investor Sensitivity | | | -15.84 | 10.12 | -19.95 | -3.511 |
| | | | (21.92) | (16.30) | (29.49) | (19.84) |
| Capital Gains | | | | | 0.00189 | 0.00361 |
| | | | | | (0.00116) | (0.00222) |
| Ln(Market Value) | | | | | -0.132 | -1.264* |
| | | | | | (0.130) | (0.702) |
| Ln(Revenue) | | | | | 0.0657 | 0.297 |
| | | | | | (0.0585) | (0.359) |
| Price to Book Value | | | | | -2.42e-05 | -3.80e-05 |
| | | | | | (2.77e-05) | (2.37e-05) |
| Amihud Illiquidity | | | | | -0.00589*** | -0.000248 |
| | | | | | (0.00135) | (0.00132) |
| Days Outstanding | | | | | -2.30e-05 | 0.000181* |
| | | | | | (0.000102) | (9.71e-05) |
| Past Return 1 Month (%) | | | | | -1.887* | -2.435*** |
| | | | | | (1.040) | (0.702) |
| Past Return 1 Year (%) | | | | | 0.0259 | 0.256 |
| | | | | | (0.219) | (0.205) |
| Past Return 3 Years (%) | | | | | -0.0402 | -0.102 |
| Closing | | | | | (0.0625) | (0.110) |
| Constant | 0.114 | 0.114*** | 0.113 | 0.115*** | 0.586 | 5.430* |
| | (0.0982) | (0.000505) | (0.0987) | (0.000819) | (0.480) | (3.170) |
| Observations | 1,609,308 | 1,609,307 | 1,599,620 | 1,599,611 | 1,276,507 | 1,276,496 |
| R-squared | 0.000 | 0.180 | 0.000 | 0.180 | 0.002 | 0.239 |
| Time fixed effects | No | Yes | No | Yes | No | Yes |
| Stock fixed effects | No | Yes | No | Yes | No | Yes |
| Investor fixed effects | No | Yes | No | Yes | No | Yes |

**Table C2. How does closing predict three week future returns?** This table presents the regressions that test how well closing predicts stocks returns three weeks after closing. Furthermore, it examines how this effect is impacted by the amount of disposition effect behaviour the investor exhibits. Regression 2, 4 and 6 include time, stock and investor fixed effects. The standard errors are clustered by time, stock and investor and are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Future three week return (%) | (2) Future three week return (%) | (3) Future three week return (%) | (4) Future three week return (%) | (5) Future three week return (%) | (6) Future three week return (%) |
|---|---|---|---|---|---|---|
| Closing | 0.154 | 0.0787 | 0.148 | 0.0672 | 0.167 | 0.0597 |
| | (0.158) | (0.0915) | (0.161) | (0.0949) | (0.175) | (0.0913) |
| Investor Sensitivity | | | -10.89 | 6.644 | -16.68 | 1.386 |
| | | | (18.88) | (8.585) | (21.74) | (8.501) |
| Close*Investor Sensitivity | | | -0.0838 | 20.85 | -18.65 | -0.312 |
| | | | (28.26) | (18.65) | (35.04) | (23.10) |
| Capital Gains | | | | | 0.00254 | 0.00507 |
| | | | | | (0.00169) | (0.00326) |
| Ln(Market Value) | | | | | -0.214 | -1.927* |
| | | | | | (0.192) | (1.042) |
| Ln(Revenue) | | | | | 0.111 | 0.417 |
| | | | | | (0.0862) | (0.530) |
| Price to Book Value | | | | | -3.75e-05 | -6.33e-05* |
| | | | | | (3.98e-05) | (3.46e-05) |
| Amihud Illiquidity | | | | | -0.00842*** | -0.000183 |
| | | | | | (0.00195) | (0.00190) |
| Days Outstanding | | | | | -3.65e-05 | 0.000249* |
| | | | | | (0.000146) | (0.000141) |
| Past Return 1 Month (%) | | | | | -3.746** | -3.555*** |
| | | | | | (1.499) | (0.991) |
| Past Return 1 Year (%) | | | | | -0.000842 | 0.343 |
| | | | | | (0.323) | (0.304) |
| Past Return 3 Years (%) | | | | | -0.0556 | -0.121 |
| | | | | | (0.0914) | (0.162) |
| Constant | 0.178 | 0.180*** | 0.175 | 0.179*** | 0.816 | 8.767* |
| | (0.130) | (0.000372) | (0.131) | (0.00101) | (0.713) | (4.562) |
| Observations | 1,608,830 | 1,608,829 | 1,599,147 | 1,599,138 | 1,276,507 | 1,276,496 |
| R-squared | 0.000 | 0.198 | 0.000 | 0.198 | 0.003 | 0.256 |
| Time fixed effects | No | Yes | No | Yes | No | Yes |
| Stock fixed effects | No | Yes | No | Yes | No | Yes |
| Investor fixed effects | No | Yes | No | Yes | No | Yes |

**Table C3. How does closing predict four week future returns?** This table presents the regressions that test how well closing predicts stocks returns four weeks after closing. Furthermore, it examines how this effect is impacted by the amount of disposition effect behaviour the investor exhibits. Regression 2, 4 and 6 include time, stock and investor fixed effects. The standard errors are clustered by year, stock and investor and are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1) Future one month return (%) | (2) Future one month return (%) | (3) Future one month return (%) | (4) Future one month return (%) | (5) Future one month return (%) | (6) Future one month return (%) |
|---|---|---|---|---|---|---|
| Closing | 0.295 | 0.152 | 0.270 | 0.126 | 0.299 | 0.122 |
| | (0.200) | (0.109) | (0.203) | (0.113) | (0.218) | (0.115) |
| Investor Sensitivity | | | -2.593 | 10.48 | -5.810 | 5.778 |
| | | | (23.72) | (11.62) | (26.93) | (10.93) |
| Close*Investor Sensitivity | | | -6.880 | 12.89 | -28.96 | -14.91 |
| | | | (30.72) | (20.57) | (40.25) | (26.72) |
| Capital Gains | | | | | 0.00331 | 0.00682 |
| | | | | | (0.00225) | (0.00427) |
| Ln(Market Value) | | | | | -0.286 | -2.634* |
| | | | | | (0.249) | (1.368) |
| Ln(Revenue) | | | | | 0.155 | 0.501 |
| | | | | | (0.113) | (0.713) |
| Price to Book Value | | | | | -5.21e-05 | -9.64e-05** |
| | | | | | (5.25e-05) | (4.63e-05) |
| Amihud Illiquidity | | | | | -0.0109*** | -0.000170 |
| | | | | | (0.00258) | (0.00261) |
| Days Outstanding | | | | | -6.02e-05 | 0.000333* |
| | | | | | (0.000196) | (0.000190) |
| Past Return 1 Month (%) | | | | | -4.930*** | -4.644*** |
| | | | | | (1.482) | (1.105) |
| Past Return 1 Year (%) | | | | | -0.0178 | 0.451 |
| | | | | | (0.436) | (0.412) |
| Past Return 3 Years (%) | | | | | -0.0761 | -0.148 |
| | | | | | (0.125) | (0.216) |
| Constant | 0.250 | 0.253*** | 0.246 | 0.251*** | 0.987 | 12.97** |
| | (0.164) | (0.000294) | (0.165) | (0.00109) | (0.971) | (6.122) |
| Observations | 1,607,992 | 1,607,991 | 1,598,349 | 1,598,340 | 1,276,507 | 1,276,496 |
| R-squared | 0.000 | 0.158 | 0.000 | 0.158 | 0.004 | 0.263 |
| Time fixed effects | No | Yes | No | Yes | No | Yes |
| Stock fixed effects | No | Yes | No | Yes | No | Yes |
| Investor fixed effects | No | Yes | No | Yes | No | Yes |

# Appendix D

**Table D1. Is keep-losers-close-winners behaviour associated with more profitable closing decisions, when capital gains are split up in positive and negative gains?** This table contains the results of the regressions where *Future One Week Return* is regressed on, inter alia, the interaction terms *Closing * Investor Gain Sensitivity* and *Closing * Investor Loss Sensitivity*. Regression 3 and 4 include *Ln(Market Value), Ln(Revenue), Price to Book Value, Amihud Illiquidity, Days Outstanding, Past Return 1 Month, Past Return 1 Year, Past Return 3 years* as control variables. They are omitted for brevity. Regression 2 and 4 include time, stock and investor fixed effects. Standard errors are clustered by year, stock and investor. They are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1)<br>Future one week return (%) | (2)<br>Future one week return (%) | (3)<br>Future one week return (%) | (4)<br>Future one week return (%) |
|---|---|---|---|---|
| Closing | 0.0415 | 0.0551 | 0.0494 | 0.0514 |
| | (0.0961) | (0.0589) | (0.105) | (0.0570) |
| Investor Gain Sensitivity | 0.930 | 0.0462 | 0.209 | -0.312 |
| | (2.581) | (0.895) | (2.986) | (0.818) |
| Investor Loss Sensitivity | 1.182 | 0.169 | 0.301 | 0.00379 |
| | (1.428) | (0.833) | (1.306) | (0.798) |
| Closing * Investor Gain Sensitivity | -9.280** | -8.112** | -7.260* | -5.945* |
| | (4.286) | (3.452) | (4.221) | (3.254) |
| Closing * Investor Loss Sensitivity | 0.460 | 1.066 | 1.832 | 2.034 |
| | (3.147) | (2.712) | (3.509) | (3.071) |
| Ln(Market Value) | | | -0.0790 | -0.691* |
| | | | (0.0709) | (0.359) |
| Ln(Revenue) | | | 0.0338 | 0.145 |
| | | | (0.0315) | (0.196) |
| Price to Book Value | | | -1.01e-05 | -1.57e-05* |
| | | | (1.19e-05) | (9.51e-06) |
| Amihud Illiquidity | | | -0.00338*** | -0.000333 |
| | | | (0.000770) | (0.000646) |
| Days Outstanding | | | -3.33e-05 | 5.36e-05 |
| | | | (5.92e-05) | (3.73e-05) |
| Past Return 1 Month (%) | | | -1.073 | -1.460*** |
| | | | (0.928) | (0.466) |
| Past Return 1 Year (%) | | | -0.00982 | 0.0801 |
| | | | (0.116) | (0.121) |
| Past Return 3 Years (%) | | | -0.0384 | -0.0866 |
| | | | (0.0361) | (0.0697) |
| Constant | 0.0603 | 0.0591*** | 0.408 | 3.218* |
| | (0.0638) | (0.000624) | (0.258) | (1.688) |
| Observations | 1,605,968 | 1,605,958 | 1,308,754 | 1,308,747 |
| R-squared | 0.000 | 0.179 | 0.001 | 0.228 |
| Control Variables | No | No | Yes | Yes |
| Fixed effects | No | Yes | No | Yes |

**Table D2. Is keep-losers-close-winners behaviour associated with more profitable closing decisions, when capital gains are split up in positive and negative gains?** This table contains the results of the regressions where *Future Two Week Return* is regressed on, inter alia, the interaction terms *Closing * Investor Gain Sensitivity* and *Closing * Investor Loss Sensitivity*. Regression 3 and 4 include *Ln(Market Value), Ln(Revenue), Price to Book Value, Amihud Illiquidity, Days Outstanding, Past Return 1 Month, Past Return 1 Year, Past Return 3 years* as control variables. They are omitted for brevity. Regression 2 and 4 include time, stock and investor fixed effects. Standard errors are clustered by year, stock and investor. They are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1)<br>Future two week return (%) | (2)<br>Future two week return (%) | (3)<br>Future two week return (%) | (4)<br>Future two week return (%) |
|---|---|---|---|---|
| Closing | 0.0271 | 0.0605 | 0.0225 | 0.0481 |
| | (0.118) | (0.0766) | (0.134) | (0.0800) |
| Investor Gain Sensitivity | 6.003 | 0.0580 | 4.981 | -0.435 |
| | (5.427) | (1.710) | (6.107) | (1.385) |
| Investor Loss Sensitivity | 4.435** | 0.0623 | 2.783 | -0.418 |
| | (2.082) | (1.529) | (1.890) | (1.379) |
| Closing * Investor Gain Sensitivity | -7.896 | -5.576 | -6.782 | -4.803 |
| | (5.318) | (4.301) | (5.572) | (4.137) |
| Closing * Investor Loss Sensitivity | -2.084 | -0.119 | -1.235 | 1.401 |
| | (4.339) | (3.630) | (3.821) | (3.329) |
| Ln(Market Value) | | | -0.150 | -1.340* |
| | | | (0.131) | (0.685) |
| Ln(Revenue) | | | 0.0715 | 0.268 |
| | | | (0.0587) | (0.376) |
| Price to Book Value | | | -2.36e-05 | -3.78e-05 |
| | | | (2.74e-05) | (2.34e-05) |
| Amihud Illiquidity | | | -0.00577*** | -0.000396 |
| | | | (0.00135) | (0.00124) |
| Days Outstanding | | | -7.71e-05 | 9.35e-05 |
| | | | (0.000102) | (7.23e-05) |
| Past Return 1 Month (%) | | | -1.951* | -2.491*** |
| | | | (1.044) | (0.707) |
| Past Return 1 Year (%) | | | -0.0247 | 0.143 |
| | | | (0.210) | (0.231) |
| Past Return 3 Years (%) | | | -0.0726 | -0.160 |
| | | | (0.0660) | (0.133) |
| Constant | 0.121 | 0.116*** | 0.660 | 6.420** |
| | (0.0979) | (0.000743) | (0.466) | (3.119) |
| Observations | 1,605,756 | 1,605,746 | 1,308,754 | 1,308,747 |
| R-squared | 0.000 | 0.180 | 0.002 | 0.239 |
| Control Variables | No | No | Yes | Yes |
| Fixed effects | No | Yes | No | Yes |

**Table D3. Is keep-losers-close-winners behaviour associated with more profitable closing decisions, when capital gains are split up in positive and negative gains?** This table contains the results of the regressions where *Future Three Week Return* is regressed on, inter alia, the interaction terms *Closing * Investor Gain Sensitivity* and *Closing * Investor Loss Sensitivity*. Regression 3 and 4 include *Ln(Market Value), Ln(Revenue), Price to Book Value, Amihud Illiquidity, Days Outstanding, Past Return 1 Month, Past Return 1 Year, Past Return 3 years* as control variables. They are omitted for brevity. Regression 2 and 4 include time, stock and investor fixed effects. Standard errors are clustered by year, stock and investor. They are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1)<br>Future three week return (%) | (2)<br>Future three week return (%) | (3)<br>Future three week return (%) | (4)<br>Future three week return (%) |
|---|---|---|---|---|
| Closing | 0.151 | 0.0797 | 0.215 | 0.0969 |
| | (0.158) | (0.0925) | (0.179) | (0.0923) |
| Investor Gain Sensitivity | 10.56 | 0.484 | 8.924 | -0.615 |
| | (8.133) | (2.380) | (8.989) | (1.815) |
| Investor Loss Sensitivity | 3.121 | -0.404 | 1.328 | -1.161 |
| | (3.673) | (2.101) | (3.437) | (1.855) |
| Closing * Investor Gain Sensitivity | -6.314 | -6.887 | -5.979 | -7.024 |
| | (5.907) | (4.578) | (6.499) | (4.801) |
| Closing * Investor Loss Sensitivity | 0.962 | 0.0749 | 1.006 | 2.154 |
| | (5.587) | (4.815) | (5.237) | (4.605) |
| Ln(Market Value) | | | -0.240 | -2.038** |
| | | | (0.192) | (1.016) |
| Ln(Revenue) | | | 0.119 | 0.378 |
| | | | (0.0866) | (0.555) |
| Price to Book Value | | | -3.69e-05 | -6.29e-05* |
| | | | (3.94e-05) | (3.42e-05) |
| Amihud Illiquidity | | | -0.00834*** | -0.000416 |
| | | | (0.00194) | (0.00180) |
| Days Ooutstanding | | | -0.000107 | 0.000129 |
| | | | (0.000147) | (0.000105) |
| Past Return 1 Month (%) | | | -3.848** | -3.640*** |
| | | | (1.503) | (1.000) |
| Past Return 1 Year (%) | | | -0.0629 | 0.183 |
| | | | (0.306) | (0.342) |
| Past Return 3 Years (%) | | | -0.101 | -0.204 |
| | | | (0.0958) | (0.197) |
| Constant | 0.184 | 0.181*** | 0.924 | 10.19** |
| | (0.130) | (0.000889) | (0.689) | (4.475) |
| Observations | 1,605,278 | 1,605,268 | 1,308,754 | 1,308,747 |
| R-squared | 0.000 | 0.198 | 0.003 | 0.255 |
| Control Variables | No | No | Yes | Yes |
| Fixed effects | No | Yes | No | Yes |

**Table D4. Is keep-losers-close-winners behaviour associated with more profitable closing decisions, when capital gains are split up in positive and negative gains?** This table contains the results of the regressions where *Future Four Week Return* is regressed on, inter alia, the interaction terms *Closing * Investor Gain Sensitivity* and *Closing * Investor Loss Sensitivity*. Regression 3 and 4 include *Ln(Market Value), Ln(Revenue), Price to Book Value, Amihud Illiquidity, Days Outstanding, Past Return 1 Month, Past Return 1 Year, Past Return 3 years* as control variables. They are omitted for brevity. Regression 2 and 4 include time, stock and investor fixed effects. Standard errors are clustered by year, stock and investor. They are reported between brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

| VARIABLES | (1)<br>Future four week return (%) | (2)<br>Future four week return (%) | (3)<br>Future four week return (%) | (4)<br>Future four week return (%) |
|---|---|---|---|---|
| Closing | 0.285 | 0.152 | 0.351 | 0.167 |
| | (0.202) | (0.108) | (0.224) | (0.116) |
| Investor Gain Sensitivity | 14.86 | 1.598 | 13.42 | 0.534 |
| | (11.02) | (3.046) | (12.11) | (2.270) |
| Investor Loss Sensitivity | 4.999 | 0.248 | 3.579 | -1.341 |
| | (5.015) | (3.408) | (4.953) | (2.337) |
| Closing * Investor Gain Sensitivity | -9.804 | -9.701* | -10.69 | -11.40** |
| | (7.816) | (5.572) | (8.383) | (5.658) |
| Closing * Investor Loss Sensitivity | -1.902 | -2.236 | -2.895 | 0.902 |
| | (7.230) | (6.124) | (7.208) | (6.047) |
| Ln(Market Value) | | | -0.318 | -2.778** |
| | | | (0.250) | (1.333) |
| Ln(Revenue) | | | 0.163 | 0.441 |
| | | | (0.113) | (0.746) |
| Price to Book Value | | | -5.16e-05 | -9.56e-05** |
| | | | (5.21e-05) | (4.56e-05) |
| Amihud Illiquidity | | | -0.0108*** | -0.000460 |
| | | | (0.00254) | (0.00246) |
| Days Ooutstanding | | | -0.000155 | 0.000173 |
| | | | (0.000198) | (0.000143) |
| Past Return 1 Month (%) | | | -5.058*** | -4.749*** |
| | | | (1.486) | (1.122) |
| Past Return 1 Year (%) | | | -0.0936 | 0.236 |
| | | | (0.411) | (0.461) |
| Past Return 3 Years (%) | | | -0.135 | -0.261 |
| | | | (0.130) | (0.260) |
| Constant | 0.257 | 0.254*** | 1.140 | 14.92** |
| | (0.164) | (0.00135) | (0.939) | (6.010) |
| Observations | 1,604,470 | 1,604,460 | 1,308,754 | 1,308,747 |
| R-squared | 0.000 | 0.158 | 0.004 | 0.262 |
| Control Variables | No | No | Yes | Yes |
| Fixed effects | No | Yes | No | Yes |