See it, Say it, Shorted: Strategic Announcements in Short-Selling Campaigns *

Jane Chen†

August 2023

Click for the Latest Version

Abstract

I study how hedge funds strategically disclose their private information during short-selling campaigns. Using data on hedge funds' voluntary announcements and daily short positions in the EU market, I document the existence of two groups of funds: Announcers and Followers. Announcers, typically small and young, (1) establish short positions, (2) publish research reports about short targets, and (3) realise profits from the falling price within a short time frame. Followers, usually large, enter at the release of the report and increase their short positions even after announcers exit. To understand the strategic interaction among short sellers, I provide a model to explain how size affects a short seller's incentive and behaviour. Small funds benefit more from disclosing when facing binding leverage constraints. In contrast, large funds profit from others' private information by offering capital to price discovery. I characterize the effect of such short-selling campaigns on market efficiency and confirm the model prediction that stocks with lower borrowing costs and larger mispricing are more likely to be announced by hedge funds.

Keywords: Strategic communication, short selling, mispricing, private information

*I am extremely grateful to my advisors Péter Kondor and Cameron Peng for invaluable guidance and support. I also thank Ulf Axelson, Cynthia Balloch, Georgy Chabakauri, J.Anthony Cookson, Kim Fe Cramer, Daniel Ferreira, Dirk Jenter, Wenxi Jiang, Christian Julliard, Dong Lou, Ian Martin, Igor Makarov, Stavros Panageas (discussant), Daniel Paravisini, Pedro Saffi, Dimitri Vayanos, Michela Verardo, Mindy Z. Xiaolan, Kathy Yuan and Hongda Zhong for their helpful comments. This draft has also benefited from the comments of conference and seminar participants at the SFS Cavalcade NA 2023, Indiana University, University of Colorado at Boulder, Erasmus School of Economics, Shanghai Jiao Tong University, CUHK Business School, Hong Kong Baptist University, CUHK-Shenzhen and LSE. All errors are my own.

†School of Management and Economics and Shenzhen Finance Institute, The Chinese University of Hong Kong, Shenzhen (CUHK-Shenzhen); chenjingxuan@cuhk.edu.cn

1 Introduction

In a frictionless market, informed traders are typically incentivized to keep information private. They trade cautiously so that any private information is incorporated into prices gradually and not easily inferred by other investors in the market (Kyle, 1985). In reality, however, we sometimes observe hedge fund managers, the prototype of informed traders, deviate from this conventional wisdom. While some hedge funds keep quiet about their targets, a significant number of them are publicly much louder with their trading strategies (e.g., Ljungqvist and Qian (2016), Luo (2018), Appel and Fos (2019)). They publish detailed research reports, give speeches at conferences, or post their shorting targets on social media to give away their information. Such contrasting behaviours across hedge funds raise the following questions: What are the strategic considerations among short sellers, and why do some announce their private information while others do not? Furthermore, how does this strategic interaction affect market efficiency?

I address these questions by examining hedge funds' disclosure behaviour and short-selling activities when they face leverage constraints. The paper proceeds in two steps. In the first part, I hand-collect data on hedge funds' announcements and individual short positions, and, using an event study framework, I establish the existence of two types of short sellers in short-selling campaigns. In particular, funds smaller in size tend to be more active in announcing their short targets, but also exit short positions more quickly. In contrast, larger funds tend to follow the smaller funds' entry and announcement but then stay in the market for a longer period.

In the second part, to explain such contrasting behaviours among short sellers, I develop a strategic model of trading and communication when short sellers face leverage constraints. The model rationalizes the strategic complementarity between small and large funds in short-selling campaigns. Namely, the delayed entry of the large fund helps the small fund avoid margin calls, while the large fund free-rides on the small fund's disclosed information. I discuss the ambiguous effect of announcements on market efficiency and provide further predictions. In addition, I empirically test two unique predictions derived from the model. Stocks with lower borrowing costs and wider mispricing in the current period are more likely to be targeted by hedge funds with announcements.

To study information disclosure around short campaigns, one needs data containing hedge funds' short positions in each target, along with the information releases of these hedge funds. Neither is readily available. Most importantly, mandatory reporting of hedge funds' short positions is limited.[1] For instance, only aggregated short interests at the stock level are released in the US. To address these issues, I exploit regulatory notifications from short-selling campaigns in the European Union (EU). From November 2012, short sellers with a net short position of more than 0.5% of the target's issued stock are required to notify regulators in the EU.[2] After matching position holders with hedge funds, I construct the sample of the daily net short position at the fund-target level. The sample period is from 1 November 2012 to 30 November 2021. Then, I go through all fund-target shorting events in the net short position sample and hand-collect announcements that hedge funds voluntarily make on their shorting targets. In total, fifty-eight announcements were made by twenty-seven hedge funds in the net short position sample. Finally, I merge the announcement data with the daily position sample, combined with hedge funds' characteristics, and stocks' trading and price information.

I demonstrate large and immediate stock market reactions to hedge fund announcements. On the announcement date, the price drops around 6% on average, accompanied by a notable increase in the trading volume. In contrast, there are weak reactions to public notifications. Announcements indeed contain new information to the market. I then

[1]Regulators worry that more precise and timely reporting of short selling would facilitate copycat and order anticipation strategies that discourage hedge funds' short-selling activities (SEC, 2014).

[2]These data are also used by several recent papers to study different topics. Della Corte, Kosowski and Rapanos (2021) examine the predictability of the positions on stocks' future returns. Li, Saffi and Yang (2021) study how the presence of large short positions positively influences activists' targeting decisions. Jank, Roling and Smajlbegovic (2021) and Jones, Reed and Waller (2016) study the effects of this public disclosure requirement on trading and stock prices.

define the fund of a shorting event as an *Announcer* when the fund has made announcements about the target during the shorting period. *Followers* are hedge funds that keep silent and start to add short positions after others have released information about the targets. I find that *Announcers* first increase their investments sharply. The short position reaches its peak four days before the announcements. Within 2–3 trading days after the announcements, they cover the position and realise profits from correcting the overpricing in the short term. *Followers* continue to add and hold positions longer after *Announcers* exit. Moreover, *Announcers* are usually younger and smaller in asset size than *Followers*.

To understand these empirical facts, I propose a model to analyse hedge funds' decisions on trading, information acquisition, and disclosure. Inspired by Shleifer and Vishny (1997), I build a game where two strategic hedge funds with limited capital trade against non-strategic noise traders. A subset of risky assets in the market is overpriced due to noise traders, and mispricing could worsen in the short run. Funds can take short positions subject to a leverage constraint. The novel element of my model is that hedge funds do not initially know which assets are mispriced. A fund can search for the mispriced asset at a cost. After it has established its position, it can decide to reveal this information to other hedge funds. Alternatively, a hedge fund can wait for the information revelation from the other fund and jump into the fray only then. Just as in Shleifer and Vishny (1997), funds in my model have to decide whether to enter early, risking being wiped out if the mispricing worsens, or to wait until the interim period, risking missing out on the opportunity. However, I show that the possibility of learning and communication can change this trade-off. If a fund releases its information, the entry of other funds can limit the adverse effects of noise trader shocks.

In particular, I show that there is a Nash equilibrium where one fund (called fund A to denote *Announcer*) chooses to pay the information cost, holds short positions of the overpriced asset, and reveals its information, while the other fund (called fund F to denote *Follower*) decides to wait, to not pay the cost of learning, and enters only after A's announcement. I prove that this equilibrium exists only when fund A is sufficiently small and fund F is sufficiently large. If fund A is small, its price effect is limited. Therefore, the arbitrage trade remains sufficiently profitable for fund F even if fund A has already established its position. On the other hand, to avoid costly liquidation when mispricing deepens, fund A wants to share its information and attract extra capital from fund F to drive down the price. In this sense, the size of fund F should be large enough to be able to provide this protection for fund A. To summarise, small funds voluntarily publish their information to avoid potential loss from fire sales. And large funds save the search cost by waiting for others' information and make profits from being able to trade against noise traders until the price incorporates all the information.

An important implication of the model is that the effect of announcements on market efficiency is ambiguous. With announcements, small funds are more likely to short once they find a mispriced asset because they are more protected against fire sales. This increases market efficiency. However, if large funds can free-ride on the information of the announcers, their incentive to search for other mispriced assets decreases. This decreases market efficiency. I show that the overall effect depends on the size distribution of announcers and followers. In particular, when announcers are better capitalized, the first effect can dominate. The idea is that in this case, they can significantly improve market efficiency even in the periods when the followers are still inactive.

My analysis suggests that if regulators were to validate the credibility of the disclosed information in a timely manner, this would help the market to incorporate the information in prices faster. It would not only encourage the announcers to discover and announce new evidence on more targets but would also decrease the free-riding incentives of followers.

As further testable predictions, my model suggests that we should observe more short-selling campaigns with announcements targeting stocks with lower margin requirements and lower surprise in mispricing. Larger surprise in mispricing, implies smaller mispricing in the current period and larger mispricing in the interim period, which discourages small funds to search for information and enter early. At the same time, very large margin requirements imply that even large hedge funds can only have small price effects. This limits the followers' ability to provide protections against temporarily deepened mispricing for the announcers.

I empirically examine how borrowing constraints and surprise in mispricing are associated with the likelihood of short sellers publicly announcing their positions, which is derived from the model. First, I construct the sample by focussing on short events held by identified announcers and followers in months when announcements are made. For example, in month t, announcer A made an announcement on stock i and fund F is the follower. The test sample contains all targets including stock i that are shorted by fund A or F in month t.

The findings of analysing the stocks in the shorting portfolios of *Announcers* and *Followers* within the same months of announcements provide empirical support for the model. Combining with characteristics of stocks and funds, I then estimate a Probit regression model. The dependent variable is a dummy for each shorting event, equal to one if the short seller made an announcement against the target in month t, zero otherwise. In the first test, the key independent variable is the borrowing costs of stocks in month $t-1$, measured by the daily cost of borrow score in Markit. In the second test, the key independent variable is the magnitude of mispricing in month $t-1$, which is measured by the percentage of upward revisions of analyst forecasts for stocks' EPS. Controlling other stock and fund characteristics, the results indicate that stocks with lower borrowing costs and greater mispricing have a significantly higher likelihood of being publicly announced by hedge funds.

Literature review There is a growing empirical literature studying the effects of arbitrageurs' announcements. Using 124 disclosures of short-sale campaigns in the US, Ljungqvist and Qian (2016) document that investors respond strongly to small arbitrageurs' announcements. Gillet and Renault (2018) find evidence of large market reactions to negative tweets by short sellers at intraday frequency. Wong and Zhao (2017) and van Binsbergen, Han and Lopez-Lira (2021) also examine the impact of short sellers' announcements on real economic activities. They find that target firms significantly reduce their real investment, stock issuance, and payout after announcements. Brendel and Ryans (2021) provide descriptive evidence on how target firms respond to short-seller reports and highlight the material outcomes associated with firm responses. Furthermore, several papers document evidence of the informativeness of short-seller announcements.[3] Luo (2018) and Appel and Fos (2019) show that target stocks earn a cumulative abnormal return after the announcements. Chen (2016) finds that short sellers tend to target firms that have financial reporting red flags and exhibit good reported operating performance. Kartapanis (2019) find that short sellers' allegations in their voluntary reports are a strong predictor of accounting fraud.

My main departure from this literature is that I combine announcement data with the list of short targets at the hedge fund level. Therefore, I can analyse the decisions of shorting with or without the revelation of information. My paper fills the gap in discussions about the subjects who make announcements. Using the novel dataset, I empirically test the predictions generated uniquely from my model. Furthermore, my empirical results in Europe also complement the work on the impact of short-seller announcements on the US equity market.

This paper is also related to recent theoretical work on arbitrageurs' disclosing behaviours. Pagano and Kovbasyuk (2022) argue that hedge funds with short investment horizons will concentrate their disclosures on a few assets because of the limited attention of rational investors. Pasquariello and Wang (2021) propose a model to explain why

[3] A number of papers suggest that short sellers indeed have valuable information since their aggregate shorting can predict stocks' future returns. (e.g., Akbas, Boehmer, Erturk and Sorescu (2017), Wang, Yan and Zheng (2020), Hu, Jones and Zhang (2021), Chen, Da and Huang (2022))

information disclosure is optimal for mutual funds with short-term incentives. Liu (2017) develops a two-period Kyle-type model (Kyle, 1985), where it is optimal to disclose the information when the informed short-horizon investor has a higher reputation. These papers focus on the optimal choice of information disclosures of an informed short seller. Instead, I focus on the strategic game where any of the participating hedge funds can decide whether to be an announcer or follower.

The remainder of the paper is organised as follows. Section 2 presents the data and stylised facts. Section 3 describes the model and demonstrates the existence of equilibrium both under a simplified setup and in a general setting. Section 4 provides details of the sample construction and the results of testing. Section 5 concludes. The Appendix includes proofs of all lemmas and propositions and additional tables and figures.

2 Event Study on Short-Selling Campaigns

2.1 Data

In this paper, I use four types of data to study hedge funds' announcing strategies and trading behaviours: hedge funds' short positions of their targets, voluntary announcements about their shorting strategies, institutional information of hedge funds, and stock-level characteristics. The sample period is from 1 November 2012 to 30 November 2021.

2.1.1 Net Short Position of Hedge Funds

Disclosure requirements on hedge funds' short positions are limited. To address the data issue, I find information on individual short positions by regulation in the EU. According to Regulation (EU) No 236, starting on 1 November 2012, all EU members have introduced public-notification requirements for short sellers. The regulation requires holders of net short positions to notify the relevant authorities when their net short positions of shares reach 0.5% of the issued shares and then at each 0.1% above 0.5%. Notifications must be disclosed no later than the day following the trading day when the positions are held. Regulators in each country publish the latest net short positions on their official websites.[4] For example, the Financial Conduct Authority (FCA) in the UK updates short positions daily on its website.

I download and combine all historical records of net short positions from national regulators' websites in the UK, France, Germany, Netherlands, and Italy. The combined net short position dataset consists of the name of position holders, net short position, position date, and the shorting targets' name and identifier (the International Securities Identification Number, ISIN). In total, there are 1,632 stocks shorted by 722 holders in the net short position dataset from 1 November 2012 to 30 November 2021.

Since the paper focuses on hedge funds' announcements and trading activities, I exclude other types of holders: non-financial corporate firms, pension funds, banks, etc. I manually match the name of position holders in the net short position data with the name of hedge fund companies in Form ADV fillings and the Morningstar Direct global hedge fund database.[5] If matched, I identify the holder as a hedge fund company and keep it.[6] Moreover, I require the shorting targets to be common stocks that are exchange-traded using the stock information from Datastream. After applying all these procedures, I end up with a sample of 428 hedge fund companies' daily short positions in 1,314 stocks. I use NSP to stand for net short positions and call this daily position sample as *Sample NSP*.

[4] Links to the national websites where procedures for notifications of net short positions are explained: https://www.esma.europa.eu/regulation/trading/short-selling

[5] Based on Griffin and Xu (2009) and Jiang (2021), I identify hedge fund advisers from Form ADV fillings by requiring that an adviser's master fund is a hedge fund or it has more than 80% of AUM from its hedge funds.

[6] Net short position notifications are generally submitted by hedge fund companies. In a few cases, the holder's name is the fund name instead of its company name. For these, I change the holder's name to the company name. It is also consistent with the fact that the fund manager, who represents the whole fund company, usually makes announcements.

2.1.2 Voluntary Announcements of Hedge Funds

Next, I obtain hedge funds' announcement data by checking whether hedge funds have voluntarily posted any private information about their short targets contained in Sample NSP. If a report contains additional information about target stocks beyond the size of short positions, I identify it as an announcement. This information could be regarding hedge funds' expectations about falling earnings, allegations of accounting fraud, questions about high valuation multiples, etc.

To simplify the search process, I first define a short-selling link as a unique link between one hedge fund and one of its shorting targets in Sample NSP, regardless of position date. For example, Marshall Wace LLP, a London-based hedge fund, held short positions in Sky PLC from December 2014 to November 2016. This is identified as one link between Marshall Wace and Sky. There are 7,642 such links placed in Sample NSP. Then I search each link in a news database, Factiva, within the sample period.[7] If a shorting link appears in the news and the contents show short sellers' voluntary information about their targets, I take down the earliest announcement date and a summary of such news.

I also complement the announcement data from Factiva with campaigns from Activist Insight Shorts (AiS). AiS is a service module of the data provider Activist Insight. It follows and keeps records of every shorting announcement from all countries. Shorting announcements are short sellers' voluntary disclosures like their research reports or personal opinions from short sellers' websites, Seeking Alpha, Twitter, and press releases. If the target stocks of short-selling campaigns in AiS also appear in *Sample NSP*, I add these campaigns to the announcement data. The announcement sample includes 117 announcements attacking short targets in Sample NSP. Fifty-eight of them are made by 27 hedge funds. And only 12 hedge funds show up both in the announcement sample and

[7] Factiva is a global news dataset with more than 28,000 sources, including US and international newspapers, continuously updated newswires, trade journals, websites, blogs, and multimedia.

Sample NSP.

2.1.3 Other Data

To understand which funds are more likely to make announcements, I analyze fund characteristics using Form ADV filings and Morningstar Direct data. Considering that hedge funds holding short positions in the EU market originate from various countries, I collect my dataset in two steps. First, I obtain the quarterly holdings from Thomson-Reuters 13F S34 data to generate the fund size and quarterly returns of hedge funds matched with Form ADV fillings.[8] Additional characteristics like fund age and style are also sourced from Form ADV. This initial step ensures the inclusion of all US hedge funds in *Sample NSP*. Second, for the remaining hedge funds in *Sample NSP*, I aggregate the monthly fund information in Morningstar Direct to the quarterly fund-company level.

Another crucial aspect in analyzing hedge funds' decisions is to explore the relevance of stock characteristics. I obtain daily price and trading data from Datastream and accounting data for the target stocks from Worldscope. I also construct proxy variables for measuring hedge funds' borrowing cost and noise trader demand shock from Markit and IBES. More information variables can be found in Section 4.

2.2 Stock Market Reaction to Announcements

In this section, I show that the stock market reacts strongly to hedge funds' announcements. If there are multiple announcements associated with the same stock in the same month, I consider only the earliest one. Figure I shows the average return on each trading day around the release of an announcement. On the announcement date, the price drops around 6%. Figure VI in Appendix shows that the cumulative excess return reaches 9.76% if investors start shorting ten trading days before the announcement and buy back ten

[8] The link table of investment advisers between Form ADV and 13F is from Dimmock, Farizo and Gerken (2018).

days later. Figure VI also plots the daily trading volume around the announcement and shows large trading volumes between days -1 and 4. These figures all reveal investors' strong and rapid reactions to hedge fund announcements.

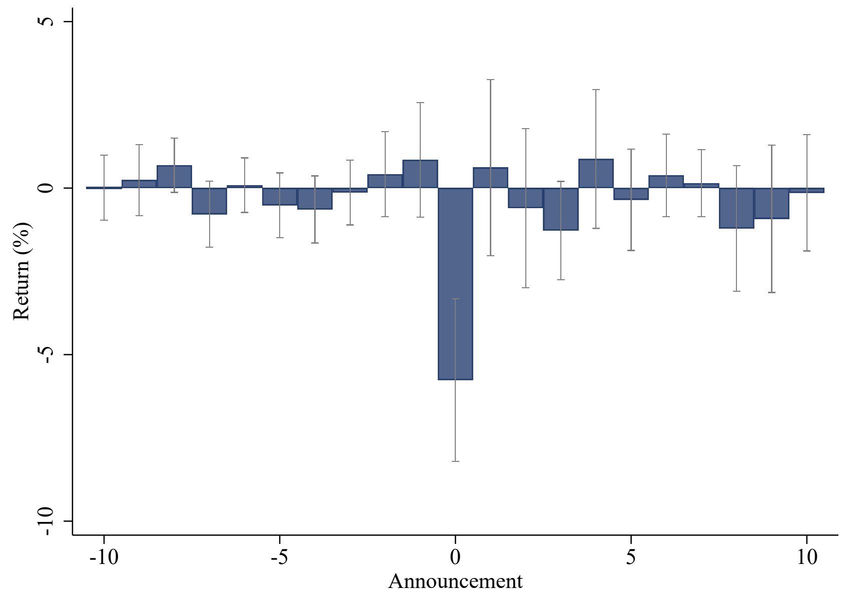


Figure I. Average daily return around the announcement

This figure plots the average return of the target stocks on each trading day around the announcement. Announcement date = 0. The error bars show the 95% confidence interval for the average return.

This strong reaction indicates hedge funds' announcements contain new information for market participants. As a control test, I show that the market reaction to public notifications of short positions is insignificant in Appendix. I identify the first notification as the earliest published position of the target stock or the subsequent position when there are no existing position holders during the past year. The daily return on the notification date and cumulative return around the events are both negative. The daily trading volume reaches its peak on the first notification day. However, the magnitude is much smaller than the reactions to announcements. Markets value the information in voluntary reports more than in mandatory disclosed positions.

2.3 Shorting Activities around Announcements

In what follows I examine how hedge funds trade around announcements. I begin by constructing the sample and then proceed to analyze the trading behaviour of two distinct groups of funds.

2.3.1 Sample Selection

First, I define short seller/target shorting events in *Sample NSP* considering that a fund might bet against a stock multiple times in the sample period. For each shorting event, I identify the first shorting date as the day when the net short position first exceeds 0.5% and the last shorting date as the first subsequent day when the notified net short position falls below 0.5%. In total, there are 15,516 shorting events identified in *Sample NSP*. Because short sellers only need to notify the regulators every 0.1% change of positions, the position dates reported in *Sample NSP* are discontinuous. Assuming that the number of positions is constant between two reported dates within each event, I construct the daily net short positions of hedge funds for all shorting events.

Then, I analyse the hedge funds' roles in each shorting event. I merge the announcement data with the daily short position sample. In this section, my primary focus is to analyze the shorting activities around announcements. To achieve this, I exclude stocks that have never been targeted by any announcements throughout the sample period. The announcement date of each shorting event is when an announcement is published against the stock. If there are multiple announcements, I keep the announcement which is closest to the position date. For each shorting event, I identify the role of short sellers as follows. If a hedge fund made announcements about its target stock, I define the fund as an *Announcer* of this stock. If the fund made no announcements and started to hold short positions after the announcement date, I call it a *Follower*. For instance, fund Y held a short position in stock X on 12 December 2013. There are two announcements about stock X; one was published on 1 November 2013, and another was posted on 5 March

2014. The announcement date of stock X shorted by fund Y on 12 December 2013 is 1 November 2013. If fund Y made the announcement, Y is an *Announcer* of stock X. If not, Y is a *Follower* of stock X. This left us with a total sample of 394 shorting events, where 48 stocks are announced by their short sellers. I call this sample as *Sample A*.

2.3.2 Different Shorting Activities

Next, I examine the shorting activities of *Followers* versus *Announcers* using *Sample A* constructed above. Figure II plots their average shorting activities on each trading day around the release of the announcement.[9] Note that there are no position records if the short position drops below 0.5%. I assume the short position as zero when there is no record. Thus the accurate short positions might be higher than in the figure, but the trend should be similar. The solid line in Figure II shows the average daily position of *Announcers*. They first increase their short position sharply around 3–4 trading days before the announcement. The average position of *Announcers* reaches a peak of 1.24% of the stock's total shares four days before the announcement. Immediately after the announcements, *Announcers* liquidate their position and realize profits rapidly. In contrast, as shown by the dashed line, *Followers* start to add in short positions after the announcement and trade in the opposite direction to *Announcers* and stay much longer. As shown in the bar chart of Figure II, there is a growing number of followers entering into short positions even after announcers exit. The aggregate short positions of *Followers* keep increasing and remain at approximately 1.4% even one year (250 trading days) after the announcement.

In terms of the impact on the market's short selling, both *Announcers* and *Followers* show distinct patterns. Figure III reveals that, in comparison to the overall short interest by short sellers, *Followers* rapidly take dominant positions after observing the announcements. Following the announcements, the role of the main short seller of the target switches from *Announcers* to *Followers*.

[9] Note that different countries have different trading calendars. I exclude each stock's non-trading days based on its exchange's trading calendar.

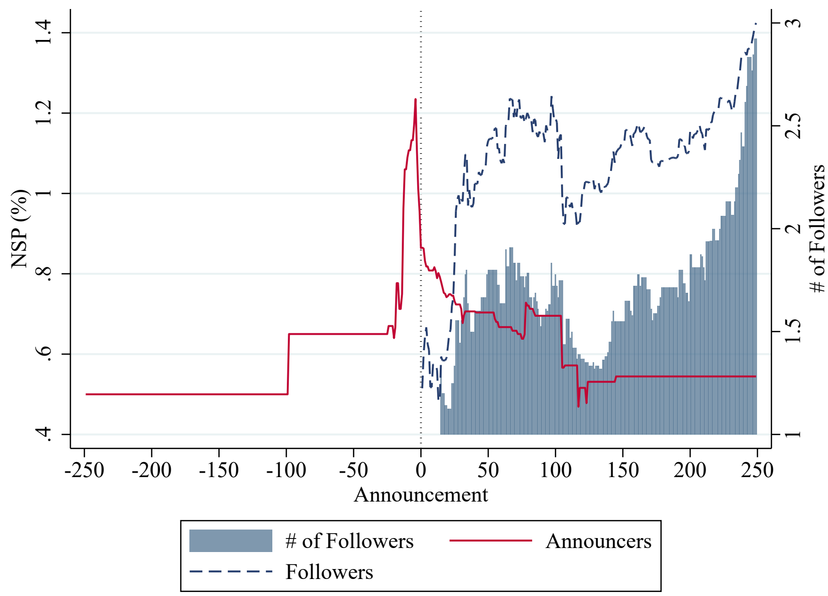


Figure II. Hedge Funds' Daily Short Positions Around Announcements

This figure reports shorting activities of *Announcers* and *Followers* around the announcement. For every announcement on each trading day, there are one *Announcer* and multiple *Followers*. This graph shows average net short positions (NSP) of *Announcers* and *Followers* 250 trading days before and after the announcement. The solid line plots the average *Announcers'* positions per announcement. The dashed line plots the average short positions of all *Followers* per announcement. The grey bar stands for the average number of *Followers* with short positions larger than 0.5% for each announcement.

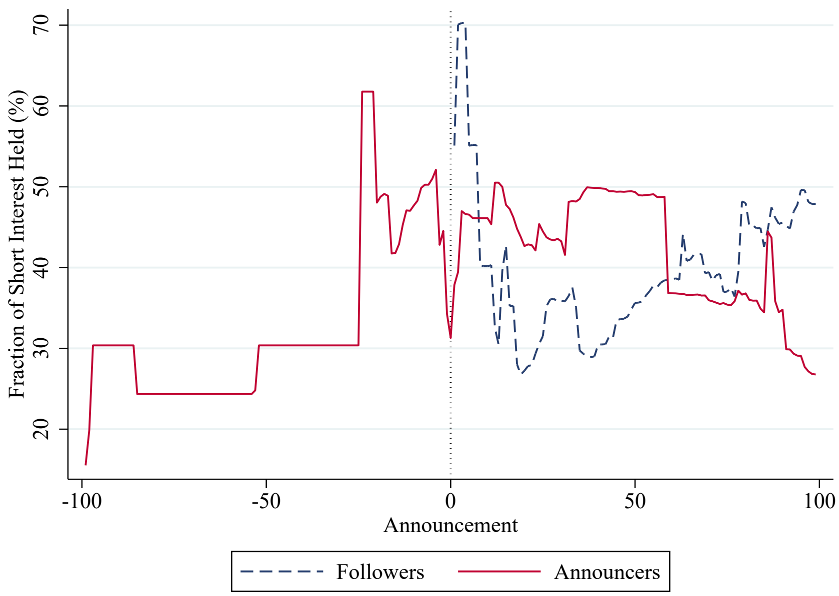


Figure III. Average Fraction of Short Interest Around Announcements

This figure reports the average fraction of short interest of *Announcers* and *Followers* around the announcement. The stock's short interest is the total net short positions held by all short sellers in the daily short position sample. For each shorting event, the fraction of each group is calculated as the individual short position divided by the short interest on each trading day. For every announcement on each trading day, there are one *Announcer* and multiple *Followers*. The solid line plots the average fraction of *Announcers* positions per announcement. The dashed line plots the average fraction of all *Followers* per announcement.

Besides the contrasting trading activities observed in the two primary groups of short sellers, I also identify a final group referred to as the Existing Short Sellers. These are short sellers who do not make announcements regarding their targets and engage in short selling prior to the announcements made by others. Figure IX illustrates that their positions remain relatively stable before and after the announcements. For the purpose of this paper, the main focus will be on the two primary groups, namely the *Announcers* and *Followers*, given their distinct trading activities.

2.4 Different Fund Characteristics

In this section, I investigate which fund characteristics are related to the funds' decisions on shorting and disclosure. First, I extract *Announcers* and *Followers* with their shorting targets and corresponding announcement dates from *Sample A*. I then merge it with hedge funds' fundamental information that corresponds to the same month as the announcement date.

Table I summarises that the average size of an *Announcer* in the dataset is around 3.04 billion dollars. In contrast, on average, a *Follower* manages 28.43 billion dollars, about ten times the size of announcers. Beyond that, the average age of announcers is 4.53 years, roughly half the age of followers. Each announcer, on average, manages 4.04 funds, and each follower manages 29.4 funds. The last column in Table I confirms that for hedge funds shorting the same group of stocks, announcers are significantly younger and smaller than *Followers*.[10]

I further explore the profits of hedge funds with different shorting strategies. Specifically, I construct the measure of the shorting return of fund j holding short positions in

[10] Existing Short Sellers are typically larger than *Announcers*. Table IV shows that they exhibit similar characteristics to the *Followers*. In practise, these short sellers have a diverse range of targets in their portfolios to hedge risks.

Table I. Summary statistics of hedge funds in two groups

This table shows summary statistics of fund-company-level variables. The sample period is from November 2012 to November 2021. *Announcers* and *Followers* are defined for each fund/target shorting event through the sample period. Target stocks that have never been announced by any hedge funds are removed from the full sample. This left 394 shorting events, where short sellers made 48 announcements. If the fund has made announcements on its target, it is an announcer in this shorting event. In contrast, *Followers* are funds which have not made any announcements and started to short the target after announcements. The table presents the summary statistics of *Announcers'* and *Followers'* characteristics in the month of shorting events when the target stocks were attacked by *Announcers*. *Size* is the total net assets (in billions of USD) under management in the fund company. *Age* equals the number of years since the inception of the company's first fund. *Number of funds* is the number of hedge funds in the company.

	Announcers			Followers				
	Mean	Std. errs.	Obs.	Mean	Std. errs.	Obs.	Diff	t-stat
Size ($B)	3.038	2.203	46	28.429	5.15	198	-25.39	-2.361
Age	4.532	0.688	48	9.407	0.479	187	-4.875	-4.835
Number of funds	4.037	0.65	27	29.446	7.134	56	-25.409	-2.463

stock i as

$$\text{Shorting Return}_{i,j} = \frac{p_{i,1}}{p_{i,T}} - 1, \tag{1}$$

where $p_{i,1}$ is the price of stock i on the first shorting date and $p_{i,T}$ is the stock price on the last shorting date. T represents the total holding period of this shorting event.

The shorting return stands for the return when funds sell on the first shorting day and buy back on the last shorting day. It captures the return on the net change of positions during the reporting period. The benefit of this measure is to better detect the return of announcements by assuming that funds keep holding the remaining positions. Table V reports the summary statistics of this measure. The average return of the announcers during the reporting period is around 19. 07%, and the return of the followers is around 1. 76%. The announcers' return is higher than that of the followers', which implies that when announcers can time the market well, they can earn superior profits on their targets.

Empirical results indicate that small funds prefer to short and reveal their information to the public, then make profits from liquidating after announcing. On the other hand, large funds usually add short positions silently after observing the announcements. Henceforth, I label the former group of hedge funds (*Announcers*) as Group A and the latter group (*Followers*) as Group F. One possible explanation for why Group A funds want to disclose their private information is that they face tighter leverage constraints. Large hedge funds have built relationships with prime brokers at investment banks willing to lend them shares. And small funds, which could not form a relationship in their early days, usually find it hard to borrow from institutional primes. Thus, funds in Group A might prefer to drive down the price in the short run by sharing their information. In the following section, I propose a model to examine the mechanism of hedge funds' decision on trading and disclosing when they face leverage constraints.

3 A Theory of Strategic Announcements in Short-Selling Campaigns

3.1 The Model Setup

In this section, I develop a model based on Shleifer and Vishny (1997), who study how informed funds optimally exploit mispricings when facing constraints on equity capital. My model departs from theirs principally by introducing the choice of being informed and the possibility of announcements. Under this setting, I examine how funds strategically exploit arbitrage opportunities against noise traders. Consider an economy with two types of market participants: two hedge funds specialised in short selling and a mass of noise traders with a downward-sloping demand curve. All agents live for three dates: 0, 1, and 2. There are one risk-free bond and N risky assets on the market. Assume that there is no discounting. Each unit of risky asset n gives a payoff of $V_{n,2}$ at date 2, which is independent across all assets with uniform distribution $V_{n,2} \sim U[V - \epsilon, V + \epsilon]$. The price of asset n at date t is $p_{n,t}$. At date 2, the price is equal to the realised value of $V_{n,2}$.

To model the mispriced assets, I assume that noise traders' demand shocks distort a subset of risky assets at date $t = 0, 1$. In particular, these assets face the shock U_t at date t.

This generates noise traders' aggregate demand of asset n as

$$QL(n,t) = (V + U_t)/p_{n,t}, \tag{2}$$

where asset n belongs to the mispriced subset. At date 1, misperception might deepen ($U_1 = U > U_0$) with probability q, or noise traders' demand recovers ($U_1 = 0$) with probability $1 - q$. These shocks might drive prices away from fundamental values.

Two hedge funds, denoted by A and F, can take short positions of assets subject to the leverage constraint at date 0 and 1. Without loss of generality, I assume that each fund can only short one asset with its full capacity or hold zero position at each date.[11] The initial wealth of fund j at date 0 is given as W_j, $j = A, F$. If hedge fund j decides to short $x^j_{n,t}$ units of asset n at date t, the total margin on its position cannot exceed its total wealth W^j_t,

$$W^j_t \geq \frac{1}{\phi} x^j_{n,t} p_{n,t}, \qquad j = A, F, \tag{3}$$

where $\frac{1}{\phi}$ is the margin requirement, exogenously given by financiers. ϕ stands for the maximum leverage that funds can take. At date $t+1$, the total wealth of fund j would be

$$W^j_{t+1} = W^j_t + x^j_{n,t}(p_{n,t} - p_{n,t+1}). \tag{4}$$

The maximum leverage is not too large, that is, $\phi \leq \min(\frac{V}{U-U_0}, \frac{U-U_0}{W_F})$. And hedge funds' initial wealth is limited, $\phi W_j < \min(U_0, \frac{U}{2})$. Thus, hedge funds' resources are insufficient to bring prices back to their fundamental values. Funds' demand for asset n is $QS(n,t) = x^A_{n,t} + x^F_{n,t}$. Given one unit supply of the asset, the market clearing condition is

$$(V + U_t)/p_{n,t} - x^A_{n,t} - x^F_{n,t} = 1. \tag{5}$$

At date 0, hedge funds can pay a cost, denoted by κ, to find one mispriced asset n_j, $j = A, F$. I assume that funds never find the same mispriced asset ($n_A \neq n_F$). This assumption is realistic because many risky assets might be on the market or funds have different

[11] If funds are allowed to short with fractional capital, they can spread out the effect of a deeper shock in the interim period by holding more capital at date 0. However, with limited capital, funds still suffer from the liquidation cost when facing larger noise trader shocks. The arguments in the model also hold.

technologies to identify mispricing.

Each fund can decide whether to announce the mispriced asset n_j to another fund at the end of date 0. Announcements are verifiable, so only funds that have identified the mispricing might announce their findings.[12] If fund j pays the searching cost and decides to keep silent, fund j would be the only informed trader of asset n_j. In contrast, if fund j announces, another fund also realises that asset n_j is mispriced. As only hedge funds can verify the information, noise traders might still trade against the hedge fund after the announcement.

Given the risk-neutral assumption, hedge funds make decisions on trading, information acquisition, and disclosure to maximize their wealth W_2^j at date 2. The decision-making process is illustrated in Figure IV.

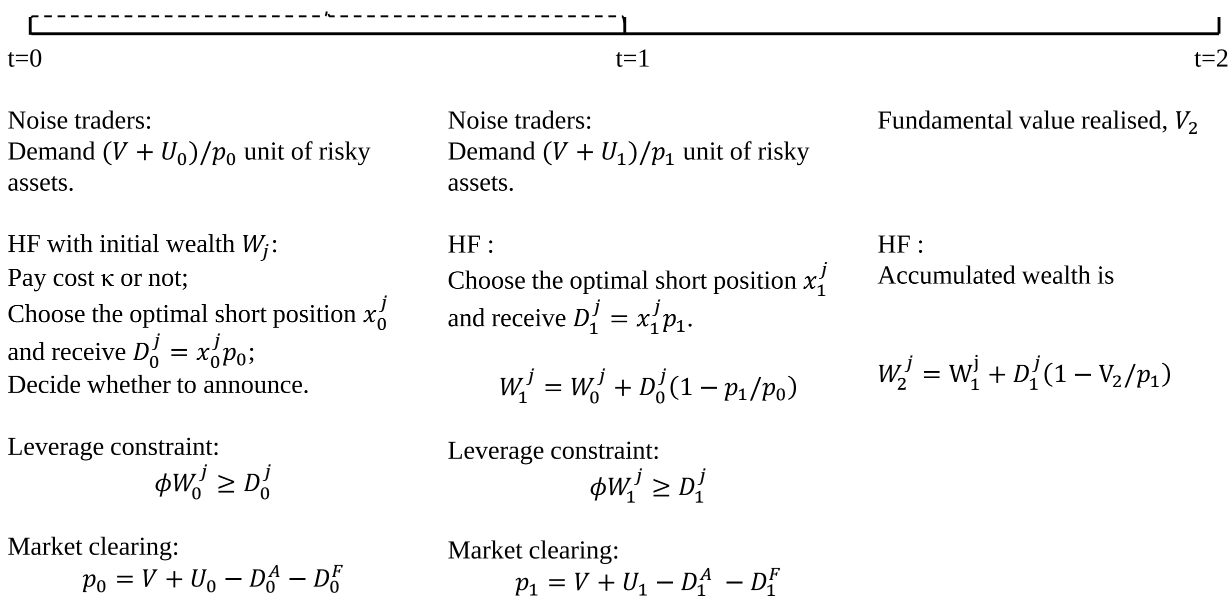


Figure IV. Decision Process

[12]In the literature of strategic communication (e.g., Crawford and Sobel (1982), Sobel (1985)), privately informed agents choose to fully reveal their information in the equilibrium if their utility is aligned with uninformed agents.

3.2 Equilibrium Concept

To summarise, the environment described above represents a two-player game

$$\Gamma = (2, \{S_A, S_F\}, \{u_A, u_F\}),$$

which is defined by (1) the set of strategies of hedge fund j,

$$S_j = \Big\{s_j | s_j \in (\{\kappa,\ 0\},\ \{Announce(A),\ Not\ Announce(NA)\},\ \{(0,1) \times (0,1)\})\Big\},$$

where $\{(0,1) \times (0,1)\}$ represents the set of decisions of trading (0 for zero position, and 1 for shorting with full capacity) at date 0 and 1; and (2) the payoff $u_j(s_j, s_{-j})$, the expected terminal wealth of fund j at date 0 when fund j chooses action s_j and the counterparty chooses action s_{-j}. Hedge funds optimally choose their strategies to maximize their wealth at date 2.

Definition 1. A Nash equilibrium of this two-fund game is a vector (s_A^*, s_F^*) such that s_j^* solves the problem

$$\max_{s_j \in S_j} E(u_j(s_j, s_{-j}^*))$$

for each fund j.

3.3 Equilibrium with Announcements

In this section, I examine the equilibrium strategy of the game described above in three steps. First, I explain what would happen without announcements. This is my version of the Shleifer and Vishny (1997) benchmark. Next, I introduce the possibility of announcements but assuming fund F has unlimited capital. In this simplified setting, the optimal strategy of fund F is trivial since fund F always has the capital to follow other's investments when observing the announcement. Therefore, I can separate fund A's incentive to announce. After paying the cost, funds that enter early can limit the adverse effects of noise trader shocks by attracting the entry of other funds via announcements. I show that the region of fund A choosing to announce is decreasing in the fund size.

Finally, in the general setup, I demonstrate why and when the equilibrium with Announcers and Followers exists when each has limited capital. Consistent with the empirical facts, small fund A prefers to announce, and large fund F waits to learn A's information to exploit the mispricing.

3.3.1 Strategy without Announcements: SV Benchmark

Consider the case without announcements, wherein each fund optimally chooses short positions after paying the cost. For concreteness, I study fund A's optimal choice in this subsection. Fund F's problem is independently identical to A's problem since each of them would be the only informed trader once paying the cost.

To begin, I examine the choice of fund A given it has paid the cost and learns asset n_A is mispriced. Let D_t denote the amount that fund A receives from short sales at date t. At date 1, when the optimistic belief of noise traders disappears $U_1 = 0$, fund A would liquidate its position and hold cash ($D_1 = 0$, $W_2^A = W_1^A$). In contrast, when the misperceptions of noise traders deepen $U_1 = U$, fund A would fully invest $D_1 = \phi W_1^A$ because the price p_1 is above the fundamental value.[13] If fund A fully invests from date 0, p_0^A represents the asset price at date 0 and p_1^{AA} is the price when the demand shock is worse at date 1. If fund A chooses to wait and begin to short at date 1, the asset price is $V + U_0$ at date 0 and p_1^A at date 1. The following Lemma 1 demonstrates the optimal choice of shorting for fund A.

Lemma 1. *If fund A has paid the cost and no announcements were made, for given W_A, U_0, U, V, and ϕ, there is a threshold q^{na} such that, for $q > q^{na}$, fund A would wait $D_0 = 0$ and for $q \leq q^{na}$,*

[13] Although fund A is a monopolist here, it would choose to short with the full capacity as long as shorting is profitable by assumption. Another explanation is that fund A's capital is limited, so the profits from short selling always increase in the shorting amount and fund A would reach the corner solution.

fund A would fully invest $D_0 = \phi(W_A - \kappa)$. q^{na} is written as

$$q^{na} = \begin{cases} \dfrac{\phi(1-\frac{V}{p_0^A})}{1+\phi(1-\frac{V}{p_0^A})+\phi(1-\frac{V}{p_1^A})} & W_A > W^* \\ \dfrac{1-\frac{V}{p_0^A}}{1-\frac{V}{p_1^A}-(1+\phi)(1-\frac{p_1^{AA}}{p_0^A})(1-\frac{V}{p_1^{AA}})} & W_A \leq W^* \end{cases},$$

where $W^* = \kappa + \frac{1}{\phi(1+\phi)}(V + U_0 - \phi(U - U_0))$. q^{na} decreases in W_A.

Lemma 1 is parallel to the results in Shleifer and Vishny (1997). The leverage constraint gives rise to the amplification of mispricing via a mechanism similar to that for capital constraints. Suppose fund A has identified the overpriced asset and takes short positions with full capacity at date 0. Fund A then has exposure to the risk of worsening mispricing at date 1. If noise traders continue to be confused and demand more shares at date 1, the increasing price triggers the margin calls. Consequently, fund A is forced to reduce short positions when the arbitrage opportunities are the best. Instead of shorting at the beginning, fund A could also wait to short sell at a higher price and avoid the potential loss from margin calls. Therefore, in cases where noise trader misperceptions are very likely to deepen—that is, the noise trader risk q is large than the threshold q^{na}—fund A would refrain from shorting early and choose to enter during the interim period instead.

The threshold q^{na} is determined differently when fund A is wealthier. Given other parameters fixed, fund A could take more short positions with larger initial wealth. The asset price at date 0, p_0^A, is smaller because of the larger price impact. If fund A has taken large short positions and mispricing worsens, there is a possibility that the increasing price would drive the fund's wealth below zero. In the extreme case, fund A is forced to buy back stocks and go bankrupt. Fund A has no capital to correct the price $D_1 = 0$ even if the asset is overpriced. More formally, when fund A holds short positions with full capacity at date 0 and 1,

$$W_1^A < 0 \quad \textit{iff} \quad p_1^{AA} > (1+\frac{1}{\phi})p_0^A. \tag{6}$$

Based on condition (6) and market clearing condition, when $W_A > W^*$, fund A is required to close short positions $W_1^A \equiv 0$ if $U_1 = U$. In contrast, when $W_A \leq W^*$, fund A can keep shorting the asset. Lemma 1 shows threshold q^{na} for fund A in each situation.

Moreover, q^{na} is decreasing in W_A. When fund A is wealthier, it has more exposure to the noise trader risks if shorting early. If the probability of deeper shock is considerable, wealthier funds choose to delay shorting and wait until date 1. More detailed proof could be found in the appendix.

Based on Lemma 1, next, I compare the expected profit of shorting with the learning cost. Lemma 1 shows when funds decide to learn.

Lemma 2. *When $W_A > \underline{W}$, the benefits of gaining the information and shorting are more significant relative to the cost κ, and fund A would always pay to learn.*

Intuitively, as long as fund A's remaining capital after paying the learning cost is not too small, fund A could take enough short positions and receive positive net profits. In the Appendix, I provide the proof of lemma 2.

3.3.2 Announcements when One Fund Has Unlimited Capital

In this subsection, I investigate the optimal strategy of funds on announcements. Assume that the initial wealth of hedge fund F is unlimited. Note that whenever fund F observes an announcement about another mispriced asset, fund F would engage in shorting since it has no shorting constraint. Only hedge fund A's decision matters in the equilibrium. In this modified setting, I can focus on the incentive of fund A to announce. Now fund A's problem is to maximize the expected assets under management $E(W_2^A)$ at date 2.

Fund A makes decisions on shorting, announcing and information acquisition. First, if fund A does not pay the learning cost, fund A would hold risk-free bonds because shorting is costly without any information. Second, consider the case when fund A has paid the cost and identified that asset n_A is mispriced. At date 1, fund A always hold short position with its full capacity if the misperception is worse. If fund A decides to keep silent, its optimal choice is determined by the noise trader shock based on Lemma 1. If fund A makes an announcement, fund F realises that the asset is mispriced. Both funds are informed and choose their optimal short positions simultaneously.[14] Compared with shorting silently, the asset price at date 1 is lower because of the entry of fund F. Hence if and only if fund A decides to short from date 0, A would announce to avoid costly liquidation. Fund A solves the maximization problem:

$$\begin{aligned}\max_{s_A} E(W_2^A) =& (1-q)W_1^A(V) + q(1+\phi(1-\frac{V}{p_1^u}))W_1^A(p_1^u)\\ s.t. \quad & W_1^A(p_1) = W_A - I_{s_A}k + D_0(1-p_1/p_0),\end{aligned}$$

where the feasible set of strategies $s_A \in \{(0, NA, 0\times 0), (\kappa, NA, 0\times 1), (\kappa, A, 1\times 1)\}$ and p_1^u is the asset price when noise traders experience a deeper shock at date 1. The following proposition 1 illustrates the optimal strategy of fund A.

Proposition 1. *For given $W_A > \underline{W}$, U_0, U, V, κ and ϕ, there is a threshold q^a such that, fund A chooses to wait $(\kappa, NA, 0\times 1)$ if $q > q^a$ and chooses to fully invest and announce $(\kappa, A, 1\times 1)$ if $q \le q^a$.*

From Lemma 2, fund A prefers to learn the mispriced asset when $W_A > \underline{W}$. If the mispricing of noise traders worsens with a large probability, it is optimal for fund A to wait and silently invest from date 1 because fund A could short when the overpricing is the most extreme and prevent costly liquidation. However, if it is very likely that the mispricing disappears at date 1, $q \le q^a$, fully investing and announcing is the best strategy for fund A to gain profits from correcting prices at date 0 and reduce the loss from the potential margin calls. Fully investing and keeping silent is a dominated strategy in this setting because (1) the shorting return is the same when the demand shock of noise traders disappears at date 1, and (2) fund A is forced to reduce more positions since the

[14] In the duopoly model where fund F has unlimited capital, fund A would short at its full capacity and fund F's profit is at the monopoly level.

asset price is higher when keeping silent. This explains why some hedge fund managers might reveal information about their shorting targets to the public.

The region of q in which fund A chooses to fully invest and announce at date 0 is determined by the given parameters. Given other parameters constant, I further check the role of the fund size in funds' announcing decisions.

Proposition 2. *q^a decreases in W_A. The area of shorting early is larger compared with the SV benchmark, $q^a > q^{na}$.*

Proposition 2 shows that small funds are more likely to reveal their shorting information. When the initial wealth is larger, fund A is less willing to invest fully at date 0 because of the potential margin calls or forced liquidation. Instead, waiting for larger mispricing is safer for a given q. Although announcements help to control the price, the benefits of announcing are less attractive when fund A is wealthier and can take more prominent positions. Large funds can wait to hold large short positions when the mispricing is deepened. It is less profitable for them to establish positions early and make announcements. This predicts it is more common to observe small funds instead of large funds sharing their information.

Moreover, announcements encourage short sellers to take positions once they find mispricing assets. Prices are more efficient with announcements. From Proposition 2, the threshold of shorting early is higher than the benchmark, $q^a > q^{na}$. This implies that if funds have the option to announce their shorting targets, they are more willing to start shorting whenever they identify an overpriced asset. Information is incorporated into prices faster than in the benchmark case.

3.3.3 Equilibrium when Two Funds Interact

In the simplified setup above, fund A's decision-making purely depends on its own profits. Fund F would always add short positions when fund A makes announcements. When fund F has limited capital and plays a non-trivial strategy, how would funds change their decisions? To address this question, I further explore the equilibrium in the general setting, where arbitrage resources are insufficient to bring prices back to the expected fundamental values. The asset price at date 1, $p_{n,1}$, is always above the fundamental value V if noise traders continue to be confused. Uninformed funds could still benefit from shorting after observing announcements at date 1. In particular, I focus on an equilibrium where fund A announces and fund F waits to invest later. I prove that the equilibrium holds under certain conditions.

First, I narrow down the feasible strategies of hedge funds in the general setting. To maximize their wealth, funds' decisions on learning, announcing, and shorting at date 0 are closely related. If the fund manager decides not to pay the cost at date 0, she would only take a short position after observing announcements at date 1. Otherwise, she would hold bonds until date 2. If the manager of fund j chooses to learn, she might announce her information to the public only when she starts shorting at date 0. Otherwise, keeping silent is preferred when she decides to enter at date 1 because she wants to sell at a higher price. Hence, there are in total four feasible strategies for each hedge fund to play, $(0, NA, 0 \times \cdot)$ (No cost paid, no announcements, and no shorting at date 0), $(\kappa, NA, 1 \times \cdot)$, $(\kappa, NA, 0 \times \cdot)$, and $(\kappa, A, 1 \times \cdot)$ (pay the cost, announce, and fully invest at date 0).

The trading decisions at date 1 is fully determined by the realization of noise trader shock. When noise traders are more optimistic $U_1 = U > U_0$ at date 1, the asset price is higher than the fundamental value because funds' capital is limited. In this case, hedge funds would always short with total capacity if they know the asset is overpriced from learning or announcements. When noise traders realise the true value $U_1 = 0$ and $p_{n,1} = V$, funds liquidate their positions and hold risk-free bonds until date 2.

Second, I pin down the expected wealth of each fund j given its strategy. Let $p_t = p_{n_j,t}$, $V_2 = V_{n_j,2}$ for notational simplicity, where asset n_j is an arbitrary mispriced asset that fund j learns by paying the cost or seeing announcements. p_1^u is the asset price when $U_1 = U$. D_t^j is the shorting value that fund j decides to take on the mispriced asset n_j at date t. The asset index is negligible here because funds can take short positions in only one asset. The expected terminal wealth of fund j can be written as

$$u_j = (1-q)[W_j - I_{s_j}\kappa + D_0^j(1-\frac{V}{p_0})] + q(1+\phi(1-\frac{V}{p_1^u}))W_1^j(s_j, s_{-j}, W_j). \tag{7}$$

I restrict the attention to the specific equilibrium where $s_A^* = (\kappa, A, 1\times 1)$ and $s_F^* = (0, NA, 0\times 1)$ and verify that it is a Nash equilibrium. In the equilibrium, fund A pays the cost, makes an announcement, and fully invests at date 0; Fund F does not pay the cost and waits to hold a short position silently at date 1; Each fund j maximizes the expected terminal wealth u_j. This equilibrium is beneficial to both funds. By fully investing at date 0, fund A gains profits from correcting the price. It also shares the mispricing information to fund F to reduce the potential loss from margin calls. Fund F chooses to save the cost of learning by waiting for the announcement. If there is an announcement and the demand shock deepens, fund F profits from absorbing the demand of noise traders.

The equilibrium exists if and only if each fund maximizes its expected wealth and no one deviates. To verify the equilibrium, I proceed in two steps. First, I derive conditions when s_F^* is the best response for fund F. Second, I find conditions that s_A^* is the best response for fund A. Combining all conditions, I present the existence of the equilibrium.

Fund F's best response is s_F^* Fund F will not deviate from the equilibrium. Given the strategy of fund A, the payoff of fund F in the equilibrium, $u_F(s_A^*, s_F^*)$, should be larger than payoffs when fund F chooses any other strategy. Suppose that fund F decides to learn and gain the information of another asset n_F. If fund F also chooses to short early and announce, neither F nor A wants to change their existing shorting targets at date 1. This is because the demand shocks are the same for both assets and the shorting return is lower at date 1 if they bet against the same asset. In addition, if they switch targets, funds have to close their previous positions at higher prices. Thus, the payoff for fund F to playing the strategy $(\kappa, A, 1\times 1)$ is the same as with $(\kappa, NA, 1\times 1)$. On the other hand, if fund F chooses to keep silent and starts shorting at date 1, define p_0^F and p_1^{FF} as prices of the asset that fund F finds and fully invests at dates 0 and 1. p_1^F represents the asset price when fund F chooses to wait and short only at date 1. p_1^{u*} is the asset price in the equilibrium when $U_1 = U$. Thus, the fact that s_F^* is the best response of fund F if and only if

$$\kappa \geq \frac{\phi \bar{R}_F + q\phi(V/p_1^{u*} - V/p_1^{FF})}{(1 + \phi \bar{R}_F + q\phi(1 - V/p_1^{FF}))} W_F \tag{8}$$

$$\kappa \geq \frac{q\phi(V/p_1^{u*} - V/p_1^F)}{1 + q\phi(1 - V/p_1^F)} W_F, \tag{9}$$

where $\bar{R}_F = (1-q)(1 - V/p_0^F) + q(1 - p_1^{FF}/p_0^F)(1 + \phi(1 - V/p_1^{FF}))$ represents fund F's expected return when choosing to short silently from date 0. Intuitively, Fund F would stay in equilibrium when the information cost is higher than the marginal benefits of learning and silently shorting overpriced assets. Condition (8) guarantees that it's not profitable for fund F learning and shorting from date 0. Condition (9) represents that the marginal benefit of changing to learning and shorting at date 1 is less than the information cost saved in the equilibrium. These conditions imply that the equilibrium price p_1^{u*} is the only channel that fund A has a impact on fund F's choice.

Rearranging conditions (8) and (9), fund F's best response is s_F^* if the equilibrium price satisfies

$$p_1^{u*} \geq \frac{V}{1 - \frac{1}{q\phi}(\frac{u_F^{na}}{W_F} - 1)}, \tag{10}$$

where u_F^{na} is the maximum wealth if fund F holds short positions silently. Fund F profits from shorting after learning about mispriced assets in others' announcements. The higher the equilibrium price, the higher the return fund F would gain. This means that the equilibrium price should be large enough that it is more valuable for fund F to wait for announcements and sell at the equilibrium price. Given the information cost κ and other parameters constant, from the market clearing condition, I derive the equilibrium price as a function of W_A and W_F:

$$p_1^{u*} = (1 + \frac{U - U_0 - \phi W_F}{V + U_0 - \phi(1+\phi)(W_A - \kappa)})(V + U_0 - \phi(W_A - \kappa)). \tag{11}$$

Thus, condition (10) for the equilibrium price characterizes the relations between W_A and W_F in the equilibrium. Lemma 3 demonstrate the conditions when Fund F won't deviate from the equilibrium.

Lemma 3. *The equilibrium price p_1^{u*}, is decreasing in W_A. There exists an upper bound $g(W_F)$ such that condition* (10) *is satisfied if and only if $W_A < g(W_F)$. In other words, given fund A's strategy s_A^*, $s_F^* = (0, NA, 0 \times 1)$ is the best response of fund F if and only if $W_A < g(W_F)$. This upper bound is decreasing in W_F, $g'(\cdot) < 0$.*

The dotted line in Figure V represents the function $g(W_F)$ for the upper bound of fund A size. For given parameters, V, U_0, U, ϕ, κ, and q, fund F has no incentive to deviate if the size of fund A is below the dotted line. Fund F would like to wait for A's information when it receives high shorting benefits at date 1. When fund A is small, its price effect is limited. Therefore it remains profitable for fund F to trade even if fund A has established its position. It is a good deal for fund F to save searching costs and benefit from shorting.

The upper bound decreases when fund F gets larger. In other words, the richer fund F is less likely to wait and not pay the learning cost. This is because when fund F has more capital, the learning cost is relatively lower than the profit of actively shorting. The opportunity cost of foregoing the arbitrage opportunity at date 0 increases as fund F is able to take larger positions. On the other hand, when the mispricing deepens at date 1, fund F gains a higher selling price if it remains silent compared to the price it would obtain from sharing information with fund A. Thus, fund A has to be much smaller when fund F is large in the equilibrium. This explains why the announcers we observe are tiny on average among other short sellers.

Fund A's best response is s_A^* Second, Fund A won't deviate in the equilibrium when the payoff $u_A(s_A^*, s_F^*)$ of fund A in the equilibrium is larger than the outcome of other strategies. Specifically, when fund A does not pay the cost, it would hold cash and the expected utility is W_A, which should be lower than $u_A(s_A^*, s_F^*)$. In addition, when fund

A chooses to learn and silently short, fund A should also receive a payoff that is below $u_A(s_A^*, s_F^*)$.

To pin down the payoff, it is important to first check whether fund A would be forced to liquidate its position at date 1 if fund A chooses to short early. As with the definition under the simplified setup, p_0^A and p_1^{AA} stand for asset prices at date 0 and 1 when fund A starts shorting silently from date 0. p_1^A represents the asset price when fund A chooses to wait and silently short from date 1. In equilibrium, fund A takes short positions from the beginning. The equilibrium price p_0^* is equivalent to p_0^A because fund A is the only informed trader at date 0. Similar to the previous discussion, suppose that fund A has to liquidate because the equilibrium price is too high, that is, $p_1^{u*} > (1 + \frac{1}{\phi})p_0^*$ from equation (6). The asset price when fund A silently shorts for two periods, p_1^{AA}, is always higher than the price in the equilibrium with announcements p_1^{u*}. When fund A is forced to liquidate in the equilibrium, fund A must also liquidate when choosing to silently short from date 0. In this case, the profit of shorting silently is the same as that of shorting loudly from date 0, and fund A will not deviate from s_A^*. When fund A can take non-zero short positions at date 1, it gives the relation between W_A and W_F in the equilibrium:

$$W_A \leq \kappa + \frac{1}{\phi(1+\phi)}(V + U_0 - \phi(U - U_0 - \phi W_F)). \tag{12}$$

The equilibrium payoff of fund A when announcing can be written as

$$u_A(s_A^*, s_F^*) = \left[(1-q)(1+\phi(1-\frac{V}{p_0^*})) + q(1+\phi(1-\frac{p_1^{u*}}{p_0^*}))(1+\phi(1-\frac{V}{p_1^{u*}}))\right](W_A - \kappa). \tag{13}$$

Again from the equation (3.3.3), fund F affects fund A's decision only through the equilibrium price p_1^{u*}. Note that based on equation (11), the equilibrium price p_1^{u*} is decreasing in the fund F size. When fund F has more capital, it can take more positions in mispriced assets and drive the price more towards the expected fundamental value. Under the assumption that ϕ is not too large, the expected wealth $u_A(s_A^*, s_F^*)$ is decreasing in p_1^{u*}. Thus, fund A profits more in the equilibrium when fund F is larger. In the appendix, I prove the following lemma that shows the second relation between W_A and W_F for the equilibrium to hold.

Lemma 4. *The payoff of fund A in the equilibrium, $u_A(s_A^*, s_F^*)$, is decreasing in p_1^{u*} and increasing in W_F. There exists a lower bound $h(W_A)$ such that given fund F's strategy s_F^* and $W_A > \underline{W}$, $s_A^* = \{\kappa, A, 1 \times 1\}$ is the best response of fund A if and only if $W_F > h(W_A)$. This lower bound is increasing in W_A, $h'(\cdot) > 0$.*

The dashed line in Figure V plots the lower bound $h(W_A)$ for the size of fund F. Any points on the right-hand side of the dashed line stand for a combination of fund size such that it is optimal for fund A to announce and fully invest at date 0. When fund A is not tiny, the manager prefers to learn the overpriced asset since she can benefit from shorting after paying the information cost. To avoid the potential cost of liquidation, fund A is willing to share the information only if the asset price after announcements is low enough. Because the asset price with announcements is decreasing in the size of fund F, W_F, fund A will not deviate from the equilibrium as long as fund F is large enough.

When the size of fund A increases, this lower bound of fund F size in the equilibrium increases. When fund A is larger, fund A will sell assets at a lower price at date 0, and the performance is poorer at date 1. In this case, fund A suffers more from margin calls, and the asset price at date 1 increases because of fund A's buying back. Thus, fund A needs to attract more capital to drive down the price at date 1 by announcements. In this sense, the lower bound of the size of fund F is higher to provide protection to fund A when fund A is rich.

In the Nash equilibrium, neither fund A nor F will deviate from their strategies. Combining Lemmas (4) and (3) together, I provide sufficient conditions of the existence of the equilibrium as follows.

Proposition 3. *There exists an equilibrium $s_A^* = \{\kappa, A, \phi(W_A - \kappa)\}$ and $s_F^* = \{0, NA, 0\}$ in the area where $W_A < g(W_F)$ and $W_F > h(W_A)$.*

The shaded area (marked as "Zone 1") in Figure V illustrates the region where the equilibrium exists. There is a lower bound for the size of fund F and an upper bound for the size of fund A. As previously discussed, the upper bound of fund A decreases when fund F is wealthier. And the equilibrium price is falling in the size of funds A and F. The feasible region would be situated in a scenario where fund A has a small size while fund F has a large size. In the appendix, I also show that $W_A < \min(h^{-1}(W_F), g(W_F)) < W_F$. This result implies that the size of funds that announce their information is usually small compared with the size of funds that passively wait for trading.

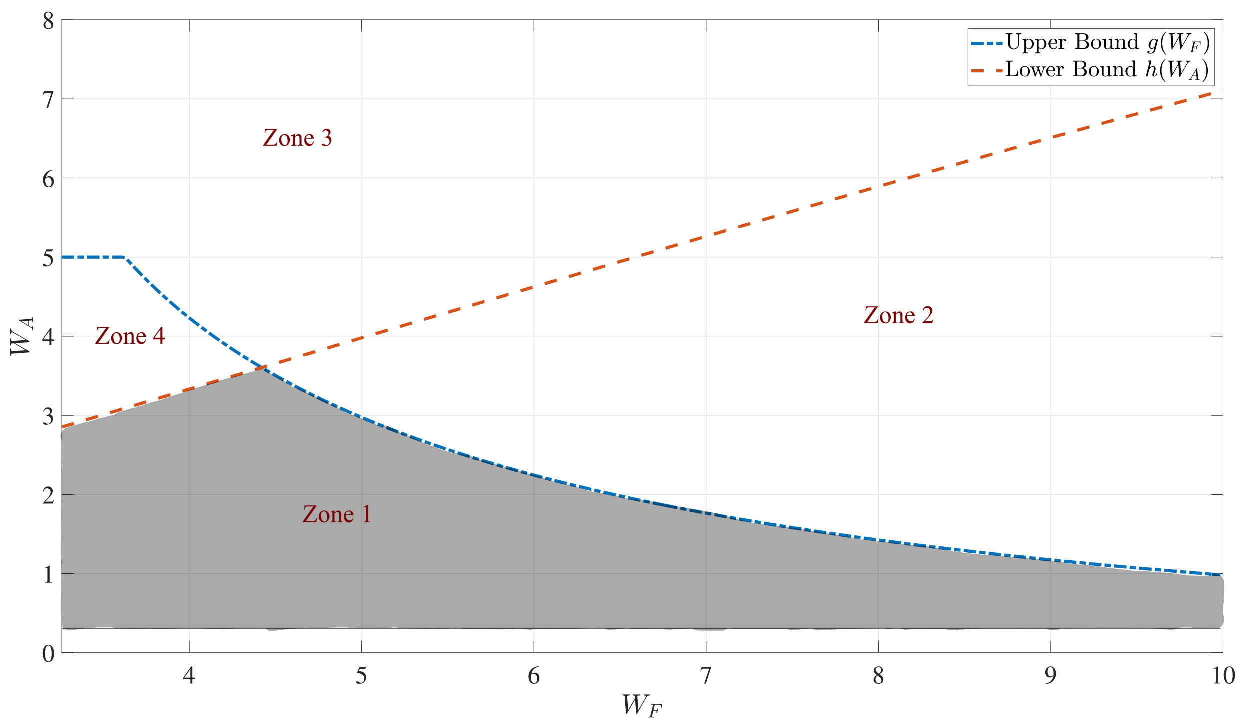


Figure V. Theoretical relation between fund A and fund F

This figure reports the relation between fund A and fund F given the following parameters that satisfy all assumptions: $V = 100, U_0 = 30, U = 60, \kappa = 0.05, \phi = 2, q = 0.35$. The dashed line gives the lower bound of fund F, and the dotted line gives the upper bound of fund A. The shaded area is the validated zone for the equilibrium to hold.

To summarise, in this two-player game, the equilibrium with Announcers and Followers exists only if fund A is small enough and fund F is large enough. Fund F benefits less from the announcements (the price impact of additional capital is weaker), which leads fund F to wait and then free-ride on fund A's information. Meanwhile, fund A faces the potential costs of liquidation and benefits more from the price drop at date 1. Size plays an important role in hedge funds' decisions on trading and disclosing.

3.4 Model Implication

In this section, I further explore the impact of announcements on market efficiency and other elements that affect funds' disclosing behaviour. First, I find that the effect of announcements on market efficiency is dependent on the size distribution of announcers and followers. Announcements improve market efficiency if announcers are better capitalized, while if announcers are tiny, the effect of announcements discouraging followers from searching for other arbitrage opportunities dominates. Second, for a given distribution of fund size, small funds make more announcements if they can take larger leverage. Last, the more volatile the noise trader shock is, the less likely the small funds will announce.

3.4.1 Market Efficiency

In the previous section, I discuss that in the simplified version, where fund F has unlimited capital, asset prices are more efficient when announcements are allowed. However, in the general setup, there are two competing forces affecting market efficiency. On the one hand, small funds are willing to short immediately since they can reduce liquidation costs by making announcements. Asset prices are corrected faster. This helps market efficiency. On the other hand, large funds lose their incentive to search by themselves and choose to wait for others' information instead. Fewer mispriced assets are identified. This hurts market efficiency. In combination, it is ambiguous whether the market is more efficient because of funds' announcements.

To study the aggregate effects formally, I build the following measure of market efficiency:

$$\text{Market Efficiency} = E_0 \sum_{n=1}^{N} (\frac{p_{n,0} + p_{n,1}}{2} - V)^2. \tag{14}$$

This is the squared sum of the price difference from the fundamental value for all assets on the market. The higher the value, the less efficient the market is. There are two main determinants of market efficiency captured by this measure. First, if asset prices keep deviating from the fundamental value in date 0 and 1, the value is higher. Second, if there are more unidentified mispriced assets, the market is less efficient.

Next, I compare the market efficiency of the equilibrium with that of the SV benchmark. Each fund would identify one overpriced asset in the benchmark with no announcements. In contrast, only one asset is found by fund A in the equilibrium. So the difference in the market efficiency comes from two assets. If an asset is not found by funds, the asset price is $V + U_t$ at date t. Figure X illustrates how the market efficiency changes in the equilibrium and in the benchmark case when one fund has a fixed size and the other fund's size varies. Given a fixed size of fund A, the market is always more efficient with announcements compared with the benchmark case. The bottom graph shows that the impact of announcements on market efficiency does not vary too much when the size of fund F increases.

However, when the fund F size is fixed, the market could be less or more efficient depending on the size of fund A. When fund A is larger and can hold some short positions, the prices at dates 0 and 1 are closer to the fundamentals. Compared with the benchmark, the benefits of announcements to avoid margin calls also increase when A is wealthier. Thus, the market is more efficient. When fund A is tiny, the effect of correcting the price early is limited and sharing information hurts fund F's incentive to search. As a result, the market is less efficient, although the magnitude is negligible. In summary, the relative size of announcers to followers determines the aggregate effects of announcements on market efficiency. When announcers manage more assets, the effect of announcers' early entry dominates and their announcements improve market efficiency.

An important implication for the regulator here is to help timely verify the announced mispricing information so that it is quickly incorporated into the price, which further encourages more funds to announce. When a group of small funds begin to short and share their information, more mispriced assets are found, and the capital can be allocated to other arbitrage opportunities.

3.4.2 The Effect of the Maximum Leverage ϕ

The probability q of mispricing worsening at date 1 plays a critical role in the existence of the equilibrium. Given the distribution of fund sizes, there is a range of q where the equilibrium exists. When it is more likely that the noise trader will meet an increased optimistic shock, fund A prefers to wait and short from date 1 instead. When q is small, fund F is less willing to passively wait for others' information. As shown in Figure XI, the area where the equilibrium exists widens when funds can take higher leverage.

Intuitively, the impact of increasing leverage is more substantial on fund F. If the margin requirement is lower, large fund F is able to take larger short positions. Fund F would like to wait since it will gain more from exploiting the mispricing at date 1, which means the lower bound of q decreases. In contrast, the increase in fund A's capacity to short is relatively minor. The upper bound of q will not differ much. Therefore, the range of q for the equilibrium to exist is larger. This generates the unique implication that we should observe more announcements from small funds when hedge funds can borrow stocks with higher leverage.

3.4.3 The Effect of Surprise in Mispricing $U - U_0$

Funds would also vary their decisions based on the targets' characteristics. In the model, the magnitude of potential demand U is directly related to funds' shorting profits at date 1. When the distribution of fund size is fixed, the equilibrium exists within a range of q. If the change in the misperceptions is larger, both funds would like to wait and short from date 1. Controlling the size of fund F, when it is more costly to short early and the impact of announcements is limited, fund A would prefer to short silently from date 1. As Figure XII indicated, small funds are less likely to reveal their information when the surprise in mispricing is very large. Moreover, the relative growth in shorting profits for large fund F is small when the scale of misperceptions increases. Hence the changes in the lower bound of q for fund F to follow A's information are small. In total, the area where the equilibrium exists is shrinking when the potential demand shock increases. It implies that more announcements would be made on stocks with lower surprise in mispricing.

3.5 Further Discussions

3.5.1 The Existence of Other Equilibriums

In contrast to the equilibrium with announcements that I have discussed so far, it is important to note that there are other equilibriums within this game. Holding other parameters constant, my focus lies in exploring the equilibrium in the space of fund size (W_A, W_F). Without the loss of generality, I confine the analysis to the region where $W_F > W_A$, as equilibriums are symmetric in the region where $W_F < W_A$.

First, an equilibrium where both funds announce their information does not exist. When both funds make announcements after shorting, no one will change the existing target. In that sense, announcements attract zero capital. Funds' payoffs are indifferent from shorting silently. Second, an equilibrium where both funds pay the cost and only one fund chooses to announce doesn't exist either. Suppose fund A chooses to announce and fund F short silently in the equilibrium. Fund F would always short early otherwise it has incentives to deviate to not paying the cost. But if fund F has already taken short positions at date 0, fund A can't attract extra capital from F by announcing. Fund A would deviate and the equilibrium does not exist. As a result, the only region where we can observe the equilibrium with announcements is when $W_A < g(W_F)$ and $W_F > h(W_A)$.

In a specific parameter space, an equilibrium without announcements exists. Each fund acts as the sole informed trader of the identified asset, resulting in independent decision-making for each fund. The strategy in the equilibrium is uniquely determined by the fund size according to Lemma 1. As shown in Zone 2 of Figure V, characterized by the presence of two large funds, both funds would pay the cost and silently trade. In particular, the larger fund would silently short from the interim period. In Zone 3, even if both funds have sizeable capital and identified the mispricing, neither of them would announce their information. In this case, whether funds are shorting from date 0 or the interim period in the equilibrium is determined by the probability of deeper demand shock. In Zone 4, both funds have very limited capital and choose to short silently. Fund A would wait to short silently when the mispricing gets worse.

3.5.2 Cost of Announcements

In the present model, I assume that the announcements are verifiable by hedge funds. Funds have accurate information about the mispriced asset. This assumption implies that the cost of spreading false information is infinitely high. Consequently, funds would only announce their information after incurring the learning cost and identifying the overpriced asset. Once the other fund observes the announcement, she would short as long as there is available capital.

However, in reality, the situation is more complex as hedge funds might obtain noisy information about the fundamental value. This leaves room for potential disparities between the realized value and the fund's expectations. Verifying the announcements directly becomes challenging. In such cases, we can assume there is a cost associated with making announcements. When the asset value in the final period significantly deviates from the announced value, the funds face penalties ex-post. For instance, this cost could be legal fees if the target company fight against the announcer aggressively, or it could be modeled as a reputation cost.

In particular, consider a variation in which there exists a legal cost c of making announcements. If the realized value $V_{i,2}$ at date 2 exceeds the expected value V announced by the funds at date 1, they would incur a punishment of L. Here, L represents the legal fee, which is typically much larger compared with regular investment sizes. As a result, the legal cost c of making announcements is defined as the minimum between the assets that could be forcibly sold and the legal fee. This can be expressed as follows:

$$c = \min\{fW_2^j, L\}, \quad j = A, F.$$

where f denotes the portion of the fund's overall wealth that is eligible for potential forced sale.

Considering the impact of legal costs, funds exercise greater caution in announcing their information to the public. The benefits of sharing the information are reduced due to potential legal expenses. Hedge funds face a similar trade-off: announcements decrease the profitability of shorting but help avoid margin calls if the mispricing widens. The key findings presented in Proposition 3 remain valid, albeit with a lower threshold for the size of fund A and a higher threshold for the size of fund F. In other words, when incorporating the legal costs of making announcements, the region of fund sizes (W_A, W_F) in which the equilibrium with announcements exists becomes more limited, holding all parameters constant. However, for the equilibrium with announcements to exist, we still need fund A to be small enough and fund F to be large enough.

This paper primarily focuses on the role of size in hedge funds' decisions on trading and disclosing. I examine this aspect using the main framework, without incorporating assumptions about legal costs. This variation of the model provides a foundation for future studies investigating how the heterogeneous precision of information affects funds' decision-making.

4 Tests of Model Predictions

This section presents empirical tests of the unique predictions derived from the model discussed in Chapter 1. The first set of tests focuses on the hypothesis regarding the relationship between borrowing constraints and hedge funds' disclosure behavior. Then, I examine the relationship between the surprise in mispricing and the probability of announcements. The findings offer empirical support for the model as a valuable framework for understanding hedge funds' decision-making in real-world scenarios.

4.1 Sample Selection

I use a two-stage process to identify the disclosing decision of short sellers within their shorting portfolio. First, I extract *Announcers* and *Followers* with their corresponding announcement date from *Sample A*, which is constructed in Section 2.3. These short sellers were betting against the same stock that was announced by one of them. Then, for each announcement, I select all shorting events in *Sample NSP* and keep month-end information where the short seller is either an identified announcer or follower in the same month as the announcement was made. Therefore, in the month when an announcement about stock i was made, the sample includes all stocks held in the shorting portfolios of hedge funds that were shorting i. Combining with characteristics of stocks and funds, this gives me a total sample of 1,362 shorting events, which I call it *Sample B*. Table VI shows the mean value for all variables used in regression analyses. Using this sample, I can examine which characteristics are related to a fund's decision on announcing her information.

4.2 Borrowing Constraints and Announcements

The first unique prediction from Chapter 1 suggests that hedge funds are more inclined to disclose their information publicly when they face lower margin requirements. The rationale behind this is that when it's easier for funds to short upon identifying mispricing opportunities, larger funds can take substantial positions to protect small funds from incurring costly liquidation. One testable implication arising from this model prediction is that stocks with lower borrowing costs are more likely to be targeted by hedge funds with announcements.

Measuring Borrowing Costs Markit provides data on global equity lending flow daily back to 2006.[15] Following Jones, Reed and Waller (2016), I use *Daily Cost of Borrow Score* as a key measure of shorting cost. It is a number from 1 to 10 indicating the cost of borrowing the security reported by securities lenders, where 1 is the cheapest and 10 is the most expensive. *Lender Concentration* is the Herfindahl index that measures the distribution of lender value on loan, where zero indicates many lenders with small loans and 1 indicates a single lender with all the value on loan. When loans are concentrated among a few lenders, it becomes more difficult for investors to increase short positions. *Percentage of Lendable Value* is the value of stock inventory which is actively made available for lending divided by the market value of the stock. The borrowing costs are lower when there are more inventories available to borrow.

To investigate the impact of borrowing constraints on hedge funds' decisions, I analyze each shorting event at the monthly level. By combining this data with *Sample B* described above, I estimate a Probit regression model with the following specifications:

$$\text{DAnnounced}_{i,j,t} = f(\mathit{Borrowing\ Costs}_{i,t-1}, \mathit{Fund\ Size}_{j,t-1}, \mathit{Control}_{i,t-1}) \tag{15}$$

The dependent variable $\text{DAnnounced}_{i,j,t}$ is equal to one if hedge fund j made announcements against stock i in month t, zero otherwise. $\mathit{Borrowing\ Costs}_{i,t-1}$ can be measured by *Daily Cost of Borrow Score*, *Lender Concentration* and *Percentage of Lendable Value*. Since large funds are more likely to wait for others' information and keep silent, I add *Fund Size* as a control for hedge funds' characteristics. Additionally, I also control for various stock

[15]This database has been widely used to study global short selling in a number of papers, such as Berkman and McKenzie (2012), Saffi and Sigurdsson (2011), and Jones et al. (2016).

characteristics including the stock size, turnover, CAPM-adjusted stock returns, and idiosyncratic volatility calculated over the past three months. Standard errors are clustered by stock and year-month.

Table II. Borrowing Constraints and Announcements

This table presents the results of Probit regressions. The dependent variable is one if hedge fund j made announcements against stock i in month t. It is equal to zero if hedge fund j kept silent on stock i. *Daily Cost of Borrow Score* is a number from 1 to 10 indicating the cost of borrowing stock i at the end of month $t-1$. It is based on Markit proprietary benchmark rate, where 1 is the cheapest and 10 is the most expensive. *Fund Size* is the total asset under management, measured in billions of dollars, within the fund company at the end of the previous quarter. *Stock Size* is the month-end market capitalization of each stock, measured in billions of dollars. *CAPM Alpha* is the adjusted monthly return using CAPM model. *Log Turnover* is the average log of turnover of each stock in month $t-1$. *IVOL* is the standard deviation of residuals from the regression of daily returns on market factor in the past three months. The columns report coefficients from the Probit regression, associated z-values, and marginal effects on announcing probability (evaluated at the average value of the other regressors). Observations are from November 2012 to November 2021. Standard errors are clustered by stock and year-month.

	Coefficient	z-value	Marginal Effects
Daily Cost of Borrow Score	-0.105	-2.33**	-0.000486
Fund Size	-0.0241	-2.08**	-0.000112
Stock Size	0.0179	3.52***	0.000083
CAPM Alpha	-0.0091	-1.5	-0.000042
Log Turnover	0.0580	0.57	0.000268
IVOL	0.0576	0.88	0.000267
Obs.	1,306		
Pseudo R^2	0.188		

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table II reports the results for the Probit model. I use *Daily Cost of Borrow Score* as a proxy for borrowing costs. The coefficient before *Daily Cost of Borrow Score* is significantly negative. The findings indicate that stocks with lower borrowing costs, as reflected by lower scores, are more likely to be publicly attacked by hedge funds. Moreover, the marginal effects suggest that stocks with small units decrease in the *Daily Cost of Borrow Score* have roughly 0.05% higher probability of being announced by hedge funds.

The result presented in Table VII, which includes various measures for borrowing costs, is also consistent with the prediction of the model. In Panel A of Table VII, the coefficient before *Lender Concentration* is significantly negative at 5% level. As the concentration of loans increases, there is a higher probability that funds would prefer to silently trade. The coefficient for *Percentage of Lendable Value* is negative though not statistically significant in Panel B. The ability to borrow stocks is positively related to the likelihood of being publicly announced by hedge funds. This observation supports the view that funds with lower borrowing costs are more likely to reveal their information.

The coefficients for *Fund Size* in all three tests are significantly negative, which is consistent with the observation in Section 2.4. An interesting finding is the significant positive relationship between the market size of stocks and the likelihood of being announced. One possible explanation is that the firm size may capture the underlying factors that influence borrowing costs, which in turn affect the probability of being announced.

4.3 Surprise in Mispricing and Announcements

The second unique prediction derived from my model in Chapter 1 is that when there is a larger change in mispricing driven by noise trader demand, hedge funds are less likely to reveal their information. Assuming the expected mispricing is constant in the next period, the model indicates a positive relationship between the mispricing in the current period and the probability of hedge funds making announcements.

4.3.1 Analyst Forecast Revisions

The noise trader demand is typically reflected in greater trading volume, which is strongly associated with investor disagreement.[16] In particular, as a common proxy for investor disagreement, I employ positive revisions in analysts' forecasts to measure the noise trader demand. For each stock i in each month t, the summary statistics of analyst forecasts of the earnings-per-share (EPS) are obtained from I/B/E/S summary database.

[16]Cookson and Niessner (2020) document robust relation between investor disagreement and trading volume and daily changes in disagreement can explain up to a third of the increase in trading volume after earnings announcements.

Percentage of Up is the ratio of the number of upward revisions to the total number of analyst forecasts for stock i's EPS in month $t-1$. When there are more analysts revising their forecast upward, it indicates higher demand and leads to an increase in mispricing.

Next, I examine the impact of demand shock on hedge funds' disclosing behaviours by running the following Probit model.

$$\text{DAnnounced}_{i,j,t} = f(Mispricing_{i,t-1}, Fund\ Size_{j,t-1}, Control_{i,t-1}) \tag{16}$$

Both the dependent variable and control variables are the same as the previous test (15). $Mispricing_{i,t-1}$ is measuring by *Percentage of Up* in Columns(1)(2) of Table III. The coefficient for *Percentage of Up* is significantly positive. This result suggests that stocks facing high demand in the current period are more likely to be publicly announced by hedge funds. The marginal effects indicate that small units increase in the percentage of upward revisions is related to approximately 0.76% higher probability of announcing. This is consistent with the model prediction. When the mispricing is greater in the current period, funds are more willing to short immediately and disclose their information in the next period.

As placebo tests, I also regress on *Analyst Dispersion* and *Percentage of Down* in Columns (3)-(6) where *Percentage of Down* is the ratio of the number of downward revisions to the total number of analyst forecasts for stock i's EPS in month $t-1$. *Analyst Dispersion* is the standard deviation of analyst forecasts divided by the mean in month $t-1$. Both of them are alternative measures of investor disagreement but are not related to the surprise in mispricing. The coefficients are positive but not statistically significant. This suggests that these two measures may not adequately capture the noise trader demand, as short sellers are primarily exposed to upward risk.

Table III. Noise Trader Risk and Announcements

This table presents the results of Probit regressions. The dependent variable is one if hedge fund j made announcements against stock i in month t. It is equal to zero if hedge fund j kept silent on stock i. *Percentage of Up* is the ratio of the number of upward revisions to the total number of analyst forecasts for stock i's EPS in month $t-1$. *Percentage of Down* is the ratio of the number of downward revisions to the total number of analyst forecasts for stock i's EPS in month $t-1$. *Analyst Dispersion* is the standard deviation of analyst forecasts divided by the mean in month $t-1$. *Fund Size* is the total asset under management, measured in billions of dollars, within the fund company at the end of the previous quarter. *Stock Size* is the month-end market capitalization of each stock, measured in billions of dollars. *CAPM Alpha* is the adjusted monthly return using CAPM model. *Log Turnover* is the average log of turnover of each stock in month $t-1$. *IVOL* is the standard deviation of residuals from the regression of daily returns on market factor in the past three months. Columns(1)(3)(4) report coefficients from the Probit regression, and the corresponding associated z-values are reported in parentheses. Columns(2)(4)(6) represents the marginal effects on announcing probability (evaluated at the average value of the other regressors). Observations are from November 2012 to November 2021. Standard errors are clustered by stock and year-month.

	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficients	Marginal Effects	Coefficients	Marginal Effects	Coefficients	Marginal Effects
Percentage of Up	1.668***	0.007590				
	(4.42)					
Percentage of Down			0.507	0.002720		
			(1.43)			
Analyst Dispersion					0.0225	0.000131
					(0.87)	
Fund Size	-0.0188*	-0.000086	-0.0198*	-0.000106	-0.0194*	-0.000113
	(-1.67)		(-1.81)		(-1.74)	
Stock Size	0.0220***	0.000100	0.0192***	0.000103	0.0216***	0.000125
	(3.55)		(3.48)		(3.79)	
CAPM Alpha	-0.0201**	-0.000091	-0.0132*	-0.000071	-0.0150**	-0.000087
	(-2.06)		(-1.81)		(-1.99)	
Log Turnover	0.156	0.000708	0.145	0.000778	0.183	0.001060
	(0.90)		(0.87)		(1.16)	
IVOL	-0.0311	-0.000142	-0.0260	-0.000139	-0.0241	-0.000140
	(-0.44)		(-0.38)		(-0.35)	
Obs.	1,014		1,014		1,003	
Pseudo R^2	0.242		0.200		0.193	

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

5 Conclusion

Hedge funds are often viewed as mysterious investment pools with a large capital base. In practise, however, they strategically give away information to the public. Using the data on short sellers' voluntary announcements and their real-time short positions at the stock level, I found that a group of specialised hedge funds, which are small in asset size, first increase their short positions by full capacity and publish research reports attacking the short targets. After the announcements, they quickly liquidate and realise profits from correcting the overpricing in the short term. Another group of larger hedge funds follows and keeps adding positions even after the announcers leave.

This paper proposes a model to explain to what extent the fund size plays a role in the strategies of hedge funds' trading and disclosing. Small funds benefit from announcing because of the threat from margin calls caused by the leverage constraint. At the same time, large funds save information costs and absorb noise trader shocks. It is beneficial to both funds. The results in the simplified setup show that there are more mispricing opportunities that funds would like to share when funds are small. More importantly, the general model claims that in the equilibrium where one fund shorts early and announces and another fund waits and shorts after observing the announcements, the announcer is small in size and the follower is larger. That is because the benefits of pushing down the price for small funds are relatively higher, while waiting is more attractive to large funds since they could still profit by taking prominent short positions without paying any information cost.

Furthermore, I test two unique predictions derived from the model by measuring borrowing costs and surprises in mispricing. Stocks with lower borrowing costs and greater mispricing in the current period are more likely to be announced by hedge funds. The results provide support for the validity of my model as a framework for understanding hedge funds' behaviour.

References

Akbas, Ferhat, Ekkehart Boehmer, Bilal Erturk, and Sorin Sorescu, "Short interest, returns, and unfavorable fundamental information," *Financial Management*, 2017, *46* (2), 455–486.

Appel, Ian and Vyacheslav Fos, "Active short selling by hedge funds," Finance Working Paper 609, European Corporate Governance Institute (ECGI) 2019.

Berkman, Henk and Michael D McKenzie, "Earnings announcements: Good news for institutional investors and short sellers," *Financial Review*, 2012, *47* (1), 91–113.

Brendel, Janja and James Ryans, "Responding to activist short sellers: Allegations, firm responses, and outcomes," *Journal of Accounting Research*, 2021, *59* (2), 487–528.

Chen, Lei, "The informational role of short sellers: The evidence from short sellers' reports on US-listed Chinese firms," *Journal of Business Finance & Accounting*, 2016, *43* (9-10), 1444–1482.

Chen, Yong, Zhi Da, and Dayong Huang, "Short selling efficiency," *Journal of Financial Economics*, 2022, *145* (2), 387–408.

Cookson, J Anthony and Marina Niessner, "Why don't we agree? Evidence from a social network of investors," *The Journal of Finance*, 2020, *75* (1), 173–228.

Corte, Pasquale Della, Robert Kosowski, and Nikolaos Rapanos, "Best short," Working Paper 2021. Available at SSRN 3436433.

Crawford, Vincent P and Joel Sobel, "Strategic information transmission," *Econometrica*, 1982, *50* (6), 1431–1451.

Dimmock, Stephen G., Jospeh D. Farizo, and William C. Gerken, "Misconduct and fraud by investment managers," doi:10.13023/NSJD-RK62 2018.

Gillet, Roland L and Thomas Renault, "When machines read the web: Market efficiency and costly information acquisition at the intraday level," Working Paper 2018. Available at SSRN 3189991.

Griffin, John M and Jin Xu, "How smart are the smart guys? A unique view from hedge fund stock holdings," *The Review of Financial Studies*, 2009, *22* (7), 2531–2570.

Hu, Danqi, Charles M Jones, and Xiaoyan Zhang, "When do informed short sellers trade? Evidence from intraday data and implications for informed trading models," Columbia Business School Research Paper Forthcoming 2021.

Jank, Stephan, Christoph Roling, and Esad Smajlbegovic, "Flying under the radar: The effects of short-sale disclosure rules on investor behavior and stock prices," *Journal of Financial Economics*, 2021, *139* (1), 209–233.

Jiang, Wenxi, "Leveraged speculators and asset prices," Working Paper 2021. Available at SSRN 2525986.

Jones, Charles M, Adam V Reed, and William Waller, "Revealing shorts an examination of large short position disclosures," *The Review of Financial Studies*, 2016, *29* (12), 3278–3320.

Kartapanis, Antonis, "Activist short-sellers and accounting fraud allegations." PhD dissertation, University of Texas at Austin 2019.

Kyle, Albert S, "Continuous auctions and insider trading," *Econometrica: Journal of the Econometric Society*, 1985, pp. 1315–1335.

Li, Tao, Pedro AC Saffi, and Daheng Yang, "Power Grab: Activists, Short Sellers, and Disagreement," *Columbia Business School Research Paper Forthcoming*, 2021.

Liu, Ying, "Why do large investors disclose their information?," Swiss Finance Institute Research Paper 18-17 2017. Available at SSRN 3073907.

Ljungqvist, Alexander and Wenlan Qian, "How constraining are limits to arbitrage?," *The Review of Financial Studies*, 2016, *29* (8), 1975–2028.

Luo, Patrick, "Talking your book: Evidence from stock pitches at investment conferences," Working Paper 2018. Available at SSRN 3190837.

Osborne, Martin J and Carolyn Pitchik, "Price competition in a capacity-constrained duopoly," *Journal of Economic Theory*, 1986, *38* (2), 238–260.

Pagano, Marco and Sergei Kovbasyuk, "Advertising arbitrage," *Review of Finance*, 2022, *26*.

Pasquariello, Paolo and Yifei Wang, "Speculation with information disclosure," Working Paper 2021. Available at SSRN 2847321.

Saffi, Pedro AC and Kari Sigurdsson, "Price efficiency and short selling," *The Review of Financial Studies*, 2011, *24* (3), 821–852.

SEC, U.S., "Short sale position and transaction reporting: As required by section 417 of the Dodd-Frank Wall Street Reform and Consumer Protection Act," 2014.

Shleifer, Andrei and Robert W Vishny, "The limits of arbitrage," *The Journal of Finance*, 1997, *52* (1), 35–55.

Sobel, Joel, "A theory of credibility," *The Review of Economic Studies*, 1985, *52* (4), 557–573.

van Binsbergen, Jules H, Xiao Han, and Alejandro Lopez-Lira, "Textual analysis of short-seller research reports, stock prices, and real investment," Jacobs Levy Equity Management Center for Quantitative Financial Research Paper 2021. Available at SSRN 3965873.

Wang, Xue, Xuemin Sterling Yan, and Lingling Zheng, "Shorting flows, public disclosure, and market efficiency," *Journal of Financial Economics*, 2020, *135* (1), 191–212.

Wong, Yu Ting Forester and Wuyang Zhao, "Post-apocalyptic: The real consequences of activist short-selling," Working Paper 17-25, Marshall School of Business 2017.

A Proofs

A.1 Proof of Lemma 1

When there are no announcements, only fund A know that asset n_A is overpriced. The expected utility of fund A when choosing the strategy s_A is denoted as $u(s_A)$. If fund A chooses to short from date 1, the expected utility is

$$u(\kappa, NA, 0 \times 1) = (1-q)(W_A - \kappa) + q(1 + \phi(1 - \frac{V}{p_1^A}))(W_A - \kappa). \tag{A.1}$$

If fund A chooses to short early, it may face a risk of liquidation at date 1. Because the function of expected terminal wealth $u(\kappa, NA, 1 \times 1)$ is different when funds are forced to liquidate at date 1, I will first discuss the case when the interim wealth is below zero and funds are forced to liquidate. At date 0, fund A shorts with full capacity, from the market clearing condition $p_0^A = V + U_0 - \phi(W_A - \kappa)$. At date 1, if the mispricing worsens and fund A continues to short fully:

$$W_1^A = W_A - \kappa + \phi(W_A - \kappa)(1 - \frac{p_1^{AA}}{p_0^A}) \tag{A.2}$$

$$p_1^{AA} = V + U - \phi W_1^A. \tag{A.3}$$

Combining these two equations, we get the price at date 1 when funds continue to short silently:

$$p_1^{AA} = \left(\frac{V + U - \phi(1+\phi)(W_A - \kappa)}{V + U_0 - \phi(1+\phi)(W_A - \kappa)}\right) p_0^A. \tag{A.4}$$

From the equation (A.2), the theoretical wealth at date 1 is larger than 0, $W_1^A \geq 0$, if and only if $p_1^{AA} \leq (1 + \frac{1}{\phi})p_0^A$. Based on the expression of p_1^{AA} in (A.4), this is also equivalent to

$$W_A \leq W^* \doteq \kappa + \frac{1}{\phi(1+\phi)}(V + U_0 - \phi(U - U_0)). \tag{A.5}$$

Otherwise, when $W_A > W^*$, the fund is forced to liquidate $D_1 = 0$, $p_1^{AA} = V + U$, and $W_1^A = 0$. Fund A chooses to short from date 0 only if $u(\kappa, NA, 1 \times 1) \geq u(\kappa, NA, 0 \times 1)$.

When $W_A \leq W^*$,

$$u(k, NA, 1\times 1) = \Big((1-q)(1+\phi(1-\frac{V}{p_0^A})) + q(1+\phi(1-\frac{V}{p_1^{AA}}))(1+\phi(1-\frac{p_1^{AA}}{p_0^A}))\Big)(W_A-\kappa). \tag{A.6}$$

Replacing the utilities with equation (A.1) and (A.6) and rearranging the inequality, I get

$$q\Big(1-\frac{V}{p_1^A}-(1-\frac{V}{p_1^{AA}})(1-\frac{p_1^{AA}}{p_0^A})(1+\phi)\Big) \leq 1-\frac{V}{p_0^A}. \tag{A.7}$$

When $W_A > W^*$,

$$u(k, NA, 1\times 1) = (1-q)(1+\phi(1-\frac{V}{p_0^A}))(W_A-\kappa). \tag{A.8}$$

Plugging equation (A.1) and (A.8) into condition $u(\kappa, NA, 1\times 1) \geq u(\kappa, NA, 0\times 1)$, I get

$$q\Big(1+\phi(1-\frac{V}{p_0^A})+\phi(1-\frac{V}{p_1^A})\Big) \leq \phi(1-\frac{V}{p_0^A}). \tag{A.9}$$

Combining the conditions (A.7) and (A.9), fund A would start to short from date 0 if $q \leq q^{na}$, where q^{na} can be written as

$$q^{na} = \begin{cases} \dfrac{\phi(1-\frac{V}{p_0^A})}{1+\phi(1-\frac{V}{p_0^A})+\phi(1-\frac{V}{p_1^A})} & W_A > W^* \\ \dfrac{1-\frac{V}{p_0^A}}{1-\frac{V}{p_1^A}-(1+\phi)(1-\frac{p_1^{AA}}{p_0^A})(1-\frac{V}{p_1^{AA}})} & W_A \leq W^* \end{cases},$$

where $p_0^A = V + U_0 - \phi(W_A - \kappa)$, $p_1^A = V + U - \phi(W_A - \kappa)$ and p_1^{AA} is calculated as (A.4). q^{na} is fully determined by W_A, U, U_0, V, κ and ϕ.

Now I show that q^{na} is decreasing in W_A. First, when $W_A > W^*$, the partial derivative of q^{na} with respect to W_A is

$$\frac{\partial q^{na}}{\partial W_A} = \frac{\phi^2 V}{(1+\phi(1-\frac{V}{p_0})+\phi(1-\frac{V}{p_1}))^2}\Big[\frac{\phi}{p_1^2}(1-\frac{V}{p_0})-\frac{\phi}{p_0^2}(1-\frac{V}{p_1})-\frac{1}{p_0^2}\Big],$$

where $p_0 \doteq p_0^A$ and $p_1 \doteq p_1^A$ for notational simplicity. Since $U > U_0$, $p_1 > p_0$,

$$\frac{\phi}{p_1^2}(1 - \frac{V}{p_0}) < \frac{\phi}{p_0^2}(1 - \frac{V}{p_1}).$$

Therefore, $\frac{\partial q^{na}}{\partial W_A} < 0$. q^{na} is decreasing in W_A when $W_A > W^*$.

Second, when $W_A \leq W^*$, p_0 and p_1 are defined the same as above,

$$\frac{1}{q^{na}} = \underbrace{\frac{1 - \frac{V}{p_1}}{1 - \frac{V}{p_0}}}_{PART1} + (1+\phi)\underbrace{(\frac{p_1^{AA}}{p_0} - 1)}_{PART2}\underbrace{\frac{1 - \frac{V}{p_1^{AA}}}{1 - \frac{V}{p_0}}}_{PART3}. \tag{A.10}$$

Plugging in the expressions of p_0, p_1, and p_1^{AA} gives

$$\begin{aligned} \frac{\partial PART1}{\partial W_A} &\propto \frac{V}{p_0^2}(1 - \frac{V}{p_1}) - \frac{V}{p_1^2}(1 - \frac{V}{p_0}) > 0 \\ \frac{\partial PART3}{\partial W_A} &\propto V + U - \phi(1+\phi)(W_A - \kappa) + (1+\phi)(U_0 - \phi(W_A - \kappa)) > 0 \end{aligned}$$

and

$$PART2 = \frac{U - U_0}{V + U_0 - \phi(1+\phi)(W_A - \kappa)},$$

which is also increasing in W_A. Therefore, $\frac{1}{q^{na}}$ is increasing in W_A. q^{na} is decreasing in W_A when $W_A \leq W^*$.

In summary, when $q \leq q^{na}$, fund A would short early. Otherwise, fund A would like to wait and start shorting at date 1. q^{na} is decreasing in the size of fund A. □

A.2 Proof of Lemma 2

Based on Lemma 1, we know that fund A would choose to wait when $q > q^{na}$. The expected wealth equal to

$$u(\kappa, NA, 0 \times 1) = (1 + q\phi(1 - \frac{V}{p_1^A}))(W_A - \kappa)$$

Because $u(\kappa, NA, 0 \times 1)$ is increasing in q, for all $q > q^{na}$,

$$u(\kappa, NA, 0 \times 1) \geq (1 + q^{na}\phi(1 - \frac{V}{p_1^A}))(W_A - \kappa)$$

When $q \leq q^{na}$, fund A chooses to fully invest at date 0. From the expected utility (A.6) and (A.8) with different initial wealth, I have

$$\frac{\partial u(\kappa, NA, 1\times 1)}{\partial q} = \begin{cases} -(1+\phi(1-\frac{V}{p_0^A}))(W_A-\kappa) \leq 0, & W_A > W^* \\ -\phi(1+\phi)(1-\frac{V}{p_1^{AA}})(\frac{p_1^{AA}}{p_0^A}-1)(W_A-\kappa) \leq 0, & W_A \leq W^* \end{cases}.$$

The expected utility is decreasing in q, for all $q \leq q^{na}$,

$$u(\kappa, NA, 1\times 1) \geq (1+q^{na}\phi(1-\frac{V}{p_1^A}))(W_A-\kappa).$$

Hence if the expected utility of fund A when $q = q^{na}$ is larger than its initial wealth W_A, which means

$$(1+q^{na}\phi(1-\frac{V}{p_1^A}))(W_A-\kappa) \geq W_A, \tag{A.11}$$

then it's always better for the fund to pay the learning cost for all $0 \leq q \leq 1$. To study when the condition is satisfied, I define

$$h(W_A) \doteq \frac{1}{q^{na}\phi(1-\frac{V}{p_1^A})} - \frac{W_A-\kappa}{\kappa}.$$

The condition (A.11) is held if and only if $h(W_A) \leq 0$. Plugging q^{na} into the function and taking the derivative with respect to W_A, I get $h'(W_A) \leq 0$. Therefore there exists $\underline{W}$ such that, for any $W_A \geq \underline{W}$, $h(W_A) \leq h(\underline{W}) = 0$. $\square$

A.3 Proof of Proposition 1

Fund A chooses the optimal strategy from $\{(0, NA, 0\times 0), (\kappa, NA, 0\times 1), (\kappa, NA, 1\times 1), (\kappa, A, 1\times 1)\}$. The expected utility of fund A when choosing the strategy s_A is denoted as $u(s_A)$ for simplicity. First, when $W_A > \underline{W}$, not learning $(0, NA, 0\times 0)$ is always a dominated strategy according to Lemma 2. Second, compared with shorting early, the expected wealth of waiting and shorting at date 1, $u(\kappa, NA, 0\times 1)$, is larger if $q > q^{na}$. Now consider the case when fund A starts shorting early and announcing. After announcements, fund F finds that asset n_A is overpriced and wants to short. Funds A and F simultaneously trade against a mass of noise traders. In the duopoly model where fund A has limited capacity to short, fund A would short with its full capacity and fund F choose the optimal level of shorting.[17] The expected shorting profits of fund F is

$$\pi_F = D_1^F(1 - \frac{V}{p_1^{ad}}),$$

where D_1^F is the amount of asset n_A that fund F decides to short, p_1^{ad} is the asset price after announcements when noise trader risks worsen. Note that the market clearing condition gives

$$p_1^{ad} = V + U - \phi W_1^A - D_1^F.$$

From the first-order condition, I have that

$$p_1^{ad} = \sqrt{V(V + U - \phi W_1^A)} \tag{A.12}$$

$$W_1^A = (W_A - \kappa) + \phi(W_A - \kappa)(1 - \frac{p_1^{ad}}{p_0^A}). \tag{A.13}$$

Rearranging, I get

$$p_1^{ad} = \frac{\phi^2 V(W_A - \kappa)}{2p_0^A} + \frac{1}{2}\sqrt{\left(\frac{\phi^2 V(W_A - \kappa)}{p_0^A}\right)^2 + 4V\Big(V + U - \phi(1+\phi)(W_A - \kappa)\Big)}, \tag{A.14}$$

where $p_0^A = V + U_0 - \phi(W_A - \kappa)$, the same as in the silent case. Equations (A.12) and (A.3) imply that $p_1^{ad} < p_1^{AA}$. When $W_A < W^*$,

$$u(\kappa, A, 1 \times 1) - u(\kappa, NA, 1 \times 1) = q(W_A - \kappa)\phi(1+\phi)(p_1^{AA} - p_1^{ad})(\frac{1}{p_0^A} - \frac{V}{p_1^{AA} p_1^{ad}}) > 0.$$

When $W_A \geq W^*$, fund A is forced to liquidate all of its positions if A keeps silent. While if fund A chooses to announce, the price is lower than in the silent case and A may not have to liquidate. Thus, shorting and announcing $(\kappa, A, 1 \times 1)$ is always better for fund A compared with shorting and keeping silent $(\kappa, NA, 1 \times 1)$. Shorting and announcing is the optimal strategy if

$$u(\kappa, A, 1 \times 1) \geq u(\kappa, NA, 0 \times 1).$$

[17] See Osborne and Pitchik (1986) for more detailed discussions in a capacity-constrained duopoly.

Plugging the utility of waiting and shorting, (A.1), and the utility of shorting and announcing into the condition gives

$$\begin{cases} q \leq \dfrac{\phi(1-\frac{V}{p_0^A})}{1+\phi(1-\frac{V}{p_0^A})+\phi(1-\frac{V}{p_1^A})} & W_A > W_{ad}^* \\ q \leq \dfrac{1-\frac{V}{p_0^A}}{1-\frac{V}{p_1^A}-(1+\phi)(1-\frac{p_1^{ad}}{p_0^A})(1-\frac{V}{p_1^{ad}})} & W_A \leq W_{ad}^*, \end{cases}$$

where

$$W_{ad}^* = \kappa + \frac{1}{1+\phi}\Big((1+\frac{1}{\phi})(V+U_0) - \sqrt{V(V+u)}\Big). \tag{A.15}$$

W_{ad}^* is the threshold of the fund A size when A needs to liquidate all its positions even with announcements. To summarise, fund A's optimal strategy is shorting and announcing when $q \leq q^a$; otherwise, fund A would choose to wait if $q > q^a$. q^a can be written as

$$q^a = \begin{cases} \dfrac{\phi(1-\frac{V}{p_0^A})}{1+\phi(1-\frac{V}{p_0^A})+\phi(1-\frac{V}{p_1^A})} & W_A > W_{ad}^* \\ \dfrac{1-\frac{V}{p_0^A}}{1-\frac{V}{p_1^A}-(1+\phi)(1-\frac{p_1^{ad}}{p_0^A})(1-\frac{V}{p_1^{ad}})} & W_A \leq W_{ad}^* \end{cases},$$

From previous definitions of p_0^A, p_1^A, p_1^{ad}, we know that q^a can be expressed in terms of W_A, U, U_0, V, κ and ϕ. □

A.4 Proof of Proposition 2

First, I show that q^a is decreasing in W_A. Comparing the thresholds of full liquidation (A.5) and (A.15), we know that $W_{ad}^* > W^*$. When $W_A > W_{ad}^*$, q^a is equal to q^{na}, which is decreasing in W_A. When $W_A \leq W_{ad}^*$, let $p_0 \doteq p_0^A$ and $p_1 \doteq p_1^A$ for notational simplicity.

$$\frac{1}{q^a} = \underbrace{\frac{1-\frac{V}{p_1}}{1-\frac{V}{p_0}}}_{PART1} + (1+\phi)\underbrace{(\frac{p_1^{ad}}{p_0}-1)\frac{1-\frac{V}{p_1^{ad}}}{1-\frac{V}{p_0}}}_{PART4}. \tag{A.16}$$

From the previous discussion in Proof A.1, we know that $\frac{\partial PART1}{\partial W_A} > 0$. $PART1$ is increasing in W_A. Plugging the expressions of p_0, p_1, and p_1^{ad} into $PART4$ gives

$$\frac{\partial PART4}{\partial W_A} \quad \propto \quad \Big(\frac{p_1^{ad}}{p_0} - \frac{V}{p_1^{ad}}\Big)\Big(\frac{p_1^{ad}}{p_0} - (1+\frac{1}{\phi})\Big).$$

Since $p_1^{ad} \leq (1+\frac{1}{\phi})p_0$, when $W_A \leq W_{ad}^*$:

$$\begin{aligned}\frac{p_1^{ad}}{p_0} - \frac{V}{p_1^{ad}} &= \frac{p_1^{ad^2} - Vp_0}{p_0 p_1^{ad}} \\ &= \frac{p_1^{ad} + D_1^F - p_0^A}{p_0 p_1^{ad}} \leq 0.\end{aligned}$$

Therefore $PART4$ is also increasing in W_A. $\frac{1}{q^a}$ is increasing in W_A. q^a is decreasing in W_A when $W_A \leq W_{ad}^*$. In summary, q^a is decreasing in the size of fund A.

Moreover, when $W_A \leq W_{ad}^*$:

$$\begin{aligned}\frac{1}{q^a} - \frac{1}{q^{na}} &= \frac{1+\phi}{1-\frac{V}{p_0^A}}\Big(\frac{V}{p_1^{ad}} + \frac{p_1^{ad}}{p_0^A} - \frac{V}{p_1^{AA}} - \frac{p_1^{AA}}{p_0^A}\Big) \\ &= \frac{1+\phi}{1-\frac{V}{p_0^A}}(p_1^{ad} - p_1^{AA})\Big(\frac{1}{p_0^A} - \frac{V}{p_1^{ad}p_1^{AA}}\Big) < 0.\end{aligned}$$

Thus $q^a > q^{na}$. $\square$

A.5 Proof of Lemma 3

To verify it is a Bayesian-Nash Equilibrium, first fund F will not deviate from the equilibrium. Given the strategy of fund A, the payoff of fund F is equal to

$$u_F(s_A^*, s_F^*) = [1 + q\phi(1 - V/p_1^{u*})]W_F, \tag{A.17}$$

where $p_1^{u*} = V + U - \phi W_1^A - \phi W_F$, $p_0^* = V + U_0 - \phi(W_A - \kappa)$, $W_1^A = (1 + a\phi(1 - \frac{p_1^{u*}}{p_0^*}))(W_A - \kappa)$. From the previous discussion, if fund F decided to learn and gained the information of another asset n, neither fund would switch their target at date 1 when fund F also announces because the size of the optimistic shock is the same to both assets. Thus strategy $(\kappa, A, 1\times 1)$ is identical to $(\kappa, NA, 1\times 1)$. The payoff of the latter strategy, $u_F(s_A^*, (\kappa, NA, 1\times 1))$, would be

$$[(1-q)(1+\phi(1-\frac{V}{p_0^F}))+q(1+\phi(1-\frac{p_1^{FF}}{p_0^F}))(1+\phi(1-\frac{V}{p_1^{FF}}))](W_F-\kappa). \tag{A.18}$$

where $p_0^F = V + U_0 - \phi(W_F - \kappa)$, $\quad p_1^{FF} = V + U - \phi(1+\phi(1-\frac{p_1^{FF}}{p_0^F}))(W_F-\kappa)$. If fund F chose to wait and fully invest at date 1 when keeping silent, the payoff would be

$$u_F(s_A^*, (\kappa, NA, 0\times 1)) = [1 + q\phi(1 - V/p_1^F)](W_F - \kappa), \qquad p_1^F = V + U - \phi(W_F - \kappa). \tag{A.19}$$

Thus, to guarantee that fund F will not deviate from s_F^*, the following conditions must hold:

$$u_F(s_A^*, (\kappa, NA, 1\times 1)) \leq u_F(s_A^*, s_F^*) \tag{A.20}$$

$$u_F(s_A^*, (\kappa, NA, 0\times 1)) \leq u_F(s_A^*, s_F^*). \tag{A.21}$$

Plug in the previous expressions of payoffs (A.17), (A.18), and (A.19) and get the following conditions that κ must satisfy,

$$\kappa \geq \frac{\phi \bar{R}_F + q\phi(V/p_1^{u*} - V/p_1^{FF})}{(1 + \phi \bar{R}_F + q\phi(1 - V/p_1^{FF}))} W_F$$

$$\kappa \geq \frac{q\phi(V/p_1^{u*} - V/p_1^F)}{1 + q\phi(1 - V/p_1^F)} W_F.$$

where $\bar{R}_F = (1-q)(1 - V/p_0^F) + q(1 - p_1^{FF}/p_0^F)(1 + \phi(1 - V/p_1^{FF}))$. Intuitively, the information cost should be higher than the marginal cost of switching assets for fund F.

Since the payoffs of fund F are not related to fund A's size when F chooses to pay the cost and trade silently, these payoffs are determined by $W_F, V, U, U_0, \phi, \kappa$ and q. Therefore, define

$$MAXF \doteq \max\Big\{u_F(s_A^*, (\kappa, NA, 1\times 1)), u_F(s_A^*, (\kappa, NA, 0\times 1))\Big\}.$$

Condition (A.20) and (A.21) can be combined together. Plugging equation (A.17) into the equilibrium price p_1^{u*} gives

$$p_1^{u*} \geq \frac{1}{1 - \frac{1}{q\phi}(\frac{MAXF}{W_F} - 1)}. \tag{A.22}$$

Since

$$\frac{\partial p_1^{u*}}{\partial W_A} = \frac{\phi p_1^{u*}}{p_0^*}\Big(\frac{p_1^{u*}(1+\phi)}{U - U_0 - \phi W_F} - 1\Big) < 0 \tag{A.23}$$

according to the assumption that $\phi \leq \frac{U-U_0}{W_F}$, p_1^{u*} is decreasing in the size of fund A. Therefore, there exists an upper bound $g(W_F)$ such that when $W_F \leq g(W_F)$, condition (A.22) is satisfied, and fund F will not deviate from the equilibrium. □

A.6 Proof of Lemma 4

Given the strategy s_F^* of fund F, the payoff of fund A in the equilibrium is equal to

$$u_A(s_A^*, s_F^*) = (1-q)(1+\phi(1-\frac{V}{p_0^*}))(W_A - \kappa) + q(1+\phi(1-\frac{V}{p_1^{u*}}))W_1^A, \tag{A.24}$$

where p_0^*, p_1^{u*}, W_1^A are defined in equation (A.17). If fund A does not pay the cost, it would hold cash and the expected utility is W_A. If fund A has paid the cost and decides not to announce, the payoff of investing at date 0, $u_A((\kappa, NA, 1\times 1), s_F^*)$, would be

$$[(1-q)(1+\phi(1-\frac{V}{p_0^*})) + q(1+\phi(1-\frac{p_1^{AA}}{p_0^*}))(1+\phi(1-\frac{V}{p_1^{AA}}))](W_A - \kappa), \tag{A.25}$$

where $p_1^{AA} = V + U - \phi(1 + a\phi(1 - \frac{p_1^{AA}}{p_0^*}))(W_A - \kappa)$. The payoff of waiting would be

$$u_A((\kappa, NA, 0\times 1), s_F^*) = [1 + q\phi(1 - V/p_1^A)](W_A - \kappa), \qquad p_1^A = V + U - \phi(W_A - \kappa). \tag{A.26}$$

To summarise, the payoff of fund A in the equilibrium should satisfy that

$$u_A((\kappa, NA, 1\times 1), s_F^*) \leq u_A(s_A^*, s_F^*) \tag{A.27}$$

$$u_A((\kappa, NA, 0\times 1), s_F^*) \leq u_A(s_A^*, s_F^*) \tag{A.28}$$

$$u_A((0, NA, 0), s_F^*) = W_A \leq u_A(s_A^*, s_F^*). \tag{A.29}$$

The payoffs of fund A when it keeps silent, given by (A.25) and (A.26), are not correlated with the size of fund F. Define

$$MAXA \doteq \min\Big\{u_A((\kappa, NA, 1\times 1), s_F^*), u_A((\kappa, NA, 0\times 1)\Big\}.$$

When $W_A > \underline{W}$, it is always good to pay the cost and identify the overpriced assets, $MAXA > W_A$. Therefore, combining conditions (A.27)(A.28)(A.29), I get

$$u_A(s_A^*, s_F^*) \geq MAXA, \tag{A.30}$$

where $MAXA$ is a function of W_A, V, U, U_0, ϕ and q.

Since

$$\frac{\partial u_A^*}{\partial W_F} = \frac{\partial u_A^*}{\partial p_1^{u*}} \frac{\partial p_1^{u*}}{\partial W_F}, \qquad \frac{\partial p_1^{u*}}{\partial W_F} < 0,$$

note that

$$\frac{\partial u_A^*}{\partial p_1^{u*}} = q(W_A - \kappa)\phi(1+\phi)\Big(\frac{V}{p_1^{u*2}} - \frac{1}{p_0^*}\Big) < 0. \tag{A.31}$$

based on the assumption that $\phi W_F < U - U_0$ and $\phi W_A \leq \frac{U}{2}$. Therefore, $\frac{\partial u_A^*}{\partial W_F} > 0$, the payoff of fund A in the equilibrium is increasing in the size of fund F. From condition A.30, there exists a lower bound $h(W_A)$, such that fund A won't deviate if $W_A \leq h(W_A)$. $\square$

B Additional Tables and Figures

B.1 Market Reactions to Hedge Funds' Announcements

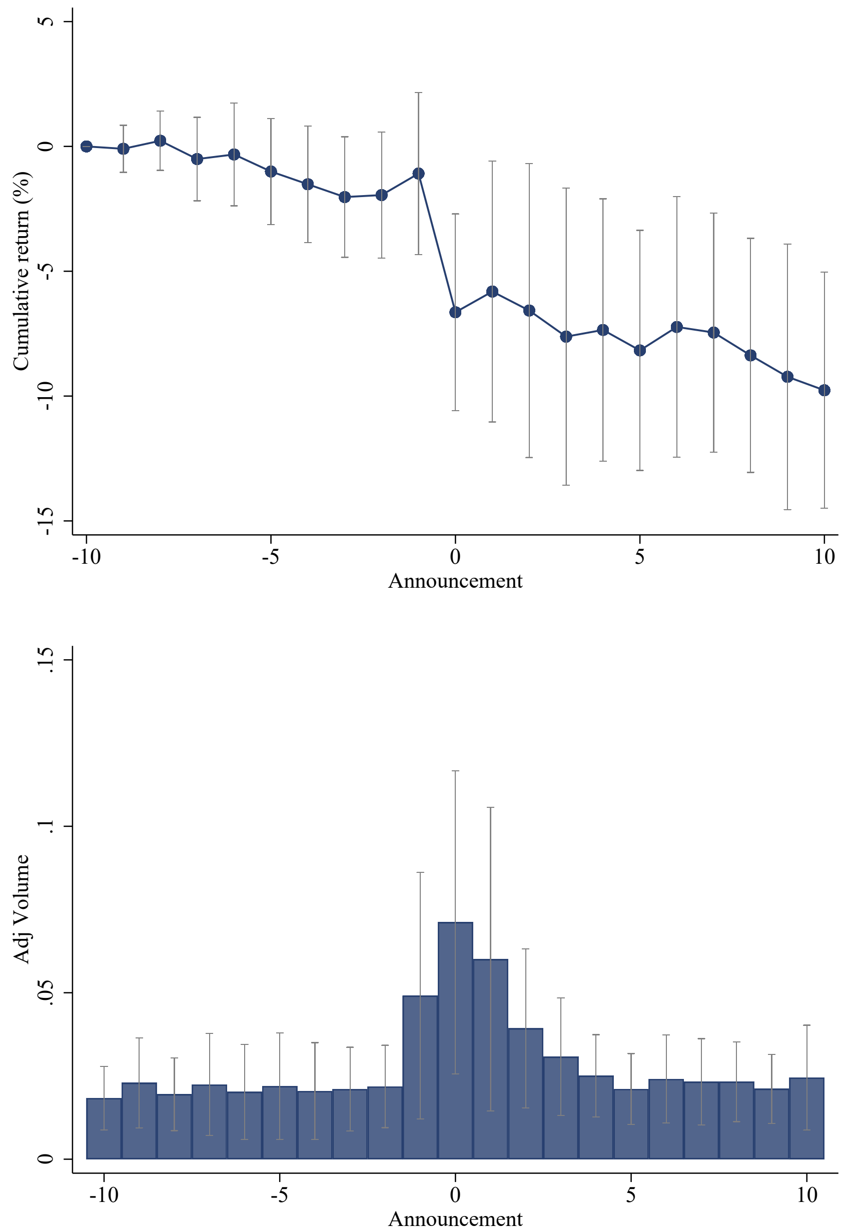
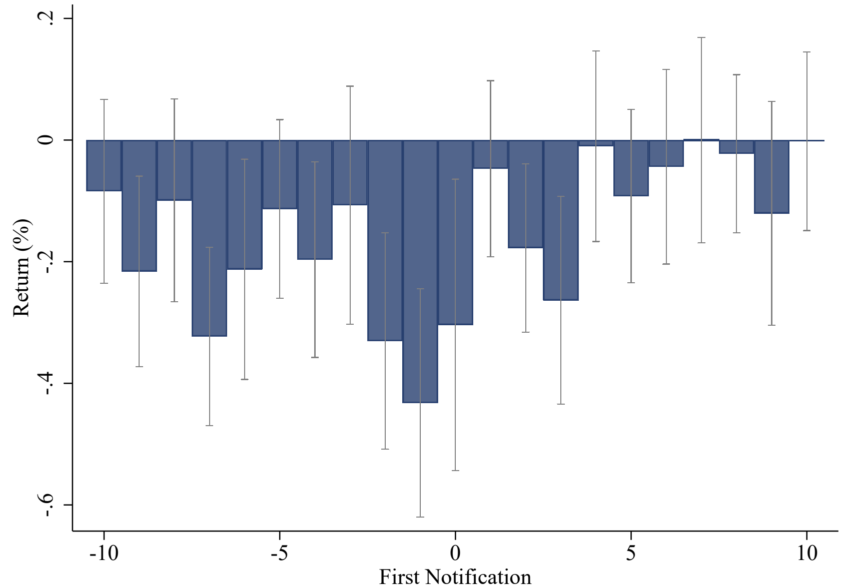


Figure VI. Average cumulative return and trading volume around the announcement

This figure plots the average cumulative excess return and adjusted trading volume on each trading day around the announcement. The excess return is measured by the daily return minus the market return, which is the daily return of the EURO STOXX 50. Adjusted trading volume (Adj Volume) is measured by the daily trading volume in shares divided by the total outstanding shares of the stock

B.2 Market Reaction to Notifications of Short Positions



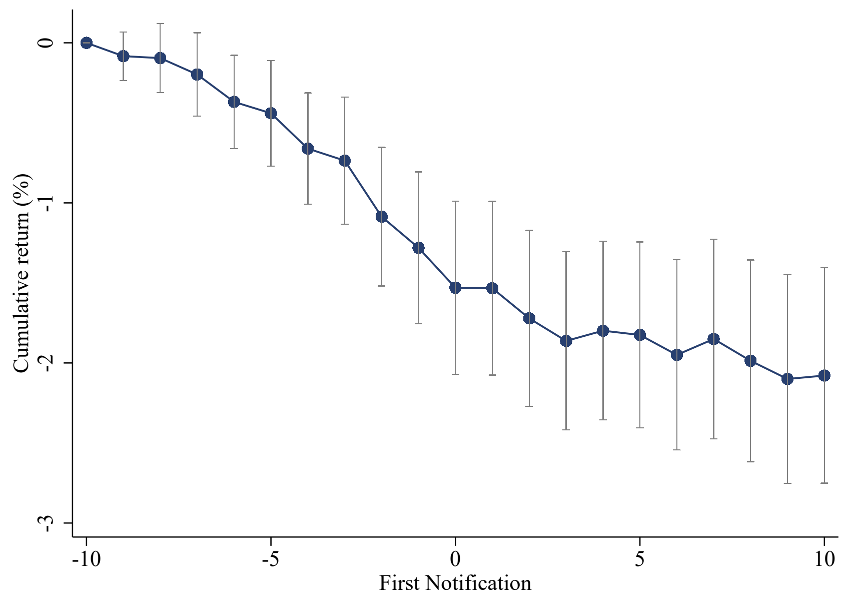


Figure VII. Average return around the first notification of short positions

This upper graph plots the average daily return on each trading day around the first notification of short positions. The bottom graph shows the average cumulative excess return. The excess return is measured by the daily return minus the market return, which is the daily return of the EURO STOXX 50. The event date is identified when the regulator published the first record of positions in each target stock within the past one year.

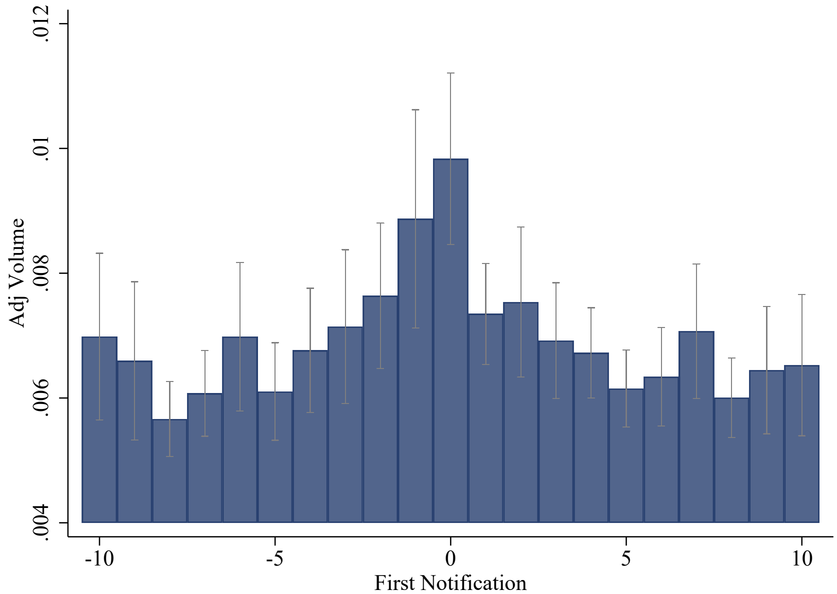


Figure VIII. Average trading volume around the first notification of short positions

This figure plots the average adjusted trading volume on each trading day around the first notification of short positions. Adjusted trading volume (Adj Volume) is measured by the daily trading volume in shares divided by the total outstanding shares of the stock

.

B.3 Shorting Activities of Existing Short Sellers

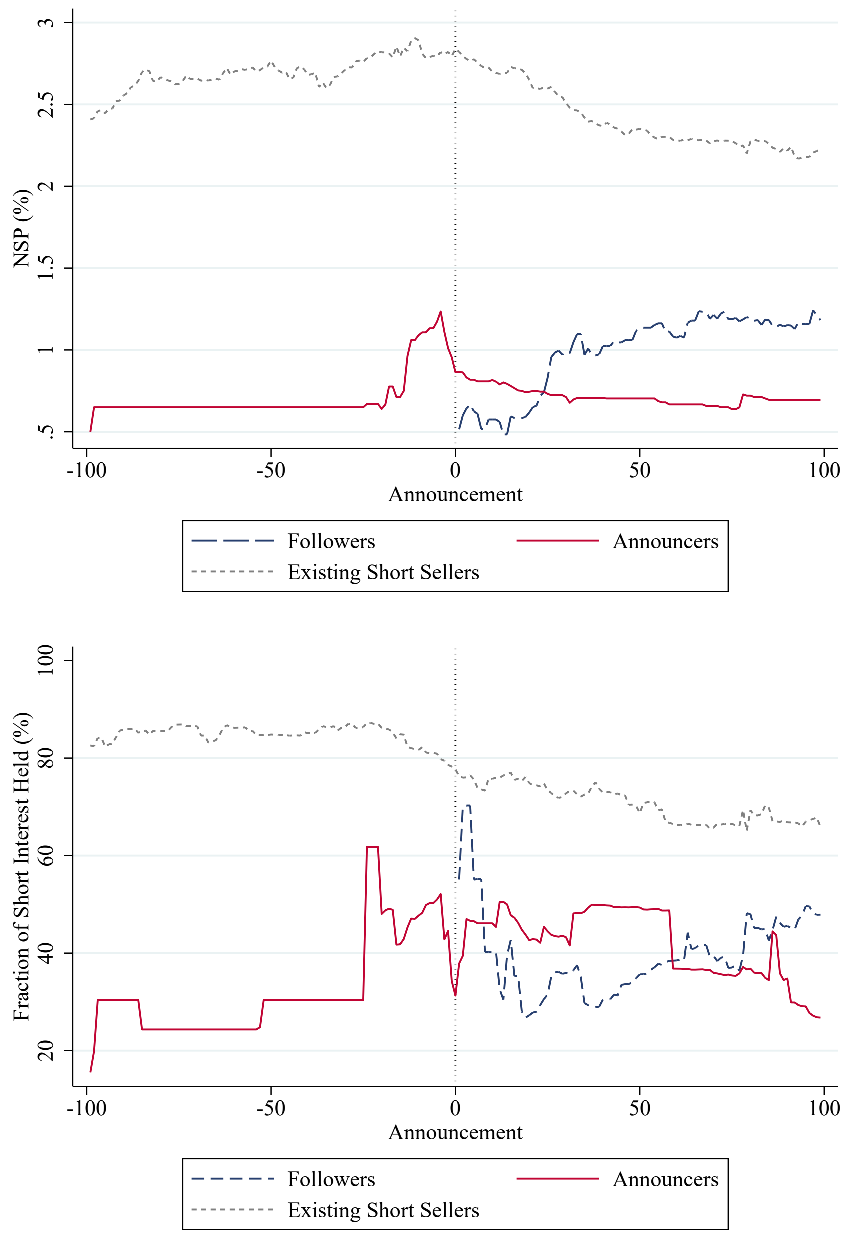


Figure IX. Average shorting activities around the announcement

This upper graph plots the average net short position on each trading day around the announcement. The bottom graph plots the average fraction of short positions of each group to the total short interest. The solid line represents the shorting of *Announcers*, the long-dashed line represents the shorting of *Followers* and the short-dashed line represents the shorting of *Existing Short Sellers*.

B.4 Fund Characteristics of Existing Short Sellers

Table IV. Summary statistics of Existing Short Sellers

This table shows summary statistics of fund-company-level variables. The sample period is from November 2012 to November 2021. *Existing Short Sellers* and *Followers* are defined for each fund / target shorting event throughout the sample period. Target stocks that have never been announced by any hedge funds are removed from the sample. *Followers* are funds that have not made any announcements and started to short the target after the announcements. If funds who never made announcements and held short positions before the announcements, it is a *Existing Short Seller*. The table presents the summary statistics of *Existing Short Sellers'* and *Followers'* characteristics in the shorting events when target stocks were attacked by *Announcers*. *Size* is the total net assets (in billions of USD) under management in the fund company. *Age* equals the number of years since the inception of the company's first fund. *Number of funds* is the number of hedge funds in the company.

	Existing Short Sellers			Followers				
	Mean	Std. errs.	Obs.	Mean	Std. errs.	Obs.	Diff	t-stat
Size ($B)	38.936	6.01	187	28.429	5.15	198	10.508	1.333
Age	10.551	0.480	184	9.407	0.479	187	1.144	1.6878
Number of funds	45.167	8.496	60	29.446	7.134	56	15.72	1.4068

B.5 Shorting Profits

Table V. Summary statistics of shorting profits in two groups

This table shows summary statistics of shorting returns of hedge funds. The sample period is from November 2012 to November 2021. *Announcers* and *Followers* are defined for each fund-target shorting event throughout the sample period. If the fund has made announcements on its target, it is an announcer in this shorting event. In contrast, *Followers* are funds that have not made any announcements and have started to short the target after the announcements. *Shorting Return* is the period return measured by the stock price on the last position reporting date divided by the price on the first position reporting date minus one. The table presents the summary statistics of *Announcers'* and *Followers'* shorting returns on stocks that were attacked publicly by *Announcers*.

	Announcers			Followers				
	Mean	Std. errs.	Obs.	Mean	Std. errs.	Obs.	Diff	t-stat
Shorting Return (%)	19.07	18.84	12	1.76	1.38	356	17.304	2.102

B.6 Model Implications and Predictions

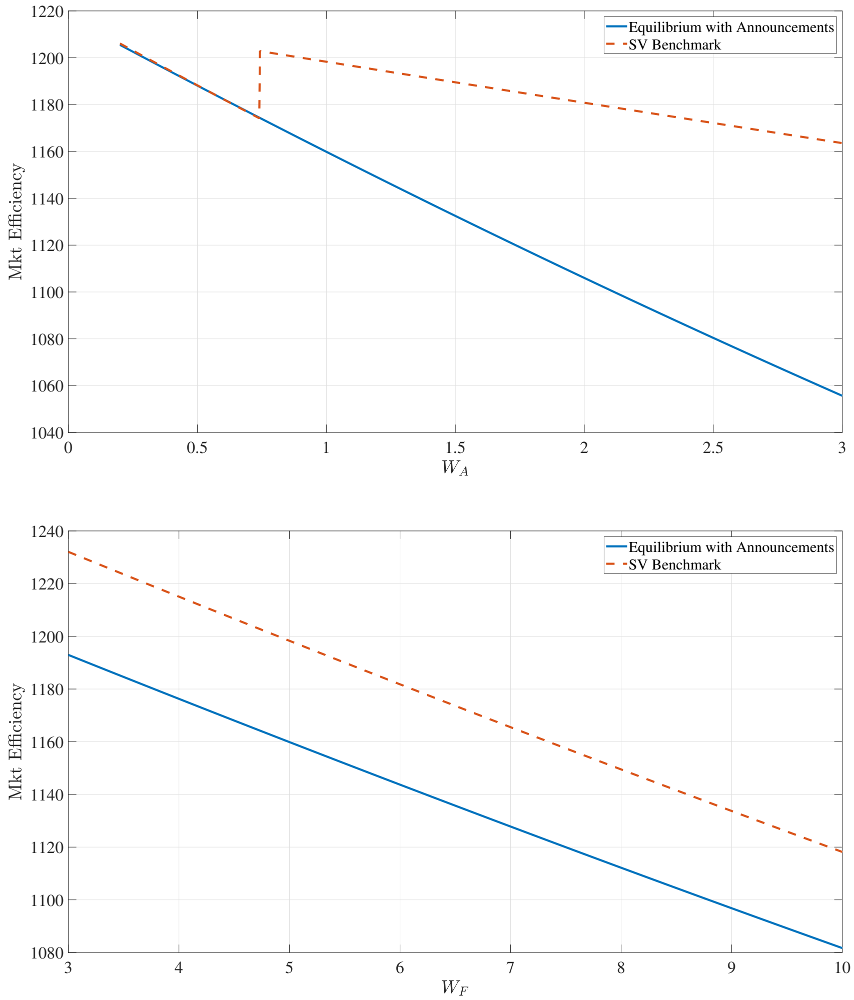


Figure X. Market efficiency under different fund sizes

This figure reports the market efficiency of the equilibrium and the benchmark. $V = 100, U_0 = 30, U = 60, \kappa = 0.05, \phi = 2, q = 0.35$. The upper graph plots the market efficiency when the size of fund F is fixed, $W_F = 5$, and the bottom graph plots the market efficiency when the size of fund F is fixed, $W_A = 1$.

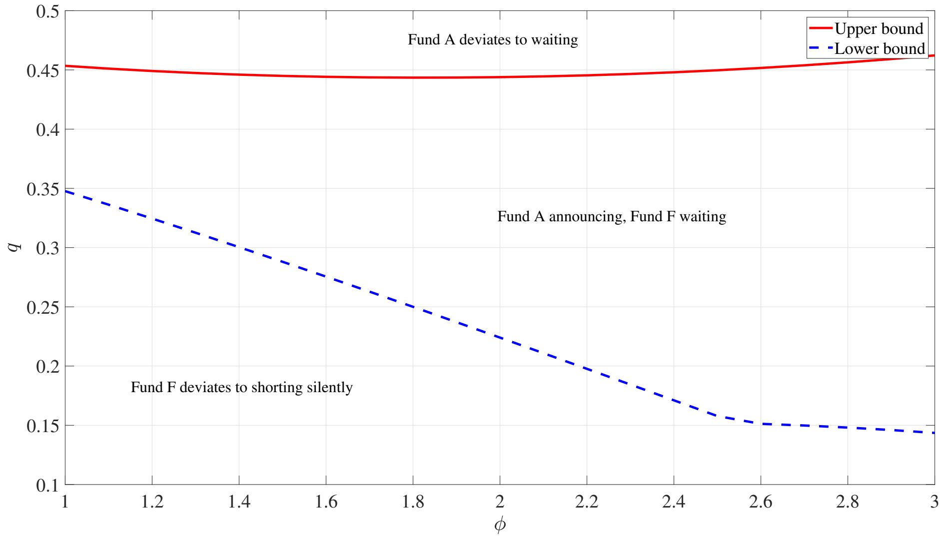


Figure XI. Thresholds for the equilibrium to hold under different leverage ϕ

This figure reports the thresholds of noise trader risk q under different ϕ given following parameters that satisfy all assumptions: $V = 100, U_0 = 30, U = 60, \kappa = 0.05, W_A = 0.5, W_F = 6$. The solid line plots the upper bound and the dashed line plots the lower bound of q in the equilibrium.

.

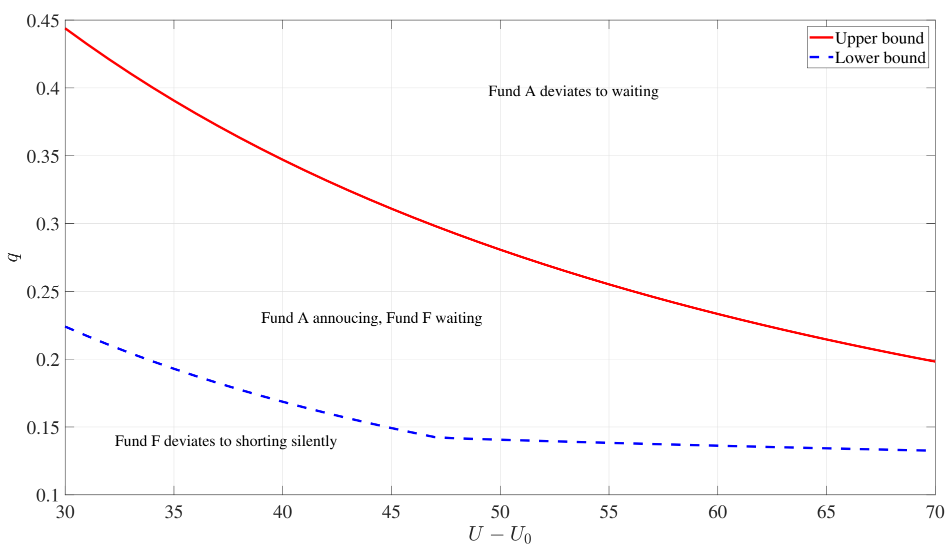


Figure XII. Thresholds for the equilibrium to hold under different surprise in mispricing $U - U_0$

This figure reports the thresholds of noise trader risk q under different U given following parameters that satisfy all assumptions: $V = 100, U_0 = 30, \phi = 2, W_A = 0.5, W_F = 6$. The solid line plots the upper bound and the dashed line plots the lower bound of q in the equilibrium.

B.7 Test of Model Predictions

Table VI. Summary statistics of regression sample

This table presents the mean value for variables used in regression analyses. *Daily Cost of Borrow Score* is a number from 1 to 10 indicating the cost of borrowing the target stock at the end of the month. It is based on Markit proprietary benchmark rate, where 1 is the cheapest and 10 is the most expensive. *Lender Concentration* is the Herfindahl index that measures the distribution of lender value on loan, where zero indicates many lenders with small loans and 1 indicates a single lender with all the value on loan. *Percentage of Lendable Value* is the value of stock inventory which is actively made available for lending divided by the market value of the stock. *Percentage of Up* is the ratio of the number of upward revisions to the total number of analyst forecasts for the stock's EPS. *Percentage of Down* is the ratio of the number of downward revisions to the total number of analyst forecasts for the stock's EPS. *Analyst Dispersion* is the standard deviation of analyst forecasts divided by the mean in month $t-1$. *Fund Size* is the total asset under management, measured in billions of dollars, within the fund company at the end of the previous quarter. *Stock Size* is the month-end market capitalization of each stock, measured in billions of dollars. *CAPM Alpha* is the adjusted monthly return using CAPM model. *Log Turnover* is the average log of turnover of each stock in month $t-1$. *IVOL* is the standard deviation of residuals from the regression of daily returns on market factor in the past three months. The columns report coefficients from the Probit regression, associated z-values, and marginal effects on announcing probability (evaluated at the average value of the other regressors). Observations are monthly-level shorting events from November 2012 to November 2021.

	All	Target is announced	Target is not announced
Daily Cost of Borrow Score	2.09	1.71	2.10
Lender Concentration	0.24	0.20	0.24
Percentage of Lendable Value	14.70	17.00	14.70
Percentage of Up	0.12	0.25	0.11
Percentage of Down	0.22	0.35	0.22
Analyst Dispersion	0.11	0.32	0.11
Fund Size	52.80	4.11	53.90
Stock Size	4.16	6.95	4.10
CAPM Alpha	-0.16	-2.99	-0.10
Log Turnover	-5.69	-4.97	-5.70
IVOL	2.30	2.98	2.29
Obs.	1362	29	1333

Table VII. Borrowing Constraints and Announcements: Robustness

This table presents the results of Probit regressions. The dependent variable is one if hedge fund j made announcements against stock i in month t. It is equal to zero if hedge fund j kept silent on stock i. *Lender Concentration* is the Herfindahl index that measures the distribution of lender value on loan, where zero indicates many lenders with small loans and 1 indicates a single lender with all the value on loan. *Percentage of Lendable Value* is the value of stock inventory which is actively made available for lending divided by the market value of the stock. *Fund Size* is the total asset under management, measured in billions of dollars, within the fund company at the end of the previous quarter. *Stock Size* is the month-end market capitalization of each stock, measured in billions of dollars. *CAPM Alpha* is the adjusted monthly return using CAPM model. *Log Turnover* is the average log of turnover of each stock in month $t-1$. *IVOL* is the standard deviation of residuals from the regression of daily returns on market factor in the past 3 months. The columns report coefficients from the Probit regression, associated z-values, and marginal effects on announcing probability (evaluated at the average value of the other regressors). Observations are from November 2012 to November 2021. Standard errors are clustered by stock and year-month.

Panel A: Borrowing Costs Measured by Lender Concentration

	Coefficient	z-value	Marginal Effects
Lender Concentration	-1.754	-2.18**	-0.00734
Fund Size	-0.0244	-2.09**	-0.000102
Stock Size	0.0216	3.71***	0.000090
CAPM Alpha	-0.0104	-1.79*	-0.000044
Log Turnover	0.002	0.02	0.000008
IVOL	0.0382	0.58	0.000160
Obs.	1,309		
Pseudo R^2	0.193		

Panel B: Borrowing Costs Measured by Percentage of Lendable Value

	Coefficient	z-value	Marginal Effects
Percentage of Lendable Value	0.0114	1.29	0.000060
Fund Size	-0.0232	-2.04**	-0.000122
Stock Size	0.0189	3.55***	0.000099
CAPM Alpha	-0.0094	-1.6	-0.000049
Log Turnover	0.0402	0.43	0.000211
IVOL	0.0367	0.61	0.000193
Obs.	1,308		
Pseudo R^2	0.181		

*** Significant at 1%, ** Significant at 5%, * Significant at 10%