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# MARKET IMPACT OF SHORT SALE POSITION DISCLOSURES

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## PREFACE

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A wide range of academic and policy research has demonstrated that short selling contributes to market liquidity, efficient asset price discovery, and helps to detect fraud at publicly traded companies. However, short selling is also regarded as controversial by some policy officials and stakeholders because short sellers benefit when prices decline. Accordingly, an important consideration for preserving the benefits of short selling for financial markets while addressing the concerns of sceptics is to assess the optimal regulatory and disclosure framework in which short selling can operate to balance these features.

This paper examines the impact of short sale disclosure rules in the European Union and United Kingdom that were implemented beginning in 2012. The rules require individual investors to publicly disclose short positions in shares of publicly listed companies where those positions are equal to or greater than 0.5 percent of issued share capital. The impact of the disclosure requirement has been examined in several economic research papers, including Jank, et al., employees from the German central bank<sup>1</sup> and European Securities and Markets Authority (ESMA)<sup>2</sup>. Notably, the United States has a different approach to short sale disclosure. In the United States, aggregate short interest in the market is required to be public, but individual investor disclosures are not publicly disclosed as they are in the EU and UK.

Against this backdrop, the Managed Funds Association has asked Copenhagen Economics to investigate the impact of the individual investor public disclosure requirement on financial markets, based on new data. Specifically, we were asked to:

- Investigate how the public disclosure requirement is expected to impact market functioning, based on previous research.
- Update empirical findings from previous research, e.g. studies from the European Securities and Markets Authority (ESMA) and the Deutsche Bundesbank.
- Contribute to the knowledge base with new estimations on short selling's impact on market efficiency, specifically in relation to the EU and UK rules on the individual investor public disclosure threshold.

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<sup>1</sup> Jank, S. et al. (2021). Flying under the radar: The effects of short-sale disclosure rules on investor behavior and stock prices.

<sup>2</sup> ESMA (2018). ESMA Report on Trends, Risks and Vulnerabilities.

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## EXECUTIVE SUMMARY

### Main econometric results

The EU and UK regulatory regimes require individual investors to disclose their short interest in a publicly listed company when the investor's net short interest equals or exceeds 0.5 percent of the public company's issued shares (hereafter referred to as the "individual public disclosure requirement"). Based on data from 2015-2020, covering around 73 percent of equity activity in the EU 27 equity markets, including France, Germany and Netherlands, we estimate the impact of the EU and UK short selling public disclosure requirement. These are our main results:

- **Consistent with earlier findings by the European Securities and Markets Authority (ESMA) and the German central bank (Bundesbank), our regression analysis reveals clear indications that public disclosures in the EU and UK cause herding behaviour, in which investors copy each other's short positions.** An investment manager's public disclosure of a short position, prompted by that position reaching or exceeding the 0.5 percent reporting threshold, increases the probability by 12 percent that another investor will subsequently exceed the threshold. While ESMA and the Bundesbank have previously described this effect, we expand on their research in our estimation by controlling for a range of factors to obtain the isolated effect of the public disclosure by individual investors.
- **Using a richer Danish data set allowed us to gain further confidence in our finding that individual public disclosure causes herding.** For the Danish market, we used data for non-publicly disclosed short interest (i.e. short positions between 0.2 percent and 0.49 percent of a company's share capital) to confirm that the herding we observe is a result of the public disclosure of short positions and not just an effect of multiple investors reacting to the same information.
- **Disclosure induced herding increases volatility.** Following a required public disclosure for a given stock, we find an increase in daily volatility of 1.5 percent. We find indications that the higher volatility is a result of an exaggerated downward price adjustment, as we find that a required public disclosure leads to a reduction in daily returns of 0.06 percent.

Short selling is an investment strategy used in financial markets that allows investors to profit from falling prices. When establishing a short position, an investor borrows a security (for example, a share of a company) from another market participant and then immediately sells the security. If the price of the security declines, the investor can buy it back at a cheaper price and return the security to the market participant who originally lent it out, earning a profit corresponding broadly to the difference between the prices at which it was initially sold and then subsequently repurchased.

It is well documented in economic research that short selling is an important mechanism for effective price discovery and therefore it is also beneficial for market efficiency. Short selling allows investors who believe an asset is overvalued to act upon this information, even if those investors do not already own the asset. As such, short selling facilitates the incorporation of all relevant information in the financial market. Short selling has also been shown to increase liquidity, reduce transaction costs, and detect fraud.

Despite the fact that economic research finds clear market benefits of short selling, it is sometimes a frowned upon aspect of financial market activity, possibly because short sellers profit from downward price adjustments.

Some regulatory jurisdictions, such as the European Union and the United Kingdom, have enacted special disclosure requirements for short positions that are more intrusive than the requirements for conventional long positions: investors in Europe are required to publicly disclose their position when they have a short position that equals or exceeds 0.5 percent of the issued share capital (in contrast, the threshold for a long position is usually 5 percent), and to privately disclose their position to regulators at 0.2 percent of the issued share capital.<sup>3</sup>

### **The individual public disclosure requirement impacts the behaviour of financial market participants**

Individual public disclosure requirements can be expected to influence market functioning, as investors in general, need to take account of the signals their public disclosure would send to other market participants, company executives, and regulators. As such, the disclosure requirement might affect an investor's decision to take a significant short position:

- *Without the public disclosure requirement*, the decision is simply: "Do I believe that the price of a certain company's stock is likely to decline."
- *With a public disclosure requirement*, an additional condition is added to the decision: "Do I want other investors or the shorted company's management to know that I believe that the price of the company's stock is likely to decline."

These are fundamentally two different decisions, where the latter question creates a disincentive for investors to build short positions to the extent they otherwise would.

### **Empirical studies show that investors avoid the individual public disclosure threshold**

Identifying the exact impact of the disclosure requirement on market efficiency is complex because market outcomes are the product of multiple inputs.

Nevertheless, there are reasons to believe that investors prefer not to disclose their short position in a way that is likely to distort their investment decisions: *First*, investors' short positions provide insight into their views on the stock's outlook, which they might be reluctant to "give away" to the market. *Second*, short sellers are vulnerable to the predatory trading strategy known as a "short squeeze". This occurs when other investors go long in a stock forcing the short sellers to unwind their trades by buying back the stock at a higher price than where they initially borrowed and sold it.

The avoidance of public disclosure has been well documented in studies by the European Securities and Markets Authority (ESMA)<sup>4</sup> and the Bundesbank<sup>5</sup>. Using non-public data on positions below

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<sup>3</sup> The United Kingdom recently lowered the private disclosure threshold to 0.1 percent.

<sup>4</sup> The paper studies net short position data between 1 January 2013 and 31 December 2016. See ESMA (2018). ESMA Report on Trends, Risks and Vulnerabilities.

<sup>5</sup> The paper studies short position disclosures between 1 November 2012 and 31 March 2015. See Jank, S. et al. (2021). Flying under the radar: The effects of short-sale disclosure rules on investor behaviour and stock prices.

the public disclosure threshold<sup>6</sup>, they find evidence of clustering, where investors tend to stop increasing their short positions to avoid breaching the 0.5 percent public disclosure threshold. In addition, they tend to hold this position just below the threshold longer than other positions, which have already been publicly disclosed or are not close to the disclosure threshold. ESMA and the Bundesbank find that this longer holding period below the threshold suggests a reluctance by individual investors to breach the public reporting threshold.

In preparing this report, we did not obtain as detailed data as covered by the previous ESMA and Bundesbank studies. However, we did obtain data on non-disclosed data for the Danish market, where we see indications that prior results hold, as there is more movement below the public disclosure threshold than above the threshold.

This impediment to shorting due to investor reluctance to cross the public disclosure threshold has consequences for market functioning. Given that shorting, in general, is beneficial for price discovery, a limitation on shorting is likely to impair price discovery and thus reduce market efficiency. This is supported by the study from Bundesbank, which finds that stock prices are, in general, more out of sync with fundamentals when the disclosure threshold is binding. This leads Bundesbank to conclude that “*the short-sale transparency regulation imposes negative externalities on stock market efficiency*”.<sup>7</sup>

### **The individual public disclosure requirement can lead to herding behaviour**

Another aspect that could impair market functioning is the possibility that the disclosure requirement causes herding behaviour.

Herding behaviour can be described as the process when some investors do not act on their own beliefs, but rather copycatting other market participants including those who are believed to be informed investors. In the case of shorting, herding can occur when investors short a given stock directly as a result of a disclosed short position by another investor. This type of behaviour has been found to exaggerate price adjustment and therefore reduce market efficiency while leading to higher market volatility.

Based on data covering the major European markets, from 2015-2021, we find that the public disclosure requirement indeed does seem to lead to herding behaviour. Concretely we find that if there has been a short interest public disclosure in a stock over the past four days, the probability of observing a new public disclosure for the given stock is around 12 percentage points higher than it otherwise would have been. In estimating this, we controlled for other factors that could influence correlated behaviour among market participants. The results remain statistically significant when controlling for market volatility, returns, and trading volume, as well as general market trends (specifically by including date and stock fixed effects).

We confirm these results using the Danish dataset, where we also observe total *non*-publicly disclosed short interest (above the 0.2 percent threshold). Obviously, investors cannot react to non-

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<sup>6</sup> EU and UK short sale regulations require investment firms to disclose to the national competent authority any position that exceeds 0.2 percent of issued share capital, and to continue reporting those positions when they exceed 0.3 and 0.4 percent. When the position reaches 0.5 percent or more it must be publicly disclosed.

<sup>7</sup> Jank, S. et al. (2021). Flying under the radar: The effects of short-sale disclosure rules on investor behavior and stock prices.

public short positions. Thus, we would expect to see a larger effect from a disclosure made publicly than from one that only goes to regulators if herding after short-interest disclosures exists. This is indeed what we find; the impact of changes in publicly disclosed shorts on total disclosed short interest is more than double the impact from changes in non-publicly disclosed shorts. However, there is still some reaction from non-disclosed data in the estimation, indicating that we do not perfectly control for the negative news.

Finally, we have investigated whether we can identify a direct link between the disclosure of short positions and increased market volatility. Given the wide range of factors that impact financial market volatility, we do not expect public disclosures to be the main driver, but nonetheless believe that implications from the disclosure requirement such as herding might contribute to greater volatility. We do in fact find a modest, but statistically significant increase in volatility from a disclosure filing when examining our European dataset, covering 2015-2020. Concretely, we find that a short interest disclosure for a given stock increases stock volatility by 1.5 percent.

Summing up, in line with academic papers, as well as research papers by major European economic institutions, we have empirically identified that public disclosure of short selling is likely to impair price discovery for two main reasons: 1) it deters informed investors from shorting assets, thereby withholding information from the price discovery process and 2) it leads to herding behaviour, which is associated with a risk of exaggerated price adjustments and therefore higher volatility.

## CHAPTER 1

**EXISTING EMPIRICAL FINDINGS ON SHORT SELLING AND PUBLIC DISCLOSURE**

Short selling has historically been a debated practice, in part because of the negative outlook of short sellers, which is at odds with the incentives of most other investors and company leadership to see asset prices rise. Short selling has been subject to regulatory obstacles in different countries. For instance, the EU and UK require individual investors who are shorting to disclose, sometimes publicly, their positions. In this chapter, we describe the fundamental mechanisms of short selling, analyse its impact on market efficiency and assess the implications of an individual investor public disclosure threshold.

In section 1.1 we review existing literature that assesses how short selling impacts market efficiency. In section 1.2 we introduce different categories of investors using short positions and in section 1.3 we explain how the disclosure requirement for individual investors might impact investment strategies and thus market outcomes. Section 1.4 describes why investors are hesitant to cross the public disclosure threshold and discuss findings from empirical studies. In section 1.5 we discuss how the individual public disclosure requirement can result in herding behaviour, and finally in section 1.6 we discuss the EU and UK individual public disclosure requirement's implication for market outcome.

**1.1 SHORT SELLING'S IMPACT ON MARKET EFFICIENCY**

Markets are efficient when prices fully reflect all available and relevant information. Efficient markets lead to an efficient allocation of capital and reduce excessive price fluctuations.

Short selling is an investment strategy used in financial markets that enables investors to express a negative view on an asset or express a view that an asset relative to other similar assets may be mispriced. It is used by investors who expect a fall in prices or as part of larger risk management, hedging and market-making strategies.

When an investor takes a short position the investor borrows the asset at the current market price, from a broker or another entity that owns the asset, and immediately sells the asset with the expectation that the price of the asset will decline in the future. The investor later closes the short position by repurchasing the asset and returning it to the entity from which it was initially borrowed. If the investor manages to buy the borrowed asset back at a price lower than it was originally sold for, the investor makes a profit equal to the difference between the two prices. In this way the short selling strategy can be summarised as *“selling high then buying low.”*

Short selling is an important contributor to market efficiency because it improves price discovery and helps ensure that all information, in particular negative information, is incorporated into market prices.

### 1.1.1 Short selling improves price discovery

It is widely established within economic literature, that short selling is an important contributor to price discovery in financial markets as it is a mechanism that helps to prevent overpricing.<sup>8</sup>

Price discovery is the process of reaching the equilibrium price for an asset at which buying and selling pressures are balanced. Market prices continuously adjust to account for changes in supply and demand, which are often driven by market news and shifting expectations. When market prices fully incorporate and reflect all investors' views, there is pricing efficiency in the market. Thus, the more views reflected in market prices, the more fully prices will reflect all available information and the more pricing efficiency there is in the market.

Short sellers contribute to this price discovery by increasing the range of views that can be expressed in the market. Through the combination of long and short positions, market participants are able to express both optimistic and pessimistic views about the value of an asset. For example, when investors believe an asset is undervalued, they take a long position, i.e. buy the asset. When many investors share the same belief and go long in the asset the market price increases. On the other hand, when investors believe an asset is overvalued, they want to sell the asset to reflect their view that the price should be lower.

As such, the possibility of taking a short position allows investors that do not already own an asset to participate in price discovery when they believe an asset is overvalued. Therefore, short selling ensures that more market participants can contribute to price discovery, increasing price efficiency.

The fact that short selling contributes to price discovery and market efficiency is backed up by academic research:<sup>9</sup>

- For example, one academic study<sup>10</sup> analysed daily short data in the United States over six months in 2007 and found that **when short sellers are more active, relevant information, such as earnings releases, are incorporated faster into market prices.**<sup>11</sup> They found that this is most pronounced for negative information, which is consistent with the understanding that short selling supports downward price adjustments.
- The same study found that **short sellers are informed traders** that seem to recognize temporary price changes. The study assessed how investors reacted when prices changed significantly and then subsequently reversed in a brief period of time. They found that short activity did not increase when these temporary price changes took place.
- A study from 2013<sup>12</sup> assessed short selling's impact on market efficiency by examining the impact of different market bans on short selling from around the world during the 2007-2009 crisis. Since countries implemented bans on short selling to varying degrees and at different times, this study could identify how the bans affected the market. The study

<sup>8</sup> Jiang, H., Habib, A. & Hasan, M. M. (2020). Short selling: A review of the literature and implications for future research.

<sup>9</sup> For example, see Dechow, P.M., Hutton, A.P., Meulbroek, L. & Sloan, R.G. (2001) Short-sellers, fundamental analysis, and stock returns.; Boehmer, E., Jones, C.M. & Zhang, X. (2008) Which shorts are informed?; Diether, K.B., Lee, K.H. & Werner, I.M. (2009) Short-sale strategies and return predictability.; Saffi, P.A. & Sigurdsson, K. (2011) Price efficiency and short selling.

<sup>10</sup> Boehmer, E. & Wu, J. (2013) Short selling and the price discovery process.

<sup>11</sup> This is assessed by measuring how closely transaction prices move relative to a random walk while incorporated daily frequency.

<sup>12</sup> The speed of incorporation is assessed by comparing autocorrelations during the short selling ban to autocorrelations outside of the ban period. Beber, A. & Pagano, M. (2013) Short-selling bans around the world: Evidence from the 2007-09 crisis.

found that when countries implemented bans on short selling, **negative information was not transferred into market prices as quickly** as it was in countries that did not have a ban on short selling.<sup>13</sup>

Another way of looking at short selling's impact on price discovery, is to recognize that short selling puts downward pressure on the prices of overvalued assets, lessening the odds that bubbles will grow. There are several recent examples when overvaluation and fraud were revealed through increases in short sales. For example, short sellers contributed to exposing Wirecard's accounting fraud in 2020 see Box 1.

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<sup>13</sup> See also Bris, A., Goetzmann, W.N. & Zhu, N. (2007) Efficiency and the bear: Short sales and markets around the world, where they use cross-autocorrelation between lagged market return and individual stock returns to measure speed of information being incorporated into prices.

**Box 1 Wirecard case: Short sellers identify an overvalued asset**

In June 2020, Wirecard, a German payment processor and financial services provider, filed for insolvency after admitting that almost €2 billion in cash was “missing”. The accounting fraud that eventually led to the €24 billion fintech’s demise was predicted by many investors who had short positions against the company several years earlier, as early as 2015.

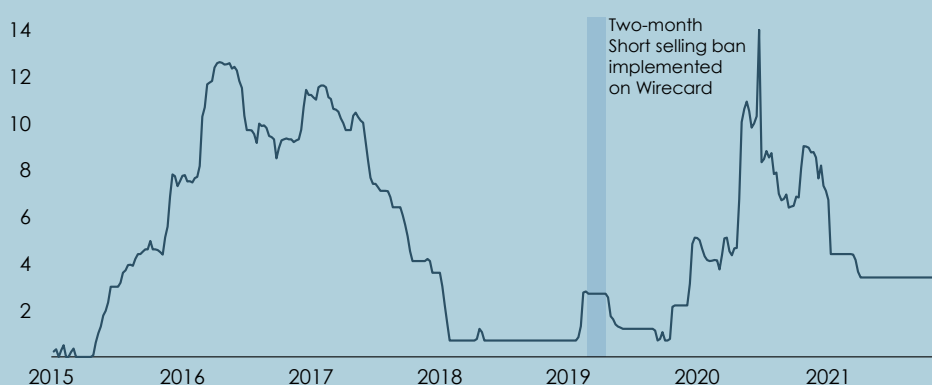
The investors who shorted Wirecard were frequently derided for their insistence that the financial statements and the value of the company’s investment did not add up. Wirecard claimed that the decline in its stock price was unfounded and the result of a deliberate attack by investors and journalists. The German federal financial supervisory authority, BaFin, agreed with Wirecard and in February 2019 short sellers and journalists were criminally investigated by Germany. In addition, BaFin issued a short selling ban for Wirecard stock after shorts caused a steep decline in Wirecard’s share price.

Anecdotal evidence from interviews with hedge funds revealed that many funds that were short Wirecard before the ban were reluctant to cross the public disclosure threshold of 0.5 percent. This reluctance is consistent with the thesis that a public disclosure threshold imposed on individual investors suppresses price discovery and impedes market efficiency.

It is clear after the company’s bankruptcy filings that those hedge funds and other investors who were short Wirecard were able to accurately identify that the company was overvalued. Short selling was ultimately an important contributor in revealing that Wirecard was committing fraud, in spite of counter regulatory pressure. Unfortunately, in the case of Wirecard, policy-makers’ decision to constrain short sellers meant that Wirecard’s fraud was permitted to continue for longer. The constraints on short sellers likely contributed to billions of euros of unnecessary losses for European investors in Wirecard.

**Wirecard short interest, 2015 – 2021**

Disclosed short interest, percent of outstanding shares (%)



Note: We assume that a position holder’s position size is unchanged until we see a record in the data saying otherwise. The figure also reflects seven-day means.

Source: Copenhagen Economics based on data from German Bundesanzeiger

Source: The Economist (2020) Wirecard’s scandal shows the benefits of short sellers, <https://www.economist.com/leaders/2020/06/24/wirecards-scandal-shows-the-benefits-of-short-sellers>; Reuters (2021) The ex-convict’s tale: Germany’s role in Wirecard scandal under microscope, <https://www.reuters.com/business/finance/ex-convicts-tale-germanys-role-wirecard-scandal-under-microscope-2021-04-23/>; Financial Times, Inside Wirecard, <https://www.ft.com/wirecard>

## 1.2 DIFFERENT STYLES OF SHORT SELLING HAVE DISTINCT IMPACTS ON MARKET OUTCOME

For the purpose of this study, it is relevant to examine the varying motivations of short investors. On a high level, we observe two distinct types:

### 1) *Discretionary investors*

These investors establish short positions because they have the fundamental view that a specific stock is overvalued and its price will decline. Discretionary investors have usually done company-specific fundamental market research and analysis which informs their decision to take a short position.

### 2) *Systematic investors*

This group comprises investors that may short securities as part of a more general strategy and not necessarily because they believe a specific asset is overvalued relative to fundamentals. This may, for example, be an investor who uses short positions to hedge risk from other long positions. In these strategies, short positions often help to finance long positions in other companies—adding more liquidity to the market.<sup>14</sup>

We expect the trade patterns of the two investment styles to differ. With discretionary investors we expect to see discrete jumps in short positions, when they decide to act on their fundamental analysis. With systematic investors, who often use algorithms as an input to their market activities, we are likely to see a more continuous change as they update their short positions to match their desired portfolio balance.

When discussing the avoidance of the individual public disclosure threshold in this paper, we will primarily focus on *discretionary investors*, as the disclosure threshold is more likely to impact their investment strategy.<sup>15</sup>

## 1.3 THE INDIVIDUAL PUBLIC DISCLOSURE REQUIREMENT IMPACT ON SHORT SELLING

In 2012, the European Commission and the European Securities and Markets Authority (ESMA) implemented regulations on short selling<sup>16</sup> which, among other requirements, introduced the obligation for investment fund managers to publicly disclose net short positions above certain thresholds to the relevant governmental authorities.

Currently, investors with a short position equivalent to at least 0.2 percent of the issued share capital must report their position to the regulatory authorities.<sup>17</sup> If those positions exceed 0.5 percent of

<sup>14</sup> See for example Committee on capital markets regulation (2018); Diether, K.B., et al. (2009); and Evans et al. (2009).

<sup>15</sup> Systematic investors may still be impacted by the disclosure requirement due to the cost and compliance burden related to reporting or due to public-image and reputational impacts, discussed in section 1.4.

<sup>16</sup> See Regulation (EU) No 236/2012 Of The European Parliament And Of The Council of 14 March 2012 on short selling and certain aspects of credit default swap (2012) OJ L86/1.

<sup>17</sup> From 16 March 2020, ESMA lowered the disclosure threshold to 0.1% of the issued share of capital to improve monitoring activity during the period of unusual selling activity and market volatility resulting from the COVID-19 pandemic. ESMA has since issued an opinion to permanently maintain the lower threshold at 0.1% of the issued share of capital. See ESMA (2021) Opinion for the adjustment of the threshold for the notification of net short positions in shares set out in Article 5(2) of Regulation (EU) No 236/2012 [https://www.esma.europa.eu/sites/default/files/library/esma70-156-4262\\_opinion\\_for\\_the\\_adjustment\\_of\\_the\\_threshold\\_set\\_out\\_in\\_article\\_52\\_of\\_ssr\\_o.pdf](https://www.esma.europa.eu/sites/default/files/library/esma70-156-4262_opinion_for_the_adjustment_of_the_threshold_set_out_in_article_52_of_ssr_o.pdf)

the total issued capital, they are publicly released. Subsequently, investors must also report changes in their short position for every additional 0.1 percent of the issued share of capital.

Note that for long positions, the public disclosure requirement in EU member states is much higher; in many this threshold is set at 5 percent of shareholding.<sup>18</sup>

In general, the investment fund manager disclosure requirement can be expected to impact the behaviour of these financial market participants. As described above, financial market participants can be expected to include all relevant available information in their market decision making. Disclosed short positions can be very informative as they reveal beliefs that a certain stock is overvalued.

Intuitively, this could have two implications:

1. *The Price Discovery Problem:* Investors might be *reluctant to cross the disclosure threshold*, because they, for various reasons, do not want other participants or company management to find out that they believe a certain stock is overvalued. This could lead to less shorting, which in turn will impair market efficiency due to short selling's beneficial contribution to price discovery.
2. *The Herding Problem:* Investors might act on the information that other investors have taken a short position (and thus believe that a certain stock overvalued), which could lead to *herding behaviour* in the financial markets.

As we will outline in the following two sections, both implications have been found to hold true when tested empirically.

## 1.4 REASONS INVESTORS ARE RELUCTANT TO CROSS DISCLOSURE THRESHOLDS

For different reasons, investors might be reluctant to reveal their negative view and therefore prefer to stay below the public disclosure threshold. With a disclosure requirement, an investor's decision to take a substantial short position becomes two-fold: 1) Do I believe that the stock is overvalued? and 2) Do I want to publicly reveal that I believe that the stock is overvalued?

In this way, the disclosure requirement can put a lid on short selling when investors want to short a stock (satisfying condition 1), but for various reasons do not want to reveal their views (not satisfying condition 2).

Financial market strategies are highly complex and there are many reasons why investors do not want to reveal their views to the market, including their short position. On a high level, we can categorise three reasons for the hesitancy to cross the public threshold:

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<sup>18</sup> Some countries such as PT, NL, ES, AT, CZ, DE, IE, and IT have public disclosure thresholds lower than 5% of shareholding, but no thresholds are smaller than 1% of shareholding. See ESMA (2021) Practical Guide National rules on notifications of major holdings under the Transparency Directive [https://www.esma.europa.eu/sites/default/files/library/practical\\_guide\\_major\\_holdings\\_notifications\\_under\\_transparency\\_directive.pdf](https://www.esma.europa.eu/sites/default/files/library/practical_guide_major_holdings_notifications_under_transparency_directive.pdf).

*Intellectual property*

Investors' short positions provide insight into their views on the market outlook, just as investors' long positions can be revealing. Investors might be reluctant to give this information to others in the market for free.

Many investors spend significant time developing proprietary models which incorporate a wide range of relevant information, e.g. a combination of market information, financials, and macro indicators, to assess the value of a company. When their models and market knowledge suggest that an asset is over- or undervalued, they take the respective short or long position to express these views in the market. Since financial markets are very competitive, investors often do not want to reveal their research by publicly announcing their position, both because doing so can make it more expensive to build their desired position and because it can allow others to decipher their investment process.

Similarly, investors may also be hesitant to reveal their general strategies, i.e. how they combine different positions to hedge their risk or which sectors their portfolio is focusing on.

*Short positions can be vulnerable to squeezes*

With a long position, losses are limited to the amount of the investment, but with a short position, there is in theory no upper bound for the potential loss.

This can make short investors vulnerable a trading strategy<sup>19</sup> known as a "short squeeze". When it becomes known to market players that a stock has been significantly shorted, they can put pressure on the short positions by going long and buying shares of the stock. This increases the price of the asset, which ultimately results in short sellers having to post additional cash margin,<sup>20</sup> or close out their position. The closing of short interest further increases the price of the asset, possibly forcing other short investors to cover their position, thereby benefitting the squeezers. Introducing a public disclosure of short positions could, at least in theory, lead to short squeezes becoming more common.

This mechanism bears some resemblance to the recent GameStop case. Many hedge funds regarded GameStop stock as being overvalued, believing that the company's brick-and-mortar retail strategy for video game and console sales was archaic, see Figure 1. When these short positions became known to individual investors,<sup>21</sup> particularly those who valued GameStop (perhaps for nostalgic reasons), they used social media to encourage purchases of GameStop shares to squeeze out the shorts. The rush to invest in GameStop coupled with the rush by short sellers to close out their positions likely resulted in the price of GameStop increasing from under \$20 per share to almost \$350 per share over the course of just 15 days.

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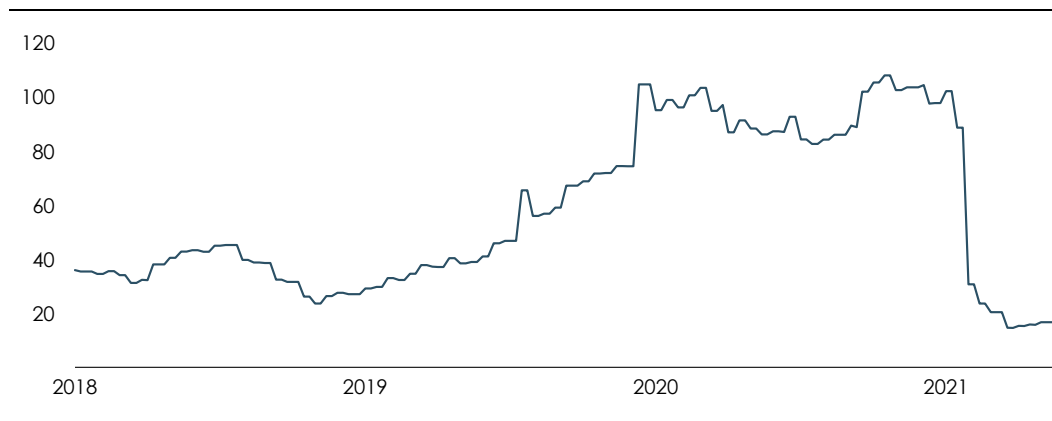
<sup>19</sup> Brunnermeier, M.K. & Pedersen, L.H. (2005). Predatory trading.

<sup>20</sup> Since short selling involves borrowing an asset and the risk associated with short selling is infinite, short selling requires investors to post a margin to ensure that the borrowed asset is eventually returned. In the US the initial margin is 150% of the value of the short sale. When the price of the borrowed asset increases the investor is required to post additional margin.

<sup>21</sup> Although the United States does not require individual investors to make public disclosures of short selling, some market participants were able to assume that a few hedge funds were holding large short positions against GameStop based on options market data reported in Form 13F.

**Figure 1**  
**GameStop short interest, 2018-2021**

Short interest, percent of outstanding shares (%)



Source: Data on short interest for the stocks in S&P 500 from Refinitiv Eikon

#### *Reputational risk*

Finally, there can be reputational repercussions with conducting short selling. Short selling expresses a negative outlook on a company's value, which for various "non-financial market" reasons the investor might prefer to avoid. For example, the investor would want to avoid disclosing that they have a short position in companies with whom they have a business relationship. In other cases, simply the fact that short sellers profit from betting against a company can be seen as unsavoury.

#### **1.4.1 Empirical research confirms that investors are reluctant to cross public disclosure thresholds**

The literature on the impacts of existing short selling disclosure requirements shows that the disclosure requirement decreases the amount of short selling. In particular, investors (i) avoid the public disclosure threshold and (ii) stay longer below the threshold.

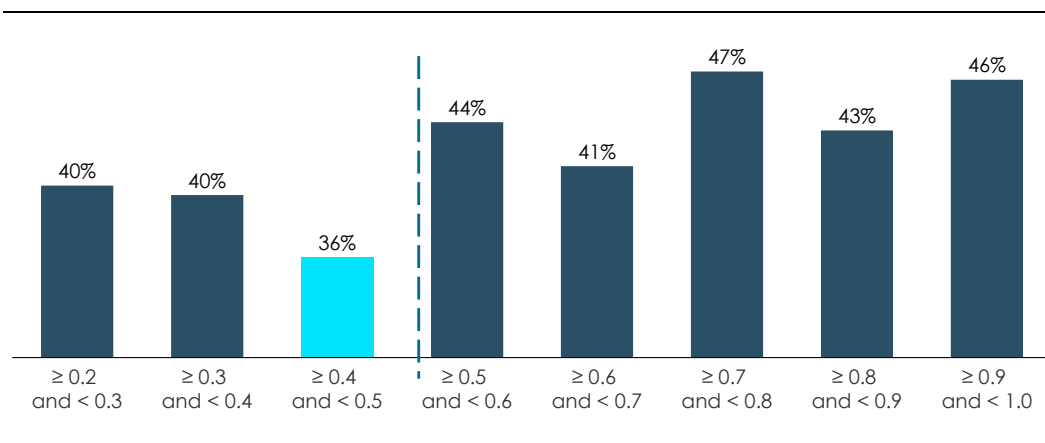
Several studies have found that disclosure requirements act as a constraint on investors' shorting strategies, which ultimately has a negative effect on price discovery.

A study from the German central bank, Deutsche Bundesbank, from 2016,<sup>22</sup> assessed the likelihood of investors avoiding the disclosure threshold based on data from Germany between 2012 and 2015. The researchers received access to unique data on the positions that were disclosed to regulators but not the broader public (between 0.2 percent-0.49 percent of issued share of capital), allowing them to analyse how/if investors avoided the threshold. They found that positions in the "bin" just below the disclosure threshold, i.e. short positions between 0.4 percent and 0.5 percent, had the lowest probability of increasing. Specifically, this bin was 34 percent less likely to see positions increase than the positions in the bins above it.

<sup>22</sup> Jank, S. et al. (2021). Flying under the radar: The effects of short-sale disclosure rules on investor behavior and stock prices.

Similarly, a 2018 study from ESMA<sup>23</sup> found that the positions within the bin just below the disclosure threshold were the least likely to increase; only 36 percent of positions in this bin increased their net short position, which was the lowest of all bins, see Figure 2.

**Figure 2**  
**Probability that investors will increase their position**  
Frequency (%) of net short position increases



Note: The dotted line represents the public disclosure threshold. Frequency of net short position increases in EU shares from 01/01/2013 to 31/12/2016, grouped in 0.1 percent increments (in percent of issued share capital, based on the previous reporting bin)

Source: ESMA (2018). ESMA Report on Trends, Risks and Vulnerabilities.

In addition to avoiding the threshold, these two studies also found that positions in the bin just below the disclosure threshold also remain unchanged for a significantly longer time than other bins. That is, investors might move around between the different bins below the threshold, but once they reach the bin just below 0.5 percent public threshold, they tend to stay put to a larger degree than positions in other bins do.<sup>24</sup>

## 1.5 THE INDIVIDUAL PUBLIC DISCLOSURE REQUIREMENT CAN LEAD TO HERDING BEHAVIOUR

There is an additional channel through which the disclosure requirement can impair market outcome: via encouraging herding behaviour.

In general, herding behaviour occurs when investors accumulate similar positions. This can occur when some investors make decisions by copy-cattling decisions previously made by other investors who are believed to be informed.<sup>25</sup> Even if the original position was justified, subsequent investors, who do not have access to the underlying analysis, may continue to short even when the price reaches the initial investor's target, thereby overshooting the fundamentally justified price

<sup>23</sup> ESMA (2018). ESMA Report on Trends, Risks and Vulnerabilities.

<sup>24</sup> Concretely, the Deutsche Bundesbank study was able to split their sample into positions that were at their record maximum position, i.e. when an individual's short position was the largest, or below their record maximum. This allowed them to identify that the longer duration in the bin just below the threshold was driven by the positions that will never cross the threshold.

<sup>25</sup> Banerjee, A. (1992) A simple model of herd behavior.

adjustment. This will contribute to price volatility as investors will then reassess the overstated price of the asset and adjust their investment to reflect their view.

This increased volatility due to herd behaviour has been confirmed empirically. For example, a study of Spanish stocks in 2012<sup>26</sup> assessed historical and realised volatility and found that higher volatility can be expected when there is a greater herding intensity.<sup>27</sup>

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Herding traders either add momentum to price changes or cause prices to overshoot the fundamental price, resulting in more volatile, perhaps, less informative prices.

Source: Blasco, N., Corredor, P., & Ferreruela, S. (2012). Does herding affect volatility? Implications for the Spanish stock market.

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The same can happen with short selling. Some investors might use disclosed positions as a model for their own investment strategy. Concretely, in terms of short selling, herding can take several forms, including:

- **Copycat investing:** Copycat investing occurs when an investor copies the position of another investor who they believe is well informed. While shorting in general leads to efficient pricing, this copycat investing has been found to exaggerate price movements, leading to an inferior market outcome.
- **Systematic copycat investing:** Systematic investors might also contribute to herd behaviour due to the specifications of the algorithm they use to determine their position on the market. If these algorithms incorporate information about public disclosures into their decision to short, then public disclosures will cause herding. This type of herding is mostly relevant for systematic investors.
- **Anticipation that systematic positions will continue to grow:** Some market participants might expect large systematic investment funds to continue building short positions even after crossing the public disclosure threshold, and accordingly other market participants might attempt to get ahead of this development to make a profit by frontrunning.<sup>28</sup> Anticipatory trading occurs when an investor, investor A, believes that a particular trade from investor B is coming, which will likely affect prices. Then investor A attempts trades in anticipation of the price impact of B's trade to get ahead of this development to make a profit by frontrunning. This type of herding is relevant to both discretionary and systematic investors.

Economic research has identified herd behaviour related to the disclosure threshold in Europe:

- The ESMA study from 2018<sup>29</sup> found evidence that public disclosures were often followed by other public disclosures. Specifically, the study shows that the probability of a public

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<sup>26</sup> Blasco, N., Corredor, P., & Ferreruela, S. (2012) Does herding affect volatility? Implications for the Spanish stock market.

<sup>27</sup> See also Venezia, I., Nashikkar, A. J., & Shapira, Z. (2009) Herding in trading by amateur and professional investors.

<sup>28</sup> Since short positions impact the stock price negatively, publicly disclosing short positions might also lead to anticipatory trading when investors identify short positions and subsequently take out a larger short position to "get ahead".

<sup>29</sup> ESMA (2018). ESMA Report on Trends, Risks and Vulnerabilities.

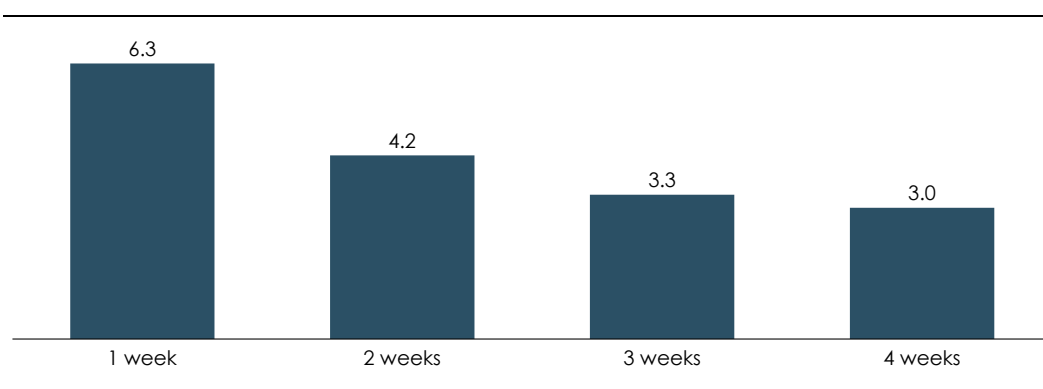
disclosure is six times higher if another public disclosure on the same stock has taken place in the last week, see Figure 3.

- An academic study from 2016<sup>30</sup> also found that disclosures led to additional disclosures. The study found that the probability of disclosure increased from a baseline probability of 0.08 percent to 0.24 percent if there was a disclosure in the same stock in the last week.

**Figure 3**

**Previous disclosures increase the likelihood of future disclosures**

Odds ratio of a new public disclosure following a previous disclosure in the week(s) prior



Note: Odds ratios are from a logit regression, where the dependent variable is a dummy variable indicating whether a position is public or not, and the explanatory variables are lagged dummy variables indicating whether a short position disclosure has taken place in the last one, two, three or four weeks. All estimates statistically significant at the 1 percent level. Source: ESMA

Source: ESMA (2018). ESMA Report on Trends, Risks and Vulnerabilities.

## 1.6 THE INDIVIDUAL PUBLIC DISCLOSURE REQUIREMENT IMPLICATIONS FOR MARKET OUTCOMES

As described above, the EU and UK public disclosure threshold imposed on individual investment firms has been found to have negative implications for market outcomes through two channels; (i) it reduces the amount of short selling taking place, impairing market efficiency, due to short selling's beneficial impact on price discovery and (ii) it leads to herding behaviour, with the risk of exaggerating price adjustments.

In addition to documenting the two channels, the direct negative implications of the short selling disclosure requirement have also been confirmed by economic research:

- An academic study from 2014<sup>31</sup> found that prices were less informative following the introduction of a public disclosure threshold in Japan by examining the return predictability of shorts. They found that prices became less informative because of a change in short sellers' strategies, which resulted in short sellers shifting to smaller, and more risky stocks.
- The study from Deutsche Bundesbank also recognises that the public disclosure requirement for investment funds restricts "a large fraction of investors" in taking short position, which they find to impair price discovery. This leads to their conclusion: "Overall, these

<sup>30</sup> Jones, C.M. et al. (2016) Revealing shorts: An examination of large short position disclosures.

<sup>31</sup> Duong, T.X. et al. (2015). The costs and benefits of short sale disclosure.

*findings suggest that the investors' reluctant behaviour in response to the short-sale transparency regulation imposes negative externalities on stock market efficiency.*<sup>32</sup>

- Similarly, the 2018 ESMA study also identified that investors are reluctant to cross the public disclosure threshold, and furthermore, that the public disclosure requirement contributes to herd behaviour.

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<sup>32</sup> Jank, S. et al. (2021). Flying under the radar: The effects of short-sale disclosure rules on investor behavior and stock prices.

## CHAPTER 2

**NEW EMPIRICAL FINDINGS**

In the previous chapter, we demonstrated that constraints on short selling can lead to adverse market outcomes, based on existing research. We reviewed studies that focused on the European short selling disclosure requirement and its implementation in 2012. In this chapter, we 1) explore whether these results still hold based on recent data through the coronavirus pandemic crisis and 2) investigate the impact of public disclosures by individual investment firms on market indicators such as asset returns and volatility.

Based on data from the recent COVID-19 crisis, in line with previous research, we see indications that the public disclosure requirement causes investors to avoid taking short positions. Furthermore, we find evidence that the public disclosure requirement leads to herding behaviour, with an associated risk of exaggerated price adjustments and therefore higher market volatility.

In section 2.1 we present our descriptive statistics confirming the prior results from Chapter 1 that investors avoid public disclosure. In section 2.2 we present evidence that the disclosure requirement leads to herding behaviour and in section 2.3 we present our findings that this herding behaviour has implications for volatility. Finally, in section 2.4, we conclude and summarize our empirical contribution.

**2.1 ARE INVESTORS AVOIDING THE DISCLOSURE REQUIREMENT IN THE EU?**

The studies by ESMA and the Bundesbank investigating the impact of the public disclosure threshold outlined in Chapter 1 relied on short position data that included data points both above and below the public disclosure threshold. This data allowed the researchers to clearly document that investors were reluctant to cross the threshold.

In the preparation of this study, we did not have access to similar data on short positions below the EU's public disclosure threshold and we are therefore not able to replicate the results. Instead, taking a different approach, we set out to explore whether we see indications that investors avoid breaching the disclosure threshold, based on recent data from the COVID-19 crisis. In addition, we use data from Denmark, which includes non-publicly disclosed short positions,<sup>33</sup> to confirm our findings at the European level.

**2.1.1 Investors in Europe bound by the threshold were less likely to react to the coronavirus pandemic crisis**

As a starting point, it is instructive to compare investment strategies in Europe with those in the United States in order to understand how investors react to the public disclosure threshold in Europe. In the United States, aggregate short positions on for the entire market are known for publicly traded shares, but unlike in the EU and UK, in the US individual investment firms are not required

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<sup>33</sup> The Danish Supervisory Financial Authority (DSFA) also publishes daily information on the *total short interest* in each stock reported to the DSFA above the 0.2% issued share of capital threshold. Thus, the data does not include individual positions.

to disclose their short positions. Generally, the US has a more active market for short selling than in Europe, even after accounting for differences in market size.

We have chosen to use the COVID-19 pandemic as a case study for assessing short investments in Europe compared to the United States.

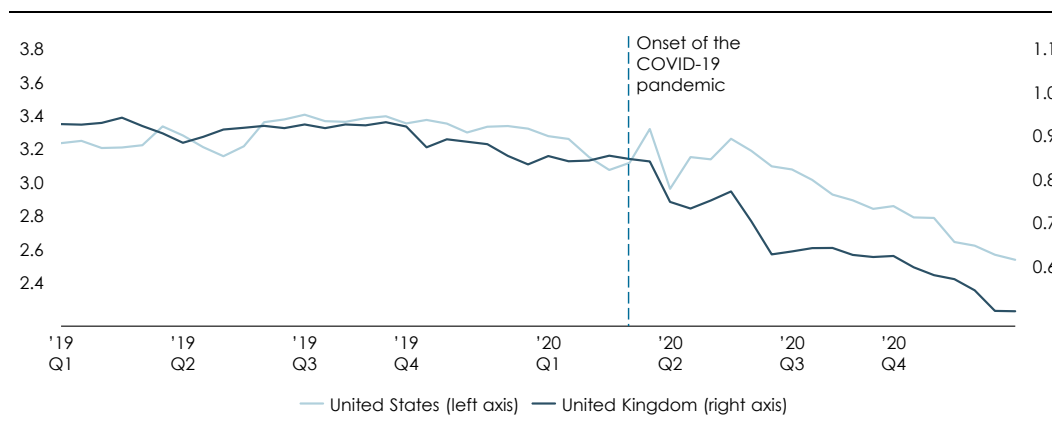
When we look at the total short interest in the United States and the total disclosed short interest in the United Kingdom since the pandemic, we see that there has been an overall decline in short interest in both jurisdictions.

However, a closer look reveals that there were opposing initial reactions to the COVID-19 shock in the US and UK. Although there is an overall declining trend, the lockdowns were initially followed by an increase in total short interest in the US. This suggests that investors in the US first believed that the crisis would have a negative impact on markets and took large short positions to reflect that belief.

This did not happen in the UK even though it is likely that investors also believed that the pandemic and the accompanying lockdowns would have the same negative impact on the market. While there are several reasons why these two markets reacted differently to the onset of the pandemic, this could indicate that the investment decisions in the UK were constrained by the disclosure threshold.

**Figure 4**  
**Total short interest in the US and UK, 2019-2020**

Short interest (%) in the US and in the UK



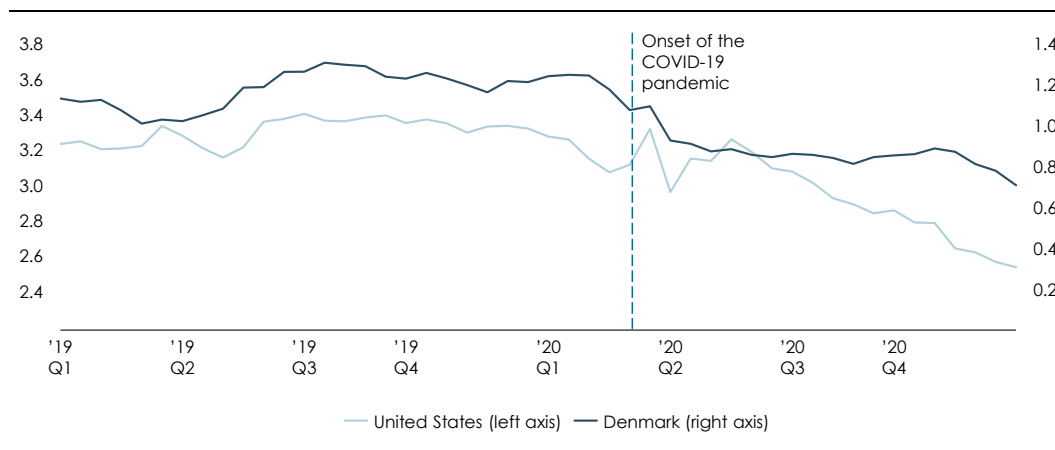
Note: The vertical line represents the onset of the COVID-19 pandemic.

Source: Copenhagen Economics based on data from Refinitiv Eikon and the Financial Conduct Authority (FCA)

The data for total short interest in Denmark (including non-disclosed short interest) points in the same direction: Just after the onset of the pandemic, there is a slight increase in total short interest in Denmark, see Figure 5. While the increase in total short interest is not as strong as it was in the US, this could be attributed to the fact that the increase in Denmark was driven by smaller nondisclosed positions rather than larger positions that would have required public disclosure. We do see that the large decline in short interest at the onset of the pandemic is driven by a large decrease in disclosed short interest.

**Figure 5**  
**Total Short interest in US and DK, 2019-2020**

Short interest (%) in the US and in DK



Note: The vertical line represents the onset of the COVID-19 pandemic.

Source: Copenhagen Economics based on data from the Danish Financial Supervisory Authority (DFSA) and data on short interest for the stocks in S&P 500 from Refinitiv Eikon

### 2.1.2 Smaller reaction in disclosed positions

As mentioned above, in Denmark we have data on short interest for positions that are disclosed to regulators, but not publicly, i.e. positions that are between 0.2 percent - 0.49 percent of the issued share capital. This window into activity below the public disclosure threshold allows us to analyse if there are indications that investors avoided the public threshold, as was seen in previous studies.

We look at how positions below and above the public disclosure thresholds contribute to movements in total short interest in Denmark. On days when the market for shorting is active we would expect that activity levels would be similar above and below the threshold as investors with all positions react to the same relevant information.

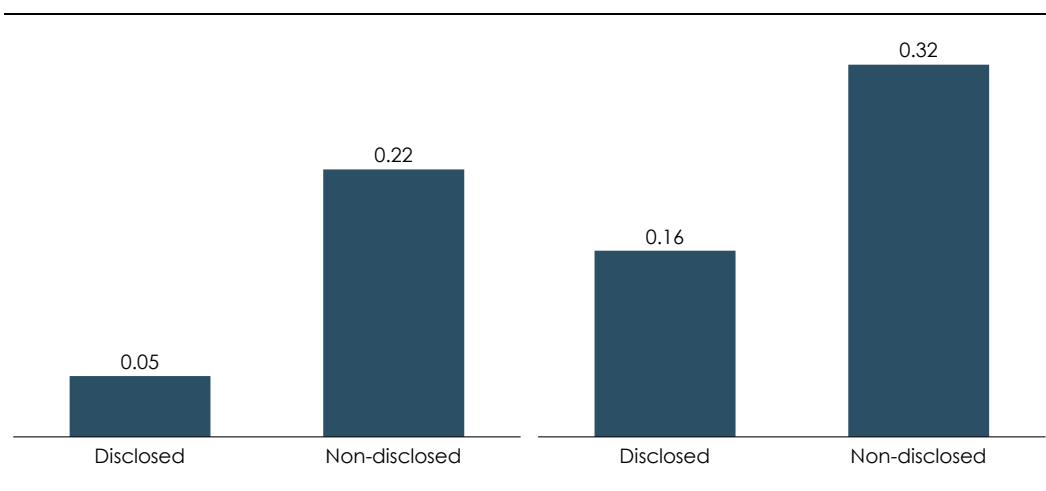
Instead see we that investors are far more active below the public disclosure threshold. In general, we find that on days when the short interest market is more active, non-publicly disclosed short interest changes much more than publicly disclosed short interest, see Figure 6, left-hand side. Even on days, where a specific stock is shorted heavily, we still see a significantly larger increase in the non-publicly disclosed position than in the publicly disclosed, see Figure 6, right-hand side. Although this does not rule out other reasons why investors are more active below the disclosure threshold, this pattern indicates that investors prefer to stay below the public disclosure threshold.

**Figure 6****Average movement when the increase in total short interest is above the median**

Average percentage point change in short interest

**Average movement when the increase in total short interest is among 10% highest**

Average percentage point change in short interest



Note: The figure is based on data on short positions in Denmark between 2015 and 2021.

Source: Copenhagen Economics based on data from the Danish Financial Supervisory Authority (DFSA)

## 2.2 DOES THE DISCLOSURE REQUIREMENT CAUSE HERD BEHAVIOUR?

In Chapter 1, we identified that the academic literature shows that there is herding associated with short positions. Additionally, economic research shows that herding behaviour will increase volatility and undermine efficiency, which both have negative implications for market functioning.

In this section, we investigate whether these results still hold, using recent data covering the coronavirus pandemic crisis. *First*, we begin by assessing the presence of herding in disclosed short positions for several of the major European economies. This assessment leads us to hypothesise that public disclosures do induce additional disclosures in the same stock. *Second*, we assess herding using the non-publicly disclosed short interest data from Denmark. Our assessment of the more detailed Danish data below the public disclosure threshold allows us to confirm our hypothesis about what we are seeing in the other European markets.

### 2.2.1 Is there herding from disclosure in the European markets?

First, we assess whether there is evidence of herding behaviour as a result of disclosure of short positions. Concretely, we use panel data regressions to assess whether investors increase their short interest in a stock when it is disclosed that other investors have increased their short interest in the same stock, see Box 2. This analysis relies on our data from public disclosures between 2015 and 2020 in seven countries: Denmark, France, Italy, Finland, France, Germany, the Netherlands, and the United Kingdom.<sup>34</sup>

<sup>34</sup> In 2018, these countries represented 73% of the EU 27 equity transactions value in EU stock exchanges. See the European Central Bank's statistical data warehouse.

**Box 2 Herding analysis in Europe**

When we investigate whether there is evidence of herding in seven European markets, we run two types of regressions. The starting point of the analysis is a stock-level panel data regression of the following form:

$$y_{st} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(y_{st}) + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_s + \mu_t + \varepsilon_{st}$$

Where the outcome variable  $y_{st}$  is one if there was a short interest disclosure in stock  $s$  at time  $t$  and zero otherwise. The main explanatory variable of interest is the *sum* of this variable over the previous four days, denoted  $\text{Lag}_{t-1,t-4}(y_{st})$ . We include trading volume, stock volatility and returns in  $X_{st}$  to control for market sentiment, and let  $\delta$  be a vector of parameters that measure their effect. In addition, we include stock fixed effects  $\mu_s$  and date fixed effects  $\mu_t$ . We estimate that an additional past disclosure increases the probability of a new disclosure by 11.9 percent.

A key concern with this regression is that part of the herding effect stems from the same investor placing positions several days in a row in the same stock. To address this, we run the following more granular regression:

$$y_{ist} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(y_{ist}^{\text{others}}) + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_{is} + \mu_t + \varepsilon_{it}$$

Where the outcome variable  $y_{ist}$  in the preferred specification is the change in short interest disclosure for investor  $i$  in stock  $s$  at time  $t$ . The primary explanatory variable of interest is the *sum* of the change in short interest for *all* investors *except* investor  $i$  in the same stock, summed over the past four days. In this regression, we remove the effect of investor  $i$ 's own past positions and we find that when other investors increase their disclosed short interest by 1 percentage points it on average causes investor  $i$  to increase her short interest by 0.0007 percentage points.

Source: Copenhagen Economics. See Appendix A.2 for more details.

We find that short interest activity in a stock tends to be followed by additional short interest disclosures in the same stock. Specifically, we find that for each additional day with a disclosure in the stock, the probability of observing at least one disclosure increases 11.9 percentage points.<sup>35</sup>

This result suggests that investors tend to follow the movements in total short interest placed by other investors, which is an indication that short interest disclosures lead to herding. Our result is in line with what has previously been documented in the academic literature. For example, a paper from 2016<sup>36</sup> finds that the probability of observing a short interest disclosure in a stock increases by 16 percent points if a disclosure has taken place within the past six days.

We also look at whether individual investors are more likely to disclose short interest positions if there has been short interest activity in the stock recently. To avoid any correlation resulting from the same individual investor placing several short positions in a single stock for several days in a row, we conduct a regression to analyse whether investors are more likely to increase their short positions if *other* investors have increased short positions in the same stock previously. In examining this, we do find a positive impact on total short interest from disclosures. In particular, we find that

<sup>35</sup> See Table 6 in the Appendix.

<sup>36</sup> Jones, C.M. et al. (2016). Revealing shorts: An examination of large short position disclosures.

a 1 percentage point increase in total short interest disclosure tends to be followed by an additional 0.1 percentage point increase within the next four days.<sup>37</sup>

An important concern related to assessing how disclosures impact subsequent disclosures and short interest is that short interest disclosures are correlated over time, mainly because the arrival of news in a stock is correlated with market activity. We control for this by including volatility, volume and returns as control variables. In addition, we use fixed effects to remove any impact on short disclosures that varies at the daily level, i.e. due to the general news cycle, or any effect that is specific to an investor in a given stock.

Nevertheless, it is difficult to ensure complete control over all factors that might be driving disclosures. Our data from Denmark, which includes data on non-publicly disclosed positions, allows for more direct identification of the effects of public disclosure.

### **2.2.2 Identifying herding using Danish data for nondisclosed short position**

After identifying herding in the European disclosed short data, we turn to our more detailed data of publicly disclosed and non-publicly disclosed data in Denmark. The data from Denmark also covers the time period from 2015 to 2020 and includes total short interest for positions that are above 0.2 percent of the issued share capital.

We can use this data from below the disclosure threshold to confirm our previous findings of herding. In order for herding to be present, market participants need to be able to observe what other market participants are doing so that they can replicate it. Thus, we expect that the reaction of total short interest in a stock to changes in non-publicly disclosed positions will not be as strong as the reaction to changes in publicly disclosed positions because the market is unable to observe changes in the non-publicly disclosed positions in real time.<sup>38</sup> We investigate this using panel data regression, see Box 3.

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<sup>37</sup> The regression analysis shows that on the individual investor level, a public disclosure resulting in a 1 percentage point increase in total disclosed short interest leads to a 0.008 percentage point increase in disclosed short interest four days later. Since on average stocks in our dataset include 15 short positions from investors, the total effect on the stock level is 0.1 percentage points on average. See the Appendix and in particular Table 7 for more details.

<sup>38</sup> While it is possible to infer the non-disclosed short interest from the total short interest data published on the website of the DFSA, the data is not made available in real time. It is therefore not possible for traders to use the information when they place their positions.

**Box 3 Herding regression analysis Denmark**

In the Danish data we can study whether disclosed and non-disclosed short interest has different effects on future short interest.<sup>39</sup> We therefore run the regression below

$$y_{st} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(\Delta \text{Total Disclosed } SI_{st}) + \beta_2 \text{Lag}_{t-1,t-4}(\Delta \text{Total NonDisclosed } SI_{st}) + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_s + \mu_t + \varepsilon_{it}$$

Where the outcome of interest,  $y_{st}$ , is the change in either total short interest, total disclosed short interest or total non-disclosed short interest in stock  $s$  at time  $t$ . The key explanatory variables of interest is the lagged change in disclosed and non-disclosed short interest. Since the non-disclosed short interest is not available to the investors in real time, we can use the comparison of the effect of disclosed and non-disclosed short interest to find evidence of a causal effect of disclosure. We do indeed find that the effect of disclosed short interest is significantly larger than non-disclosed short interest.

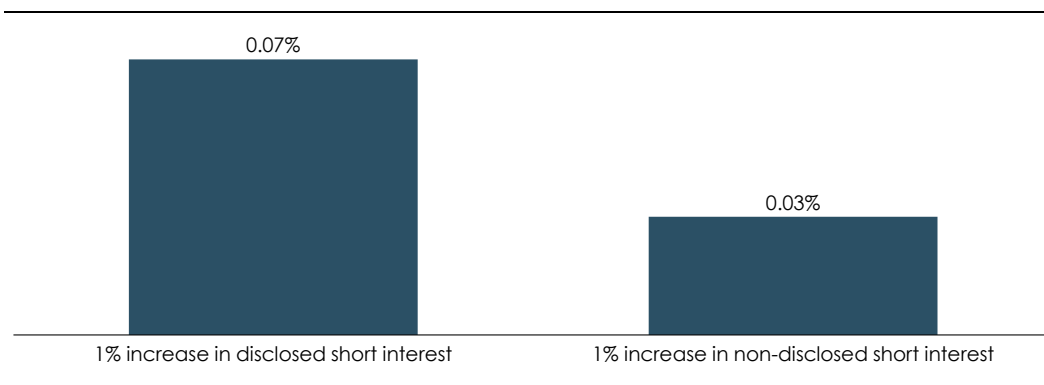
Source: Copenhagen Economics. See Appendix A.2 for more details.

Our findings using the Danish data shows that this is exactly the case; the market reaction to a publicly disclosed position is significantly stronger than it is to a non-publicly disclosed position. Our regression model shows that the total short interest increases by 0.07 percentage points in response to a 1 percentage point increase in disclosed short interest over the past four days,<sup>40</sup> see Figure 7. At the same time, total short interest increases by only 0.03 percentage points when non-publicly disclosed short interest increases by 1 percentage points. That is, the effect of publicly disclosed short interest on changes in total short interest is more than double the effect of non-publicly disclosed short interest.

<sup>39</sup> The non-disclosed short interest in the Danish data is computed by subtracting the disclosed short interest from the total short interest.

<sup>40</sup> See Column I of Table 8 in the Appendix.

**Figure 7**  
**There is a stronger reaction to changes in disclosed short interest**  
 Percentage point change impact on total short interest



Note: The figure is based on data on short positions in Denmark between 2015 and 2021. See Table 8 in the Appendix for more details.

Source: Copenhagen Economics based on data from the Danish Financial Supervisory Authority (DFSA)

It is important to note that we do still find some effect on non-publicly disclosed short interest from changes in non-publicly disclosed short interest. This indicates that we do not perfectly control for negative news, at least in the Danish regression and probably also in the European regression. More data provision by other European jurisdictions would help researchers to explore this question.

### 2.2.3 Herd behaviour among discretionary and systematic investors

As described in section 1.2, we have separated short sellers into two categories to better understand trade patterns. Our theoretical definition categorised *discretionary short investors* as investors that make short investments based on available market information and their own fundamental analysis indicating that a stock is overvalued. *Systematic investors*, on the other hand, do not take short positions based on views about the overvaluation of a specific stock, but rather shorts are based on more general market or sector trends.

In an effort to match our theoretical definition, we have empirically categorised the investors in our data as discretionary or systematic based on how frequently an investor's position is exactly at the disclosure threshold.<sup>41</sup> Our hypothesis is that discretionary investors take specific short positions based on their market intelligence, while systematic investors tend to continuously increase their position. Therefore:

- **Systematic investors:** Can be expected to be observed at integers, e.g. at 0.5, 0.6, etc. We only observe investors when they cross an integer – but not when they move between two integers. When systematic investors increase their position continuously, this would mean that we would observe them at integers.
- **Discretionary (or fundamental) investors:** Do not increase their position continuously but take discretionary short positions. This means that the first observation is likely to be in between two integers, as it is unlikely they would exactly hit an integer.

<sup>41</sup> In our analysis, systematic investors are identified as investors that have a higher share of positions at the disclosure threshold than the median investor. Discretionary investors are investors that have positions at the disclosure threshold less than the median. See the Appendix for more details.

With this approach, we find that 75 percent of disclosures are generated by systematic investors, while the remaining 25 percent of disclosures are generated by discretionary investors. However, since some investors are likely to make both discretionary and systematic investments our classification does have some shortcomings. Thus, we cannot expect to see a clear difference in the estimated trade patterns.

Using this classification, we do find a tendency for discretionary investors to react more to disclosures by other discretionary investors and for systematic investors to react more to disclosures by other systematic investors.<sup>42</sup> This is aligned with the forms of herding we discussed in section 1.5 - copycat investing generally results from discretionary investors responding to other discretionary investments and strategic copycat investing is the direct result of systematic investors incorporating other systematic investors positions into their decision making algorithm.

Our results are a first indication that identifying investors' investment strategies might help us to better understand what drives herd behaviour. While our findings are robust across specifications, further research is needed to further understand how to classify investors and to understand how these different investor classifications react to their peers.

### **2.3 DO SHORT INTEREST DISCLOSURES AFFECT SHORT-TERM STOCK RETURNS AND VOLATILITY?**

Our econometric analysis described above has found that short selling disclosure leads to herding, in line with the findings of numerous research papers. In this section we seek to determine if we can establish a direct link between short interest disclosure, stock volatility and returns. To our knowledge, the direct effect from short interest public disclosures to volatility has not previously been identified in the literature.

As discussed in Chapter 1, if investors trade on the information contained in a short interest disclosure, this may lead to excess stock price adjustments, which could result in higher volatility. However, there is a long range of different factors that contribute to financial market volatility, and in this context, disclosures will only be a small component, i.e. a priori we should not expect disclosure to be a main contributor to volatility.

We test the hypothesis that short interest disclosures affects volatility and returns, both using our pan-European and Danish datasets, see Box 4.<sup>43</sup> To control for the arrival of news related to a company's stock we include past volatility, trading volume and returns as control variables, similar to what we have included in our previously presented estimations. In addition, we include fixed effects at both the stock and date level.

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<sup>42</sup> For both types of investors, the reaction coefficient on the opposite investor is numerically half as large. See Discretionary and systematic investors in the European data and Table 10 in the Appendix.

<sup>43</sup> We conduct a robustness analysis in which we measure volatility at a weekly level and aggregate all explanatory variables at a weekly level as well. In doing this, our measure of volatility gets closer to the concept of realized volatility. By running a regression in this way, we find similar results.

**Box 4 Volatility and returns regression analysis**

We conduct several regression analyses in order to investigate the effect of short interest disclosures on volatility and stock returns. We use daily stock returns and compute volatility using the natural logarithm of the absolute value of the daily stock returns. For the volatility regression on European data we use the following regression specification

$$y_{st} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(I_{st}^{\text{disclosure}}) + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_s + \mu_t + \varepsilon_{st}$$

Where the outcome variable of interest is the daily volatility and the explanatory variable is the sum of the variable  $I_{st}^{\text{disclosure}}$  over the past four days, indicating whether a disclosure took place at day  $t$  in stock  $s$ . For the returns regression, we use instead daily returns as outcome variable and replace the disclosure dummy with the sum of the change in total short interest at the stock level over the past four days. We include the same control variables and fixed effects as for the herding regressions in Box 2.

For the *Danish data* we conduct a stock-level panel data analysis using a regression specification identical to the one used in Box 2, only now using daily returns and volatility as outcome variables (instead of changes in disclosed short interest). That is, we regress volatility and returns on changes in disclosed and non-disclosed short interest to see if disclosed short interest has a higher effect on volatility and returns than non-disclosed short interest has.

For both the European and Danish regression analysis we conduct a **robustness check** where we aggregate all variables up at the weekly level, that is, volatility is computed as a weekly average and returns and all control variables are summed at the weekly level.

We find that following a disclosure for a given stock there is an increase in daily volatility of 1.5 percent. Additionally, disclosure leads to a reduction in daily returns by 0.06 percent.

Source: Copenhagen Economics. See Appendix A.3 for more details.

On a pan-European level, we do indeed find a small but statistically significant effect; one additional short interest disclosure over the previous four days increases price volatility for a given stock by 1.5 percent.<sup>44</sup> This amounts to 4 percent of the standard deviation in volatility. In our Danish data, we do not find any significant impact on volatility.<sup>45</sup>

As described earlier, our hypothesis for the implications of increased volatility caused by disclosures primarily relates to exaggerated downward adjustment from copy-cat investing. This means, that we should expect that, controlling for all other factors, a public disclosure would lead to a temporary decline in returns.

This hypothesis seems to be supported by the data. In our European dataset, we find that an additional disclosure in a stock reduces daily return by a modest but significant 0.06 percent.<sup>46</sup> This means that when there is an increase in total disclosed short interest over the past four days, this leads to a 0.06 percent decline in the stock price on the following day. As mentioned before,

<sup>44</sup> See Table 11 in the Appendix.

<sup>45</sup> See Table 13 in the Appendix.

<sup>46</sup> See Table 12 in the Appendix.

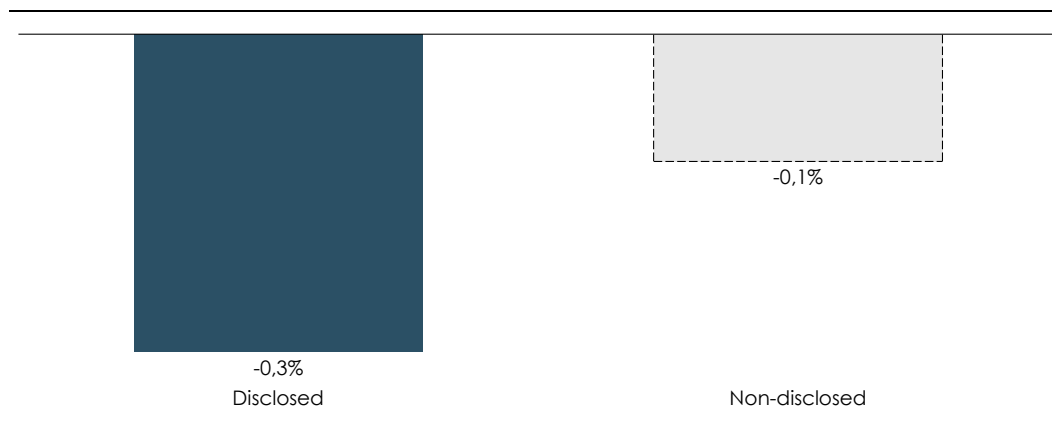
disclosures are merely a minor component in the long list of drivers behind returns in the stock market, so the effect is small.

As with the herding estimation, we can test whether our regression sufficiently controls for negative news associated with a stock by using the same methodology with our Danish data for disclosed and non-disclosed positions. Since investors cannot see positions that are below the public disclosure threshold, if we adequately control for negative news, we would not expect to see a reaction due to changes in non-disclosed short interest. Instead, we would expect to only see a reaction from changes in disclosed short interest.

Our results confirm this hypothesis: while non-disclosed short interest has no significant effect on daily returns in Denmark, we do find that an additional public short interest disclosure reduces daily returns by 0.3 percentage points,<sup>47</sup> see Figure 8.

**Figure 8**  
**Disclosed short interest effects daily stock returns**

Daily stock returns, percentage points



Note: Non-disclosed short interest has no significant effect on daily returns in Denmark. See also Table 13 in the Appendix.

Source: Copenhagen Economics based on data from the Danish Financial Supervisory Authority (DFSA)

The link between exaggerated downward adjustment and disclosures has also been investigated in economic literature. For example, a paper from 2016,<sup>48</sup> finds no significant effect of short interest disclosures on short-run returns but does find a significant -5.23 percent effect on 90-day abnormal returns, suggesting that short interest is placed by informed investors. In addition, a second paper from 2016,<sup>49</sup> finds evidence that when short sellers are constrained by requirements, the stocks in question subsequently underperform.

## 2.4 SUMMING UP OUR EMPIRICAL FINDINGS

In short, in our empirical research we have found:

<sup>47</sup> See Table 13 in the Appendix.

<sup>48</sup> Jones, C.M. et al. (2016). Revealing shorts: An examination of large short position disclosures.

<sup>49</sup> Jank, S. et al. (2021). Flying under the radar: The effects of short-sale disclosure rules on investor behavior and stock prices

- Findings from previous research on investors' reluctance to cross the public disclosure threshold still holds. More specifically, data from the recent COVID-19 crisis demonstrate that the public disclosure threshold has a distortionary effect on investor behaviour.
- Evidence of herding behaviour: Controlling for news sentiment, a disclosure increases the probability of a new disclosure. That is, we have empirically identified that a disclosed short position by an investor, in itself, causes additional shorting.
- Indications that this observed herding behaviour has a direct implication for market outcome, i.e. exaggerated downward price adjustment leads to increased market volatility.
- Evidence that investors are more likely to copycat investments made by similar types of firms.
- A possible way forward is further research on how systematic vs. discretionary investors lead to different types of herding behaviour.

### *Concluding remarks*

Summing up, in line with academic papers, as well as research papers by major European economic institutions, we have empirically identified that public disclosure of short selling is likely to impair price discovery for two main reasons: 1) it deters informed investors from shorting assets, thereby withholding information from the price discovery process and 2) it leads to herding behaviour, which is associated with a risk of exaggerated price adjustments and therefore higher volatility.

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## APPENDIX A

**EMPIRICAL ANALYSIS**

In this section we provide the technical details surrounding the empirical analysis.

**A.1 DATA AND INSTITUTIONAL SETTING**

We collect data on short interest and stock characteristics from a number of sources.

Disclosed short interest data for the European market is made available to the public in accordance with Article 9 of Regulation (EU) No 236/2012 which states that net short positions above 0.2 percent of issued share capital should be disclosed to the relevant national authority and net short positions above 0.5 percent issued share of capital should be disclosed to the public on a centralized website. Additionally, position changes across any 0.1 percent issued share of capital threshold above the 0.5 percent public disclosure threshold should also be publicly disclosed.

**For the European market**, we collect data on net short disclosures from the websites of the national financial regulatory authorities for the countries Denmark, Finland, France<sup>50</sup>, Germany, Italy, the Netherlands and the United Kingdom.

The dataset contains, for each observation, the date of disclosure, the identity of the investor as well as an identifier for the stock. Further, it includes the short interest for a particular stock held by the investor on the day that a disclosure threshold was crossed. That is, if an investor holds a short position amounting to 0.56 percent of the issued share of capital on a given day, the dataset records 0.56 percent because the disclosed short position crossed the 0.5 percent public disclosure threshold.

**Uniquely, for the Danish market** the Danish Supervisory Financial Authority (DSFA) also publishes daily information on the *total short interest* in each stock reported to the DSFA above the 0.2 percent issued share of capital threshold. Therefore, for the Danish market, in addition to the disclosed short interest, we also have access to total short interest at the stock level between 0.2 percent and 0.5 percent of issued share of capital.

For the empirical analysis, we **transform the disclosed short interest data to panel data**, where the unit of observation is the investor, stock and date. To do this, we need to make some assumptions about the level of short interest placed by an investor in a stock on days when there is no disclosure.

We therefore assume that if investor X has disclosed that threshold M has been crossed in stock A on date t, then:

- On date t+1: Without new disclosure, the investor's position is M
- On date t+1: With a new disclosure (crossing threshold N), we assume the investor's position is N

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<sup>50</sup> Disclosed short interest data is available from 2012-2021 for most of the countries (including the total short interest data for Denmark). For France, however, consistent short interest disclosure data is only available from 2019-2021.

Using this transformation, we obtain a panel dataset that contains the total disclosed short interest held by that investor in the given stock for each date, stock and investor.

**In the US market** there are no disclosure requirements for individual short positions. Instead, weekly total short interest at the stock level is reported to the exchanges. We obtain these data for the stocks in S&P 500 from Refinitiv Eikon.

We obtain daily data on stock trading volume and market cap from Refinitiv Eikon for all stocks in our European and American short interest data. From this data we compute daily return and volatility variables which we merge onto our disclosed short interest data.

### **Variable definitions**

Throughout the analysis we will work with similar variable definitions. In Table 1 we briefly present the definitions of the important explanatory and dependent variables that we use.

**Table 1**  
**Variable Definitions**

VARIABLE	DEFINITION
Short interest	Short interest is measured as the share of stocks that have been shorted as a fraction of the total outstanding shares in a company.
Total short interest	In the Danish data a total short interest variable is available. This variable measures the sum of short interest above the 0.2 percent issued share of capital disclosure threshold (where investors are mandated to disclose positions to the authorities but not the public).
Non-disclosed short interest	In the Danish data we infer the total amount of non-disclosed short interest as a residual by subtracting the total disclosed short interest in a stock from the total short interest in a stock.
Disclosure	A short interest disclosure is a notification, by an investor to the public (by way of the financial supervisory authority), that the investor has placed a short position in a stock that crosses one of the disclosure thresholds.
Total and non-disclosed short interest adjustment	For the total and non-disclosed short interest in Denmark, we construct a variable that is tantamount to a disclosure. This variable is a dummy that is one if the total or non-disclosed short interest changed (at the stock level) and zero otherwise.
Lags	Throughout the analysis, we will use lagged variables as explanatory variables in the regressions. Given a variable $X_{it}$ we define $\text{Lag}_{(t-4,t-1)}(X_{it}) = \sum_{k \in [t-4,t-1]} X_{ik}$ to be the sum of the relevant variable over the past four days. By doing this, we are essentially including a four-period lag structure in our regression but restricting the regression parameter of all lagged variables to be the same. In this way we ensure that more than one period of information is included in the lagged variable while maintaining parsimony and interpretability in the lagged variables.
Returns	When we model returns, we use the daily change in log market capitalisation. As a robustness check we present one return regression where all variables are aggregated at the weekly level.
Volatility	We measure stock return volatility using the logarithm of the absolute value of the daily returns. As a robustness check we present one volatility regression where all variables are aggregated up at the weekly level.
Volume	We include the (lagged) logarithm of daily trading volume as a control variable in each regression.
Threshold position	We define a threshold position as a disclosed position that is right at the threshold, for instance a position equal to 0.5 percent, 0.6 percent, 0.7 percent etc. of issued share of capital.
Systematic and discretionary trader	We classify the position holders based on the share of their positions that are threshold positions. A systematic trader has placed more than the median share of threshold positions. A discretionary trader has placed less than the median share of threshold positions.

Source: Copenhagen Economics

**Sample**

Table 2 describes the sample selection for the European short interest disclosure data and the Danish dataset. In both samples, we restrict attention to the period 1 January 2015 – 31 December 2020. To the extent that stock data is available in Refinitiv Eikon, we merge stock information onto the disclosed short interest dataset. Since we were not able to collect market cap data for all stocks in the disclosure data, some observations are removed when we merge the disclosure data with stock information from Refinitiv Eikon.

**Table 2**  
**Sample selection: European & Danish disclosed short interest data**

<b>STATISTIC</b>	<b>EUROPEAN DISCLOSED SHORT INTEREST DATA NO. OF OBSERVATIONS</b>	<b>DANISH DATA NO. OF OBSERVATIONS</b>
<b>Full raw data</b>	15,735,356	151,386
<b>Sample period Jan 2015 – Dec 2020</b>	13,619,312	107,916
<b>Excluding missing stock information in Eikon</b>	7,082,706	81,377

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, and the United Kingdom and data on disclosed and total short interest from the Danish Financial Supervisory Authority (DFSA)

### **Descriptive statistics**

In this section we present summary statistics for the datasets that we use in our regression analysis, that is, summary statistics for the Danish short interest data, the European disclosed short interest data as well as the stock information that we pull from Refinitiv Eikon.

**Table 3**  
**Descriptive statistics: stock data**

	<b>DK</b>	<b>FI</b>	<b>FR</b>	<b>DE</b>	<b>IT</b>	<b>NL</b>	<b>UK</b>
Number of stocks that has been shorted at any given point	37	43	107	336	116	58	504
Volume, mean	319,871	1,335,152	1,370,288	1,083,833	5,182,309	1,905,067	2,382,696
Volume, median	171,606	244,939	253,902	128,598	472,900	283,854	420,320
Volume, std.	718,231	4,755,772	18,925,102	7,415,579	22,079,179	5,318,624	11,510,380
Market cap (billion USD), mean	6.1	5.7	13.5	7.7	5.2	12.0	5.8
Market cap (billion USD), median	2.8	2.0	4.4	1.7	1.3	2.7	1.2
Market cap (billion USD), std	8.4	9.3	23.7	18.2	11.0	32.1	18.5
Daily return bp, mean	4.9	3.0	2.8	2.7	3.0	3.1	1.9
Daily return bp, median	2.49	3.20	-0.17	0.00	-1.97	0.00	0.71
Daily return bp, std	228.3	234.7	349.9	378.5	310.1	250.4	327.3
Volatility, mean	4.42	4.42	4.49	4.63	4.57	4.41	4.49
Volatility, median	4.61	4.61	4.65	4.79	4.75	4.58	4.65
Volatility, std	1.22	1.22	1.27	1.27	1.22	1.23	1.28

Note: Market cap measured in USD. Volume measured in number of shares. The stocks included in these summary statistics had at least one short interest disclosure in the period 2012-2021.

Source: Copenhagen Economics and Refinitiv Eikon

**Table 4**  
**Descriptive statistics: Danish short interest data**

	<b>MEAN</b>	<b>MEDIAN</b>	<b>STD</b>	<b>COUNT</b>
Total short interest	0.78	0	1.82	151,386
Disclosed short interest	0.31	0	1.14	151,386
Non-disclosed short interest	0.47	0	0.94	151,386
Change total short interest	0	0	0.07	151,317
Change disclosed short interest	-0.00	0	0.06	151,317
Change in non-disclosed short interest	0.00	0	0.07	151,317

Source: Data on disclosed and total short interest from the Danish Financial Supervisory Authority (DFSA)

**Table 5**  
**Descriptive Statistics: European Short Interest Data**

	<b>DK</b>	<b>FI</b>	<b>FR</b>	<b>DE</b>	<b>IT</b>	<b>NL</b>	<b>UK</b>
No. of disclosures	5,088	7,271	1,434	30,750	16,693	13,660	69,692
No. of investors	155	179	124	360	227	217	490
No. of stocks	46	57	115	425	176	84	699
No. of positions	717	946	321	3,940	2,075	1,604	9,190
No. of disclosures per investor	32.83	40.62	11.56	85.42	73.54	62.95	14,2.23
No. of positions per investor	4.63	5.28	2.59	10.94	9.14	7.39	18.76
No. of disclosures per stock	110.61	127.56	12.47	72.35	94.85	162.62	99.7
No. of positions per stock	15.59	16.6	2.79	9.27	11.79	19.1	13.15
No. of disclosures per position	7.1	7.69	4.47	7.8	8.04	8.52	7.58
Short interest increases, mean	0.11	0.29	0.12	0.15	0.26	0.29	0.12
Short interest increases, std	0.16	0.43	0.1	1.19	2.59	0.41	0.21
Short interest increases, count	628	623	161	3,555	2,105	1,823	36,652
Short interest decreases, mean	-0.12	-0.24	-0.15	-0.14	-0.24	-0.29	-0.13
Short interest decreases, std	0.14	0.33	0.17	0.23	1.96	0.43	0.28
Short interest decreases, count	538	612	127	3,330	1,812	1,756	32,259

Note: This table provides descriptive statistics on key variables in the disclosed short interest data that we gather for European countries. We distinguish between disclosures and positions. A disclosure occurs every time an investor adjusts a position so that it crosses a disclosure threshold. A position is a series of disclosures from an investor in a stock where the investor does not go below the 0.5 percent disclosure requirement. Once an investor goes back below the 0.5 percent reporting threshold, the position ends.

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, and the United Kingdom

## **A.2 HERDING REGRESSION ANALYSIS**

In this section, we present our herding regression analysis on the European and Danish data.

### **Herding in the European data**

Using a dataset of short interest disclosures for seven European countries (Denmark, Finland, France, Germany, Italy, the Netherlands, and the United Kingdom) we investigate the hypothesis that short interest disclosures generate herding. While this data set contains far more observations than the Danish data, the analysis in this section is constrained by the fact that we do not observe

data for non-disclosed short interest. Therefore, it is not possible to compare the effect of disclosed short interest to the effect of non-disclosed short interest.

We first investigate to what extent previous short interest disclosures lead to additional short interest disclosures in the stock. To do this, we consider the following regression:

$$I_{st}^{disclosure} = \beta_0 + \beta_1 Lag_{t-1,t-4}(I_{st}^{disclosure}) + \delta' Lag_{t-1,t-4}(X_{st}) + \mu_s + \mu_t + \varepsilon_{st}$$

Where the outcome of interest  $I_{st}^{disclosure}$  indicates whether a short interest disclosure took place in stock  $s$  at time  $t$ . And the main explanatory variable  $Lag_{t-1,t-4}(I_{st}^{disclosure})$  sums the same variable over the past four days. In Table 6 below we present results for a pooled OLS and a fixed effects regression. We find that in both specifications, there is clear evidence of herding. In the OLS specification we find that the autocorrelation between lagged and current disclosures in a stock is 0.154 meaning that an additional disclosure over the past four days on average increases the probability of a new disclosure with 15.4 percentage points. When we include fixed effects at the stock and date level the estimate decreases to 11.9 percentage points.

**Table 6**  
**Herding regression: Europe**

	(I) I(CHANGE DISCLOSED)[T] (OLS)	(II) I(CHANGE DISCLOSED)[T] (FE)
I(Change in Disclosed)[t-1,t-4]	0.1539*** (582.80)	0.1185*** (391.16)
Returns t	-0.0263*** (-5.93)	-0.0142** (-3.04)
Returns[t-1,t-4]	-0.0319*** (-14.50)	-0.0310*** (-12.99)
Volatility t	0.0033*** (25.27)	0.0028*** (20.87)
Volatility [t-1,t-4]	0.0006*** (12.11)	0.0004*** (5.92)
Volume	0.0142*** (67.81)	0.0147*** (67.92)
Volume[t-1,t-4]	-0.0022*** (-40.33)	-0.0007*** (-11.12)
Cons	-0.0211*** (-15.42)	-0.0989*** (-31.32)
Stock FE		✓
Date FE		✓
N	1,613,859	1,613,859

Note: This table presents a regression where the outcome variable I(Change in Disclosed)[t] is one if there was a disclosure in a stock on date t and zero otherwise. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*, p<0.05, \*\*, p<0.01, \*\*\*, p <0.001

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, UK. Stock return, volume and volatility from Refinitiv Eikon.

An important issue with the above regression is that when we study autocorrelation in disclosures in a stock over time, we cannot rule out that parts of the autocorrelation stems from the same investor placing short positions in the same stock over several days in a row. If this is the case, the coefficient from regressing disclosures in a stock on past disclosures will not reflect herding, but merely the fact that investors are often smoothing their investments over time.

In order to address this issue, we consider an alternative regression where we zoom in on the individual investor and model how the disclosure decisions of *individual investors* react when *other investors* place short interest positions. To do this, we construct a measure of the disclosure activity of other investors than the one in question, defined below:

$$\Delta Total Disclosed SI Others_{ist} = \Delta Total Disclosed SI_{st} - \Delta Disclosed SI_{ist}$$

This measure takes the *change* in total disclosed short interest for stock  $s$  at time  $t$  and subtracts the change in disclosed short interest of investor  $i$  in stock  $s$  at time  $t$ . In this way, we obtain a measure of the change in total disclosed short interest for all investors in stock  $s$  at time  $t$  *except* for investor  $i$ . We then run the following regression:

$$y_{ist} = \beta_0 + \beta_1 Lag_{t-1,t-4}(\Delta Total Disclosed SI Others_{ist}) + \delta' Lag_{t-1,t-4}(X_{st}) + \mu_{is} + \mu_t + \varepsilon_{it}$$

Where  $y_{ist}$  is an outcome of interest for investor  $i$  in stock  $s$  at time  $t$ . We will focus on the change in disclosed short interest  $\Delta Disclosed SI_{ist}$ . The main explanatory variable is the sum of  $\Delta Total Disclosed SI Others_{ist}$  over the past four days. In addition, we again control for stock characteristics in  $X_{st}$  such as lagged trading volume, lagged volatility and lagged returns. The results are presented in Table 7 below.

The table presents results for the regression where four different fixed effects structures are used. In the first column we present results from a simple pooled OLS regression. The following regressions include, in addition to date fixed effects, fixed effects at the investor, stock or investor-stock level. We see that the results are quite robust to the fixed effects structure, indicating that the regressions are not subject to bias from unobserved fixed effects. We find that the main variable of interest  $Lag_{t-1,t-4}(\Delta Total Disclosed SI Others_{ist})$  has a significant and positive effect between 0.0007 and 0.0008 in all specifications. This means that when the total disclosed SI of other investors increase by 1 percentage points, the disclosed short interest of investor  $i$  in stock  $s$  is likely to increase 0.0008 percentage points.

**Table 7**  
**Herding regression: Europe (disclosure: total investor)**

	(I) ΔDISCLOSED SI (OLS)		(II) ΔDISCLOSED SI (FE I)		(III) ΔDISCLOSED SI (FE II)		(IV) ΔDISCLOSED SI (FE III)	
ΔTotal disclosed [t-1,t-4] others	0.0008***	(5.31)	0.0007***	(4.95)	0.0007***	(5.01)	0.0007***	(4.96)
Returns t	-0.0123***	(-6.91)	-0.0145***	(-7.29)	-0.0144***	(-7.29)	-0.0145***	(-7.29)
Returns [t-1,t-4]	-0.0017**	(-3.19)	-0.0023***	(-3.79)	-0.0022***	(-3.74)	-0.0023***	(-3.79)
Volatility t	-0.0000	(-1.39)	-0.0000	(-0.56)	0.0000	(0.30)	-0.0000	(-0.56)
Volatility [t-1,t-4]	-0.0000	(-1.62)	-0.0000	(-1.01)	0.0000	(0.63)	-0.0000	(-1.01)
Volume	-0.0001**	(-2.69)	-0.0001*	(-2.22)	-0.0001**	(-3.09)	-0.0001*	(-2.22)
Volume [t-1,t-4]	0.0000**	(2.79)	0.0001***	(5.19)	0.0000***	(3.34)	0.0001***	(5.19)
Cons	-0.0002	(-1.82)	-0.0019***	(-4.44)	0.0000	(0.17)	-0.0019***	(-4.44)
Stock FE			✓					
Investor FE					✓			
Stock-Investor FE							✓	
Date FE			✓		✓		✓	
N	10532047		10532047		10532047		10532047	

Note: This table presents regression output from regressions of volatility and returns on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*: p<0.05, \*\*: p<0.01, \*\*\*: p<0.001

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, UK. Stock return, volume and volatility from Refinitiv Eikon

### Herding in the Danish data

The Danish data is unique in the European context because in addition to the dataset on disclosed short interest, the Danish Financial Supervisory Authority (DFSA) also publishes data on total short interest at the stock level. These data include all short interest positions between 0.2 percent and 0.5 percent issued share of capital which are disclosed to the DFSA but not to the public. While this non-disclosed short interest is available at the website of the DFSA, they are published with more than a month lag. It is therefore not possible for traders to react to this data. We use these data to test several hypotheses regarding the effect of real time publication of short interest disclosures.

If short interest disclosures contain information that is relevant to the market, a key concern is that disclosures may lead to herding or copycat investing. This may harm the efficiency of the price discovery to the extent that some investors simply copy the investment decisions of others without doing a proper analysis.

An important implication of this argument is that movements in *disclosed* short interest (SI) should have a larger effect on future investment decisions than movements in *non-disclosed* short interest.

We therefore run a variation of the following regression:

$$y_{st} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(\Delta \text{Total Disclosed } SI_{st}) + \beta_2 \text{Lag}_{t-1,t-4}(\Delta \text{Total NonDisclosed } SI_{st}) \\ + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_s + \mu_t + \varepsilon_{st}$$

where  $s$  indexes a stock and  $t$  is a calendar day and  $y_{st}$  is the outcome of interest. We will study changes in total SI, disclosed SI and non-disclosed SI as well as volatility and returns. The main explanatory variables of interest are lagged changes in disclosed and non-disclosed short interest. If disclosures have an effect, we expect the coefficient on disclosed short interest to be larger than on non-disclosed short interest.

A key threat to our identification strategy is that trading behavior in a stock can be correlated over time simply because the arrival of news is correlated over time. Since information is fundamentally unobserved, we address this issue by including a battery of controls in the vector  $X_{st}$ . These controls include lagged stock characteristics such as return, stock volatility and trading volume.

On top of this, since we have a panel dataset, we can include fixed effects at both the stock and date level, contained in  $\mu_s$  and  $\mu_t$ . Including stock level fixed effects is important, because if there is a lot of variation in the cross section between different stocks in how much they are shorted, this will generate an upwards bias in the autocorrelation in short interest. For example, if one stock experiences a high growth in shorting both leads and lags of the change in short interest will be positive, even when there is no causal link between the two.

Table 8 presents the main results on herding of disclosed short interest. Column 1 presents results for the main outcome of interest. Here, we regress the change in total short interest in a stock on the lagged changes in total disclosed and non-disclosed short interest. We find that both disclosed and non-disclosed short interest has a significant effect on the change in total short interest. Specifically, the effect of total disclosed short interest is 0.067 which is significant at the 0.1 percent level, while the effect of total non-disclosed short interest is 0.025 which is also significant. We see that the effect of disclosed short interest is more than double the effect of non-disclosed short interest. This supports the hypothesis that there is a causal effect of the short interest disclosures on future investment decisions, indicating that significant herding is taking place.

In columns 2 and 3 we change the outcome variable to be changes in total disclosed short interest and changes in total non-disclosed short interest. Here we see that the herding effect takes place below the public disclosure threshold in the non-disclosed short interest. While disclosed short interest reacts only slightly more to changes in disclosed than to changes in non-disclosed short interest, we find that non-disclosed short interest reacts much stronger to disclosed short interest than to non-disclosed short interest.

**Table 8**  
**Herding regression: Denmark**

	(I)		(II)		(III)	
	$\Delta$ TOTAL SI		$\Delta$ TOTAL DISCLOSED SI		$\Delta$ TOTAL NON-DIS-CLOSED SI	
$\Delta$ Total disclosed [t-1,t-4]	0.067***	(5.28)	0.038***	(4.08)	0.029***	(3.60)
$\Delta$ Total non-disclosed [t-1,t-4]	0.025***	(3.39)	0.037***	(5.05)	-0.012	(-1.73)
Volatility [t-1,t-4]	0.128*	(2.12)	-0.052	(-0.76)	0.180*	(2.64)
Returns [t-1,t-4]	-0.155**	(-3.13)	-0.032	(-0.88)	-0.124**	(-3.05)
Volume [t-1,t-4]	0.002***	(4.08)	0.001*	(2.64)	0.001**	(2.84)
Returns $\dagger$	-0.152*	(-2.66)				
Cons	0.029***	(-4.19)	-0.014**	(-2.70)	-0.015**	(-3.06)
Stock FE			✓		✓	
Date FE			✓		✓	
N	81377		81377		81377	

Note: This table presents regression output from regressions of disclosed, non-disclosed and total short interest on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$

Source: Data on total and disclosed short interest from DSFA. Stock return, volume and volatility from Refinitiv Eikon.

Table 9 presents results from regressions similar to those presented in Table 8. However, in these regressions we instead measure whether a disclosure of short interest or a change in total short interest is likely to generate additional changes or disclosures in short interest. That is, instead of studying changes in the key variables we instead consider dummies indicating whether a disclosure or a change in total/non-disclosed short interest took place.

When we look at data this way, we do not find as clear a difference between the effect of disclosed short interest and non-disclosed short interest. Lagged disclosed and non-disclosed short interest dummies have identical positive coefficients on the probability of observing a new disclosure. For non-disclosed short interest, the effect of a past change in non-disclosed short interest is slightly larger than the effect of past disclosed short interest. On the other hand, whether we see a disclosure in this period correlates much stronger with past disclosure than with past changes in non-disclosed short interest.

In general, we prefer to look at changes in disclosed and non-disclosed short interest, rather than dummies for whether a short interest disclosure took place, or whether the non-disclosed short interest changed. The main reason is that the variables in the former specification contain more information than they do in the latter specification. Moreover, since we do not observe disclosures below the threshold, the disclosure variable here is based changes in non-disclosed short interest. However, it is possible that there has been short activity in a stock even if the non-disclosed short interest doesn't change, e.g. if positions cancel out. Therefore, it is a possibility that disclosures below the threshold are measured with error.

**Table 9**  
**Herding binary regression**

	(I) I( $\Delta$ TOTAL $\neq$ 0)		(II) I( $\Delta$ DISCLOSED $\neq$ 0)		(III) I( $\Delta$ NON-DISCLOSED $\neq$ 0)	
I(change disclosed) [t-1,t-4]	0.049***	(7.28)	0.103***	(16.29)	0.044***	(6.68)
I(change non-disclosed) [t-1,t-4]	0.089***	(15.70)	0.013***	(3.99)	0.089***	(15.64)
Volatility [t-1,t-4]	0.546**	(2.69)	0.238*	(2.01)	0.578***	(2.76)
Returns [t-1,t-4]	-0.412***	(-3.61)	-0.126	(-1.82)	-0.420***	(-3.66)
Volume [t-1,t-4]	0.027***	(4.50)	0.005*	(2.60)	0.027***	(4.50)
Cons	-0.231**	(-3.44)	-0.046	(-1.88)	-0.234**	(-3.37)
Stock FE	✓		✓		✓	
Date FE	✓		✓		✓	
N	81,426		81,426		81,426	

Note: This table presents regression output from regressions of disclosed, non-disclosed and total short interest on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*: p<0.05, \*\*: p<0.01, \*\*\*: p <0.001

Source: Data on total and disclosed short interest from DSFA. Stock return, volume and volatility from Refinitiv Eikon.

### Discretionary and systematic investors in the European data

Based on the disclosed short positions we classify the investors according to their investment strategies. Specifically, we count the share of *threshold positions*, i.e. disclosed positions right at the disclosure thresholds, that each investor holds. Threshold positions are interesting because by disclosing a position right at a threshold, the investor reveals that crossing the threshold is not a concern for the specific position. Had it been a concern, a disclosure could have been avoided by reducing the short position only slightly. We label investors who place many of these positions<sup>51</sup> as *systematic* traders while we label investors who place relatively few of these positions as *discretionary* traders.

In this section we study whether disclosures from discretionary or systematic investors generate a different degree of herding. To do this we run the following regression:

$$\Delta_{ist} \text{Disclosed SI} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(\Delta \text{Total Discrete Disclosure others}_{ist}) + \beta_2 \text{Lag}_{t-1,t-4}(\Delta \text{Total Systematic Disclosure others}_{ist}) + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_{is} + \mu_t + \varepsilon_{it}$$

where on the left-hand side we use a variable which measures the change in disclosed short interest held by investor  $i$  in stock  $s$  at day  $t$ . On the right-hand side, we include the lagged change in *discretionary* disclosures by others, i.e. excluding investor  $i$  and the lagged change in *systematic* disclosures by others, i.e. excluding investor  $i$ . We are interested in measuring if the estimate for  $\beta_1$  differs significantly from the estimate for  $\beta_2$ . We present results in Table 10.

<sup>51</sup> Above the median number of positions.

**Table 10**  
**Herding: discretionary and systematic traders**

	(I) $\Delta$ DISCLOSED SI		(II) $\Delta$ DISCLOSED SI (SYS- TEMATIC TRADERS)		(III) $\Delta$ DISCLOSED SI (DIS- CRETIONARY TRAD- ERS)	
$\Delta$ Total discretionary dis- closed others[t-1,t-4]	0.0005***	(4.03)	0.0005**	(3.13)	0.0006*	(2.57)
$\Delta$ Total systematic dis- closed others [t-1,t-4]	0.0008***	(4.33)	0.0010***	(4.41)	0.0003	(1.03)
Returns t	-0.0144***	(-7.29)	-0.0151***	(-6.35)	-0.0128***	(-3.54)
Returns[t-1,t-4]	-0.0023***	(-3.77)	-0.0021**	(-2.87)	-0.0027*	(-2.55)
Volatility t	-0.0000	(-0.56)	-0.0000	(-1.60)	0.0000	(1.18)
Volatility [t-1,t-4]	-0.0000	(-1.00)	-0.0000	(-0.69)	-0.0000	(-0.80)
Volume	-0.0001*	(-2.22)	-0.0001**	(-2.59)	-0.0000	(-0.03)
Volume [t-1,t-4]	0.0001***	(5.19)	0.0001***	(5.05)	0.0000	(1.86)
Cons	-0.0019***	(-4.44)	-0.0021***	(-3.77)	-0.0015*	(-2.48)
Investor-Stock FE	✓		✓		✓	
Date FE	✓		✓		✓	
N	10,532,047		7,507,818		3,024,217	

Note: This table presents regression output from regressions of changes in disclosed short interest on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, UK. Stock return, volume and volatility from Refinitiv Eikon

Overall, we find numerically very small differences between the estimates of difference investors. We find that overall, disclosed short interest increases 0.0008 percentage points following a 1 percentage point increase in systematic disclosures while it increases 0.0005 percentage points following a 1 percentage point increase in discretionary disclosures. The market overall therefore seems to react more strongly to systematic disclosures. This can be attributed to the fact, that the majority of investors are systematic.

We find that systematic disclosures react twice as strongly to positions placed by systematic investors compared to positions placed by discretionary disclosures, see column 2 which presents the regression results only for systematic disclosures. On the other hand, discretionary disclosures, as shown in column 3, reacts twice as strongly to changes in discretionary disclosures than to changes in systematic disclosures.

### A.3 VOLATILITY AND RETURNS REGRESSION ANALYSIS

In this section, we present our volatility and returns regression analysis on the European and Danish data.

### Volatility and returns in Europe

We also investigate whether volatility and returns are affected by past changes in disclosed and non-disclosed short interest for the European data on disclosed short interest. We measure returns using daily changes in the natural logarithm of the market capitalization and volatility as the logarithm of the absolute returns. That is:

$$\begin{aligned} \text{Return}_t &= \log(\text{market cap}_t) - \log(\text{market cap}_{t-1}) \\ \text{Volatility}_t &= \log(\text{abs}(\text{Return}_t)) \end{aligned}$$

We first run the following regression:

$$y_{st} = \beta_0 + \beta_1 \text{Lag}_{t-1,t-4}(I_{st}^{\text{disclosure}}) + \delta' \text{Lag}_{t-1,t-4}(X_{st}) + \mu_s + \mu_t + \varepsilon_{st}$$

where the outcome of interest is the daily stock volatility. We analyse both a pooled OLS regression and a FE regression including stock and date fixed effects. The results are presented in Table 11.

In both the OLS and FE specification we find a statistically significant effect of lagged total disclosures on daily stock volatility. In the fixed effects specification we find that an additional short interest disclosure over the past four days increases volatility 1.5 percent.

In column 3 we present a version where all variables are aggregated at the weekly level. This is done to measure the volatility at a finer time increment than the unit of observation in the regression, getting closer to the concept of *realized* volatility. We find very similar results. At the weekly level, an increase in the number of disclosures in a stock leads to a 0.92 percent increase in volatility.

**Table 11**  
**Volatility: Europe**

	(I) VOLATILITY (OLS)		(II) VOLATILITY (FE)		(III) VOLATILITY (WEEKLY VARIABLES)	
$\Delta$ Total disclosed [t-1,t-4]	0.0254***	(9.32)	0.0152***	(7.40)	0.0093***	(6.04)
Volatility [t-1,t-4]	0.1079***	(80.67)	0.0441***	(44.99)	0.2107***	(39.13)
Returns[t-1,t-4]	-0.4277***	(-14.57)	-0.0544*	(-2.12)	-0.2131***	(-10.25)
Volume [t-1,t-4]	-0.0013	(-1.93)	0.0225***	(18.38)	0.0609***	(13.08)
Cons	-2.5847***	(-53.65)	-4.9502***	(-71.94)	-3.3477***	(-54.21)
Investor-stock FE			✓		✓	
Date FE			✓		✓	
N	1,613,859		1,613,859		337,047	

Note: This table presents regression output from regressions of volatility on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*, p<0.05, \*\*, p<0.01, \*\*\*, p<0.001

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, UK. Stock return, volume and volatility from Refinitiv Eikon

For returns we consider identical regression specifications but now using the daily stock return as outcome variable. Results are presented in Table 12. Using a daily regression specification we find that an increase in the total disclosed short interest in a stock over the past four days reduces the daily stock return by 0.06 percentage points, or 1.03 percent for that week. This result does not depend on whether we include stock and date level fixed effects in the regression, as in column 2, or whether we run a pooled OLS as in column 1. When we aggregate at the weekly level, as in column 3, we find that an increase in total disclosures in a stock in the past week decreases the weekly return by 0.33 percentage points. When disclosures decrease short run returns, this can be an indication that disclosures cause other investors to trade on the information contained in the disclosure.

**Table 12**  
**Returns: Europe**

	(I) RETURNS (OLS)		(II) RETURNS (FE)		(III) RETURNS (WEEKLY VARIABLES)	
ΔTotal disclosed [t-1,t-4]	-0.0006*	(-2.47)	-0.0006**	(-2.81)	-0.0033	(-1.28)
Volatility [t-1,t-4]	-0.0000	(-0.60)	0.0000	(0.66)	0.0001	(0.41)
Returns [t-1,t-4]	0.0015	(0.73)	-0.0147***	(-6.74)	-0.0312***	(-6.90)
Volume [t-1,t-4]	0.0000**	(2.60)	0.0002***	(8.80)	0.0020***	(6.04)
Cons	-0.0006	(-1.85)	-0.0078***	(-7.94)	-0.0241***	(-5.10)
Investor-stock FE			✓		✓	
Date FE			✓		✓	
N	1,615,933		1,615,933		337,531	

Note: This table presents regression output from regressions of returns on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*: p<0.05, \*\*: p<0.01, \*\*\*: p<0.001

Source: Data on disclosed short interest from financial supervisory authorities in the following countries: Denmark, Finland, France, Germany, Italy, Netherlands, UK. Stock return, volume and volatility from Refinitiv Eikon

### Volatility and returns in Denmark

We also investigate whether volatility and returns are affected by past changes in disclosed and non-disclosed short interest. We measure returns using daily changes in the natural logarithm of the market capitalization. We measure volatility as the logarithm of the absolute returns. That is:

$$Return_t = \log(\text{market cap}_t) - \log(\text{market cap}_{t-1})$$

$$Volatility_t = \log(\text{abs}(Return_t))$$

We use these variables as outcome variables in the same regression as in Table 9. In other words, we use lagged disclosed and non-disclosed short interest as explanatory variables. We present the results in Table 13. In the first column we present the results for the regressions on volatility. We see that neither lagged changes in disclosed nor lagged changes in non-disclosed short interest have a significant effect on the volatility in a stock. While we also find no significant effect of past disclosures, we do find a significant effect (at the 5 percent level) of past changes in non-disclosed short interest. When there is a change in past non-disclosed short interest, volatility in a stock increases by 2.2 percent. When we look at returns, we find that past changes in disclosed short interest have a significant effect on returns, although the same is not true for non-disclosed short interest. Specifically, when past disclosed short interest increases 1 percentage points, this leads to a reduction in the daily returns of 0.25 percentage points.

**Table 13**  
**Volatility returns Denmark**

	<b>(I)</b> <b>VOLATILITY</b>		<b>(II)</b> <b>RETURNS</b>		<b>(III)</b> <b>WEEKLY RE-</b> <b>TURNS</b>	
$\Delta$ Total disclosed [t-1,t-4]	0.0194	(0.79)	-0.0025***	(-4.06)	-0.0036	(-0.33)
$\Delta$ Total non-disclosed [t-1,t-4]	-0.0019	(-0.07)	-0.0010	(-1.66)	-0.0029	(-0.16)
I(change in disclosed) [t-1,t-4]	0.0059	(0.40)	-0.0001	(-0.49)	-0.0002	(-0.05)
I(change in non-disclosed) [t-1,t-4]	0.0218*	(2.04)	0.0000	(0.04)	0.0008	(0.81)
Returns [t-1,t-4]	-1.3711	(-1.51)	-0.0786*	(-2.48)		
Volatility [t-1,t-4]	9.8149***	(7.87)	0.0494	(0.93)	0.0005	(0.24)
Volume [t-1,t-4]	0.1047***	(4.59)	0.0006	(1.73)	0.0014	(0.77)
Weekly returns [t-1,t-4]					-0.0132	(-0.60)
Cons	-6.0430***	(-23.17)	-0.0066	(-1.81)	0.0170	(0.71)
Stock FE	✓		✓		✓	
Date FE	✓		✓		✓	
N	81348		81367		81252	

Note: This table presents regression output from regressions of volatility and returns on key explanatory variables. All lagged variables are constructed by summing the value of the variable over the past four days. We include fixed effects at the stock and date level. T-values in parenthesis. Standard errors are clustered at the stock level. \*: p<0.05, \*\*: p<0.01, \*\*\*: p<0.001

Source: Data on total and disclosed short interest from DSFA. Stock return, volume and volatility from Refinitiv Eikon.