Short-sightedness, Short-sale Constraints and the Dissemination of Private Information*

Paolo Colla *Bocconi University*†

Paolo Vitale *University of Pescara*‡

October 2022

ABSTRACT

We develop a model of private information dissemination by a short-sighted raider within a market for a risky asset. Because the raider is risk-averse and atomistic, her trades do not directly affect prices. In addition, because she is short-sighted, she needs to liquidate her position before the asset price fully reflects her private information. We establish that under these conditions she finds it optimal to publicize her signal in order to move the asset price in the desired direction when her information is either very bad or very good. We prove that short-sale constraints affect the raider's dissemination policy, in that when they are tight she is less likely to disclose her signal when this is negative and when she does so it is because her information is extremely bad. We establish a number of empirical implications of the raider's dissemination policy which are coherent with the analysis of 265 damning reports published between 2010 and 2021 by a group of 12 dedicated short-bias funds.

JEL Codes: G14, G11.

Keywords: Short-sightedness, Short-sale Constraints, Information Disclosure.

*We benefited from discussions with Michela Verardo. We also thank participants at seminars at the University of Bolzano and the 2022 IBEO Workshop in Alghero. The usual disclaimers apply.

†Department of Finance, Università Luigi Bocconi, Via Röntgen 1, 20136 Milan (Italy); webpage: http://faculty.unibocconi.eu/paolocolla; e-mail: paolo.colla@unibocconi.it.

‡Department of Economics, Università Gabriele d'Annunzio, Viale Pindaro 42, 65127 Pescara (Italy); webpage: http://www.ch.unich.it/~vitale; e-mail: p.vitale@unich.it.

1 Introduction

A standard presumption of financial economics is that investors' information is impounded into securities prices via their trading activity. As investors trade on their information a market consensus on the intrinsic value of securities is eventually established. Investors which have access to privileged information on the fundamentals of securities buy and sell such securities to exploit their informational advantage. As market clearing prices depend on individuals' demands for these securities their prices eventually reflect the information which is brought to the market by these informed investors. Importantly, such investors benefit from their informational advantage and have, according to standard theory, no reason to share their information with others.

However, this argument is repeatedly contradicted as often investors share their views on securities and/or publicize their investment decisions, a practice often refereed to as "talking the book". Interestingly, this phenomenon also concerns sophisticated investors who share their views via dedicated websites, blogs or newsletters. One is then left wondering why they should freely reveal their assessment of securities fundamentals and their investment decisions and why other investors should believe what they say.

Particularly illustrative in this respect is the activity of dedicated short-bias funds.[1] These form a small group of market raiders which identify overpriced companies, take short-sale positions and wait for a price correction to cash in trading profits.[2] Such strategy may be arduous to implement in that raiders typically have limited capital to pledge to short-selling. In addition, short-selling may be limited by market regulation (short-sale bans, uptick rules, etc.) or illiquidity (because securities lenders may be hard to come by). Short-selling is also expensive because collateral must be deposited into margin accounts, which must be regulated on a daily basis, daily lending fees to securities lenders must be paid and may sky-rocket in the event of a short-squeeze. Moreover, short-selling is risky since short-term upward movements in the price of the target companies may force liquidation of short-sale positions, as stop-loss limits are reached, and induce a snowball effect.[3] Targeted companies may also take counter-moves to make short-selling more difficult (they can pay special dividends or undertake stock splits requiring the physical delivery of shares).

Owing to the foregoing hurdles in cashing in the profits associated to a short position, a

[1] The term dedicated short-bias is borrowed from Credit Suisse/Tremont's taxonomy of hedge funds. See Lhabitant (2006).

[2] Recent examples of market raiders taking on specific companies comprise *Quintessential*, which launched a successful campaign against *Bio-On* in Italy in 2019 (See https://www.reuters.com/article/us-italy-bio-on-probe) and *Hindenburg Research*, which has targeted *Nikola Motor* in the US in 2020 (See https://fortune.com/2020/09/10/nikola-motor-stock-hindenburg-research-allegations/).

[3] Short positions on equities can also be taken using options. Even these are subject to constraints and costs.

common practice among market raiders taking on specific companies is publicizing their activity. Therefore, they usually publish newsletters with detailed information and a critical appraisal of their targets. These damning reports aim at influencing market participants' opinions and ultimately at forcing a large price correction that a raider's short-sale position cannot bring about on its own.[4] In reaction to the dissemination of such damning reports, the management of the target companies can accuse dedicated short-bias funds of crimes, and hence sue them, hire private investigators to probe them and/or request that regulators investigate their activities.[5] It is therefore common that these funds engage in bitter battles which may last for long, even very long, periods of time.

As shown by Ljungqvist and Qian (2016), the activity of dedicated short-bias funds is particularly lucrative. In their study, they analyze the profitability of 17 specialized short sellers, over more than 100 campaigns, and find that on average their damning reports generate significant and large negative abnormal returns.[6]

With the objective of rationalizing the behavior of this group of sophisticated investors, we formulate a model of optimal dissemination of private information by a short-sighted, risk-averse competitive raider which operates within a market where a risky asset is traded over two periods and where short-sale constraints limit the raider's position. Our formulation bridges two lines of research related to the disclosure of private information and the impact of short-sale constraints.

On the one hand, several contributions have analyzed investors' incentives to freely disclose private information.[7] A first set of existing work deals with strategic communication in asset markets and focuses on the underpinnings to truthful private information dissemination as opposed to opportunistic disclosure.[8] van Bommel (2003) highlights the importance of reputation concerns in supporting truth-telling in equilibrium. Schmidt

[4]Appel and Fos (2020) find that short selling campaigns by activist investors generate an increase in short-interest for the target companies. Disseminating damning reports is not the only way in which hedge funds voluntarily disclose their information. Luo (2018) documents that stocks pitched by hedge funds at investment conferences –typically long pitches– outperform non-pitched stocks after the conferences, suggesting that pitches do indeed contain valuable (positive) information. Moreover, hedge funds increase their exposure to pitched stocks prior to the conferences and, instead of holding onto the pitched stocks, they start to cut down their exposure to the pitched stocks after the investment conferences.

[5]There have also been episodes of prominent short-sellers being physically threatened.

[6]Consistent with this, in a study of about 250 short selling campaigns by activist hedge funds, Appel and Fos (2020) find that target companies experience negative cumulative abnormal returns around campaign announcement dates.

[7]There is a parallel stream of the literature that deals with *costly* information sales by informed agents, say analysts (Admati and Pfleiderer (1986, 1988, 1990), Cespa (2008), Veldkamp (2006)). In this literature, as we do, information is always truthfully revealed to market participants. Different from our setup, however, the information sender is not allowed to trade the asset.

[8]A different strand of literature considers instead the possibility that opportunistic disclosure of private information may be used by the speculators to manipulate prices (Benabou and Laroque, 1992; Pasquariello and Wang, 2021).

(2020) shows that truth-telling is more attractive for short-sighted investors because the disclosed signal is more likely to be in line with subsequent information arrivals and hence it is associated to a larger short-term price impact. A second stream of the literature takes truth-telling as given and analyzes conditions that facilitate private information disclosure. Liu (2017) shows that a short-term investor discloses her private information in order to attract additional capital that pushes the price closer to fundamentals. Kovbasyuk and Pagano (2021) highlight that private information disclosure is related to limited attention: an investor endowed with signals on multiple assets optimally discloses only a subset of these signals in order not to dilute uninformed investors' attention. Colla and Mele (2010) show that information sharing between privately informed traders is profitable when private signals are negatively correlated. Similar to these papers we take truth-telling as given, also owing to the evidence in Ljungqvist and Qian (2016) as well as that in our empirical analysis that the campaigns of dedicated short-bias funds are informative.

We extend these results by showing how the dissemination policy of the raider depends on her signal, in that we establish that she finds it optimal optimal to disclose her private information after the first trading round *only* when this greatly differs from the market consensus –that is when her private signal on the liquidation value of the risky asset is either very bad of very good. Under these circumstances the dissemination of her private signal is more likely to move the asset price by a large margin. Within our formulation we also prove that the raider's dissemination policy does not harm the welfare of all the other market participants, contradicting the widespread opinion that short-sellers' activity is often harmful to small investors.

On the other hand, the impact of short-sale constraints on securities markets has been modeled by Diamond and Verrecchia (1987), Bai, Chang and Wang (2006), Yuan (2006), Marin and Olivier (2008), Lenkey (2015), Nezafat, Schroder and Wang (2017), among others. In particular, Diamond and Verrecchia consider an extension of Glosten and Milgrom's (Glosten and Milgrom, 1985) sequential trade model to the case in which a number of traders is subject to short-sale bans and show how prices become less informative, and liquidity deteriorates. Marin and Olivier instead formulate an extension of Grossman and Stiglitz's (Grossman and Stiglitz, 1980) REE model, where informed and uninformed investors are subject to constraints, including short-sale bans, on their holdings of the risky asset. They show how the standard pricing function which applies in the absence of constraints, i.e. is linear in the signal observed by informed agents, is replaced by a non-linear, discontinuous one. In particular, when informed agents have sufficiently bad news about the asset value, the equilibrium price is not responsive to such information and a market crash occurs.[9]

All these models deal with static portfolio choice problems and hence they are not suited to rationalize investors that first trade and then disseminate their private information, which instead we consider in our formulation. We are then able to establish how the presence of short-sale constraints interferes with the raider's dissemination policy, as we see that when such constraints are tight the raider is less likely to publicly disclose her private signal. Specifically, with tight short-sale constraints negative signals are disseminated only when extremely disappointing.

Within our formulation, we derive a series of empirical implications pertaining to the market quality which are consistent with a vast body of empirical investigations on short-selling activity (Saffi and Sigurdsson, 2011; Beber and Pagano, 2013; Boehmer, Jones and Zhang, 2013; Ljungqvist and Qian, 2016, among others). Thus, we establish that, in the absence of constraints to short positions, the dissemination of private signals makes the market for the risky asset more efficient and liquid. As short-sale constraints reduce the probability that the raider disseminates her private signal, we conclude that short-sale constraints impair market quality. We prove that if the raider sells short the risky asset she is bound to make her private signal public, coherently with the behavior of dedicated short-bias funds illustrated by Ljungqvist and Qian (2016). Finally, we show that in the presence of short-sale constraints the publication of a damning report by the raider will be associated with a larger price correction for the target company.

We test the main empirical implications of our model by investigating the activity of a group of 12 dedicated short-bias funds which publicly disseminate their investment recommendations as well as their short positions. We compile a database of damning reports published by these funds between 2010 and 2021 that target U.S. listed companies deemed overpriced and disclose that a short-sale position has been taken. We supplement this database with short-interest data on the target companies, as proxy of the severity of short-selling constraints prior to the damning reports' release, ending up with more than 250 events.

We then run an event study of the price impact of these damning reports by estimating cumulative abnormal returns for the target companies around the days of their publication. Consistently with the implication of our model that when in possession of a negative signal the raider first takes a short position and then disseminates her private information to induce a price correction, we find that the publication of the funds' reports induces a large

[9]The informed traders' demand for the risky asset is shown to be no longer informative –and thus associated with price crashes– also in Yuan (2006) when informed traders' borrowing capacity is tied to asset values, i.e. constraints arise when the stock price is low. In Marin and Olivier (2008), informed traders face exogenous position limits like in our model.

and significant drop –equal to about -20% on a risk-adjusted basis at a 30 trading day horizon– in the prices of the target companies. We also unveil that when the publication of a damning report concerns a target company for which short-interest is high, and hence sale constraints are severe, its price impact is larger: thirty days after the release, high short-interest targets experience a -24% price reduction, while the reaction for those with low short-interest is -8%. This result is consistent with the conclusion of our model that in the presence of short-sale constraints the raider publishes a negative signal only when this is extreme.

This paper is organized as follows. In Section 2 we present the model, describing how the market for the risky asset operates and introducing the information sets of its participants. In the following Section we determine the equilibrium in the absence of short-sale constraints. Thus, we derive the equilibrium prices and various indicators of market quality when the raider chooses to disclose her private signal and when she does not. Hence, we characterize her optimal dissemination policy. In Section 4 we extend our analysis to the case in which short-sale constraints are imposed and study their impact on the raider's dissemination policy and on the market quality. In Section 5 we illustrate the empirical exercise we conduct, the database and the methodology we employ, and the results we obtain. In a final Section we propose some concluding remarks with a discussion of our results and potential extensions. All proofs of our analytical results are relegated to a separate Appendix. A separate Internet Appendix contains supplementary empirical analyses.

2 A Model of Trading and Disclosure of Private Signals

Kim and Verrecchia (Kim and Verrecchia, 1991) formulate a dynamic extension of Hellwig's (Hellwig, 1980) REE model with public signals. They concentrate on equilibria that arise when investors observe heterogenous private signals and prices are not jointly fully revealing. They are able to identify the REE for this extension because the aggregate supply of the risky asset, while random, is equal across the two periods of trading.

In what follows we consider a simplified version of Kim and Verrecchia's model, as investors only observe public signals. We extend their analysis in three directions. Firstly, we add a short-sighted and atomistic raider, who may disclose a private signal on the fundamental value of a risky asset. Secondly, we introduce limited attention, in that investors only consider signals they observe. These include the signals the investors freely gather from the media and public sources and the raider's private signal, should she decide to disclose it. Because of limited capacity to process information the investors are assumed not to make any inference on the quality of the raider's information when she does not disseminate her private signal. This assumption, which is shared with Kovbasyuk and Pagano

(2021), can be justified arguing that the investors are uncertain on whether anybody possesses any private information on the risky asset and are therefore not able to make any inference when no private signal is disclosed.[10] Thirdly, we accommodate short-selling constraints, in a vein similar to that employed by Marin and Oliver, which may limit the action of the raider. Hence, let us introduce our benchmark specification.

2.1 The Model

We consider a securities market where two assets are traded: a risk-free (numeraire) asset, whose final payoff is normalized to 1, and a risky one, with uncertain liquidation value v. There are four periods: period 0, where a market raider observes a private signal on v, periods 1 and 2, where signals on v are publicly released and the risky asset is traded for the numeraire, and period 3 where the liquidation value is observed and all agents consume all their wealth. In accordance with Kim and Verrecchia, in the market there is a continuum of investors, indexed with $i \in [0,1]$. Investors are risk-averse and exhibit constant absolute risk-aversion (CARA) preferences, so that investor i possesses risk-tolerance τ_i.[11] In period 0 each investor is endowed with z_i units of the risky asset,[12] so that the aggregate supply of the risky-asset is $z = \int_0^1 z_i \, di > 0$.[13] We add a market raider, indexed with R. She is also endowed with CARA utility function, with risk-tolerance τ_R. For simplicity we assume that she possesses no initial endowment of the risky asset, so that $z_R = 0$.[14]

The risky asset's liquidation value, v, is normally distributed with mean μ_v and precision θ_v. In period 1, firstly, all agents observe a public signal $s_1 = v + u_1$, with u_1 normally distributed with mean 0 and precision θ_1; then the securities market opens and agents buy and sell the two assets competitively.[15] In period 2, firstly, all agents observe a second public signal $s_2 = v + u_2$, with u_2 normally distributed with mean 0 and precision θ_2; then the securities market opens and agents buy and sell the two assets competitively. All random variables are orthogonal, so that $v \perp u_1 \perp u_2$. In period 0 the raider observes a private

[10] Indeed, if there exist countless assets and the raider can collect private information on a single asset at a time, the ex-ante probability she possesses private information on a specific asset is zero.

[11] Kim and Verrecchia accommodate heterogeneity of risk-tolerance coefficients across all investors; Marin and Olivier differentiate between informed and uninformed investors.

[12] Kim and Verrecchia suppose that investor i's initial endowment of the risk-free asset is e_i. We normalize this value to zero. Indeed, given that investors are price-taker and possess CARA preferences, this assumption is not influential.

[13] We could easily accommodate a time-varying and/or stochastic aggregate supply since in equilibrium prices in period 1 and 2 fully reveal z.

[14] Giver the raider's preferences, this assumption is inconsequential for our analysis. A value of z_R different from zero would not affect the raider's optimal holdings of the risky asset and her dissemination policy both with and without short-sale constraints. The raider also possesses a null endowment of the risk-free asset. This simplification also bears no consequences for our analysis and it can be easily relaxed. Moreover, it can be justified considering that typically dedicated short-bias funds are not deep-pocket investors.

[15] Kim and Verrecchia assume that each investors also observe an individual private signal.

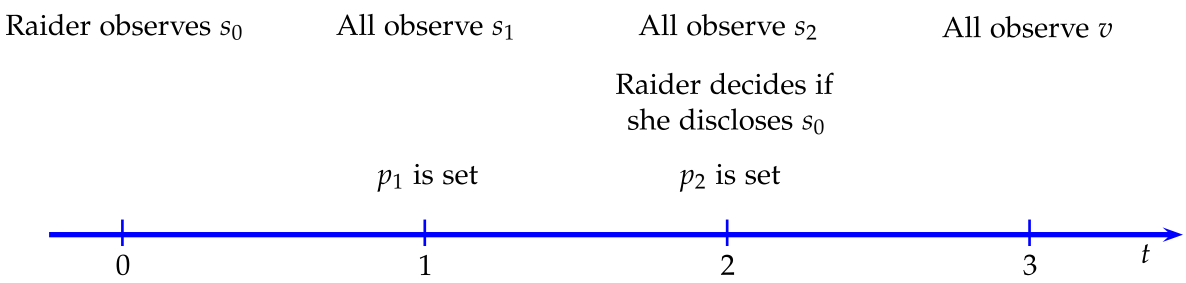


Figure 1: The model timeline.

signal $s_0 = v + u_0$, with u_0 normally distributed, with mean 0 and precision θ_0, and orthogonal to all other random variables (in Figure 1 we have representation of the model's timeline). Because she is atomistic, risk-averse and her information is imperfect (the latter two assumptions implying that she does not trade infinite quantities), her investment decisions in periods 1 and 2 do not affect the price of the risky asset. This assumption is in common with Kovbasyuk and Pagano (2021) and is also coherent with the conclusions of Ljungqvist and Qian (2016) who find that dedicated short-bias funds have very limited firepower and are able to short only a few million dollars.

Moreover, since there is no informational asymmetry among the investors the price of the risky asset in periods 1 and 2 does not reveal any information. The market raider is short-sighted in that she is forced to liquidate her portfolio in period 2. This assumption is justified considering how long it typically takes activists to enact price corrections in their campaigns. Indeed, Ljungqvist and Qian (2016) show that third party actions which precipitate the price corrections sought for by the short-sellers usually take many quarters to materialize. Therefore, the raider may decide to disclose her private signal once the first round of trading has been completed (or equivalently before the second round of trading starts).[16] In this case, all investors observe s_0 before trading in period 2, i.e. before selecting their demand schedules for the risky asset in the second round of trading.

We argue that since the raider's signal is verifiable ex-post by regulators and supervisory bodies, potential punishment should be an effective discipline device to induce truthfully revelation of s_0. Furthermore, as the management of target companies are usually more than willing to start lawsuits against market raiders, the incentive to publish falsehoods in

[16] We exclude the possibility that the raider may attempt to sell her private signal to only a group of investors. It may be argued, in fact, that such an attempt would be problematic, in that an investor may require to see the content of the private information the raider possesses before he agrees to purchase her private signal. Moreover, an investor who bought the raider's signal may himself try to sell it to other investors.

order to manipulate the asset price should be minimal and, in fact, evidence in Ljungqvist and Qian (2016) shows that the damning reports published by dedicated short-bias funds are in general very accurate and contain claims which the authors can substantiate, while follow-on probes by regulatory bodies usually concur with the overall message these reports convey.[17] All in all, we can confidently assume that the raider should never attempt to distort her signal in order to manipulate the asset price, so that if she decides to disclose her private information she reveals the true value of s_0 to all market participants.

In an extension of our benchmark formulation we depart from Kim and Verrecchia and Kovbasyuk and Pagano assuming that the market raider is subject to short-sale constraints. Specifically, the raider's minimum holdings of the risky asset is $\bar{x}$, with $\bar{x} \leq 0$. Thus, let x_R be the raiders' holdings of the risky asset. The short-sale restriction imposes that $\bar{x} \leq x_R$.

In brief, this basic formulation is similar to that of Kovbasyuk and Pagano (2021) with some important differences: i) we allow investors to trade in both periods instead of resorting to an overlapping generations setup; ii) we (attempt to) accommodate short-sale constraints.[18] In particular, the latter assumption allows us to focus on dedicated short-bias funds, which sell short securities of those corporations for which they have collected negative information, while the former permits a proper analysis of the implications of the raiders activity on investors' welfare.

3 Market Equilibrium and Main Results

We now proceed to identify the equilibrium price of the risky asset in the two rounds of trading for the two alternative scenarios we consider: in the former the raider decides not to disseminate her private signal s_0 on the liquidation value of the risky asset; in the latter she makes her signal public before trading starts in period 2. We are then able to determine the impact of the raider's choice to disseminate or not disseminate on the liquidity and efficiency of the market for the risky asset, on price volatility, on the investors' optimal holdings of the risky asset and on their expected utility. Finally we are able to determine under which conditions the raider finds it optimal to disclose her private information.

[17] While we do not model it, a reputational mechanism should strengthen the incentive to disclose truthfully. Indeed, as argued by Ljungqvist and Qian (2016), reports published by more credible short-sellers have a bigger price impact.

[18] Another difference is that in their formulation the raider may simultaneously disseminate private signals on a number of assets, while we only allow the raider to share her private information on an asset at a time. The latter assumption is consistent with evidence by Ljungqvist and Qian (2016), who show that dedicated short-bias funds run very few campaigns and usually not at the same time, and Luo (2018), who claims that funds pitching stocks at investment conferences most of the time cover single stocks.

3.1 The Benchmark Specification

We are able to prove the following Lemma which pins down the equilibrium prices of the risky asset in periods 1 and 2 when the raider disclose/does not disclose her private signal.

Lemma 1 *The equilibrium price of the risky security in period 1 is equal to*

$$p_1^* \;=\; \mu_{v|\Omega_1} \;-\; \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z\,, \tag{3.1}$$

where $\mu_{v|\Omega_1}$ is the expectation of the liquidation value of v conditional on the investors' information set in periods 1, $\Omega_1 = \{s_1\}$, $\theta_{v|\Omega_1}$ is the corresponding conditional precision, $\theta_{v|\Omega_1} = \theta_v + \theta_1$, and τ is the investors' average risk-tolerance, $\tau = \int_0^1 \tau_i di$.

With no dissemination of the raider's signal before trading in period 2, the equilibrium price of the risky security in period 2 is equal to

$$p_2^{*,nd} \;=\; \mu_{v|\Omega_2^{nd}} \;-\; \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}}z\,, \tag{3.2}$$

where $\mu_{v|\Omega_2^{nd}}$ is the expectation of the liquidation value of v conditional on the investors' information set in period 2 when the raider does not disseminate her private signal, $\Omega_2^{nd} = \{s_1, s_2\}$, and $\theta_{v|\Omega_2^{nd}}$ is the corresponding conditional precision, $\theta_{v|\Omega_2^{nd}} = \theta_v + \theta_1 + \theta_2$.

With dissemination of the raider's signal before trading in period 2, the equilibrium price of the risky security in period 2 is equal to

$$p_2^{*,d} \;=\; \mu_{v|\Omega_2^{d}} \;-\; \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{d}}}z\,, \tag{3.3}$$

where $\mu_{v|\Omega_2^{d}}$ is the expectation of the liquidation value of v conditional on the investors' information set in period 2 when the raider does disseminate her private signal, $\Omega_2^{d} = \{s_0, s_1, s_2\}$, and $\theta_{v|\Omega_2^{d}}$ is the corresponding conditional precision, $\theta_{v|\Omega_2^{d}} = \theta_v + \theta_0 + \theta_1 + \theta_2$.

Proof. See the Appendix.

Because she is risk-averse and atomistic, the raider's transaction in period 1 does not affect the equilibrium price, so that under no dissemination the market equilibrium coincides with that described by Kim and Verrecchia, when all investors observe in period 1 the public signal s_1 and in period 2 they observe the public signal s_2. However, the decision to disseminate her private signal before trading in period 2 alters the investors' information sets, as they now also observe the raider's private signal s_0. This means that the raider's dissemination conditions the equilibrium price of the risky security in period 2.

Inspection of eqs. (3.2) and (3.3) shows that the price sensitivity to the asset supply, z, is larger under no dissemination than under dissemination $\left(\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}} > \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{d}}}\right)$. As this price sensitivity represents a measure of market liquidity we reach the conclusion that the dissemination decision also conditions market quality. Interestingly, this result is consistent with evidence by Ljungqvist and Qian (2016). They show that on average after the publication of a damning report by a dedicated short-bias fund the price impact of trade imbalance falls dramatically for the target company (in fact, they see that Amihud's illiquidity measure drops by roughly 60% with respect to its baseline value calculated over a quarter ending a month before the report's publication). This effect is clearly consequence of the drop in the perceived risk associated with the risky asset.

Not only the decision of the raider to disseminate her private information affects market liquidity, but also price volatility. In fact we also derive the following Lemma:

Lemma 2 *The variance of the second period price, conditional on public information, respectively without and with dissemination is*

$$Var[p_2^{*,nd} \mid \Omega_1] = \frac{\theta_2}{\theta_{v|\Omega_2^{nd}}\,\theta_{v|\Omega_1}}, \tag{3.4}$$

$$Var[p_2^{*,d} \mid \Omega_1] = \frac{\theta_0 + \theta_2}{\theta_{v|\Omega_2^{d}}\,\theta_{v|\Omega_1}}. \tag{3.5}$$

Proof. See the Appendix.

It is immediate to see that $\mathrm{Var}[p_2^{*,d} \mid \Omega_1] > \mathrm{Var}[p_2^{*,nd} \mid \Omega_1]$, so that the raider choice to disseminate her private signal increases price volatility. Even this result is consistent with evidence proposed by Ljungqvist and Qian (2016). In fact they detect very large spikes, *vis-à-vis* baseline values, in price volatility after the publication of damning reports (on average they observe an increase of more than 200% in volatility on the day a report is published).

The raider's decision to disseminate her private signal also affects the conditional variance of the liquidation value of the risky asset given public information in period 2. In fact from Lemma 1 we see that this conditional variance is equal under respectively no dissemination and dissemination to $\theta^{-1}_{v|\Omega_2^{nd}}$ and $\theta^{-1}_{v|\Omega_2^{d}}$. Because $\theta_{v|\Omega_2^{d}} > \theta_{v|\Omega_2^{nd}}$, we reach the trivial conclusion that the raider choice to disseminate her private signal increases market efficiency.

From Lemma 1 we can derive the holdings in periods 1 and 2 of the investors and their value function in equilibrium:

Lemma 3 *Whatever the raider's dissemination policy, the equilibrium holdings in periods 1 and 2 for investor i are*

$$x_{i,1}^{*} = \frac{\tau_i}{\tau}\, z\,, \tag{3.6}$$

$$x_{i,2}^{*} = \frac{\tau_i}{\tau}\, z\,. \tag{3.7}$$

Whatever the raider's dissemination policy, the value function of investor i, conditional on the information he possesses in period 1, is given by the following expression

$$V_i = -\exp\left(-\frac{1}{\tau_i}\, p_1^{*}\, z_i - \frac{1}{2}\frac{1}{\tau^2}\frac{1}{\theta_{v|\Omega_1}}\, z^2\right). \tag{3.8}$$

Proof. See the Appendix.

This Lemma indicates that, because the investors possess common information, perfect risk-sharing ensues that their optimal holdings in equilibrium are just function of their risk-tolerance, while their expected utility in equilibrium is unaffected by the raider's dissemination policy. We then conclude that the raider's decision to disseminate her private signal does not affect investors' welfare. This result implies that only the raider can potentially benefit from the disclosure of her private signal, while general welfare remains unaffected. Thus, according to our formulation, the bad reputation earned by short-sellers in securities markets is clearly not justified.

We now turn to the trading decision and the value function for the raider under dissemination and no dissemination. By investigating her value function in the two scenarios we will be able to pin down her optimal dissemination policy. Thus, let Ω_R denote the raider's information set in period 1, $\Omega_R = \{s_0, s_1\}$. The precision of v conditional on Ω_R is $\theta_{v|\Omega_R} = \theta_v + \theta_0 + \theta_1$. Then, we can prove the following Lemma:

Lemma 4 *Without dissemination the raider's holdings of the risky asset in equilibrium are*

$$x_R^{*,nd} = \tau_R\, \theta_0\, \frac{\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_2^{d}}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{\tau_R}{\tau}\frac{\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_2^{d}}}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}}\, z\,, \tag{3.9}$$

while the corresponding value function is

$$V_R^{nd}(s_0) = -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^{d}}}\left(\frac{\theta_0\theta_2}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\frac{\theta_2}{\theta_{v|\Omega_1}}\, z\right)^2\right). \tag{3.10}$$

With dissemination the raider's holdings of the risky asset in equilibrium are

$$x_R^{*,d} = \tau_R \frac{\theta_0}{\theta_2} \theta_{v|\Omega_2^d} \left(s_0 - \mu_{v|\Omega_1} \right) + \frac{\tau_R}{\tau} \left(1 + \frac{\theta_0}{\theta_2} \right) \frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}} z \,, \tag{3.11}$$

while the corresponding value function is

$$V_R^d(s_0) = -\exp\left(-\frac{1}{2} \frac{\theta_{v|\Omega_R}}{\theta_2 \theta_{v|\Omega_2^d}} \left(\frac{\theta_0 \theta_{v|\Omega_2^d}}{\theta_{v|\Omega_R}} \left(s_0 - \mu_{v|\Omega_1} \right) + \frac{1}{\tau} \frac{\theta_0 + \theta_2}{\theta_{v|\Omega_1}} z \right)^2 \right) . \tag{3.12}$$

Proof. See the Appendix.

Importantly, in comparing eqs. (3.9) and (3.11) we notice that the raider's optimal holdings of the risky asset are more sensitive to the private signal $s_0 - \mu_{v|\Omega_1}$ when disseminating, so that under this scenario she finds it optimal to trade more aggressively. Similarly, the raider's risk-sharing quota of the risky asset is larger with dissemination.

We can now present the main result of our analysis, as we are able to determine when the raider prefers to disseminate her private signal. Let

$$\hat{s} \equiv p_1^* - \frac{1}{\tau} \frac{1}{\theta_0} \frac{2\theta_2}{\theta_{v|\Omega_2^d} + \theta_2} z \,, \tag{3.13}$$

where we immediately notice that $\hat{s} < p_1^*$. Then, we can posit the following Proposition:

Proposition 1 *For $s_0 < \hat{s}$ or $s_0 > p_1^*$ $V_R^d(s_0) > V_R^{nd}(s_0)$, so that the raider prefers to disseminate her private signal. On the contrary, for $\hat{s} < s_0 < p_1^*$ $V_R^{nd}(s_0) > V_R^d(s_0)$, so that the raider prefers not to disseminate it.*

Proof. See the Appendix.

The diagram in Figure 7 graphically illustrates Proposition 1.

We conclude that the raider prefers to disseminate when her private signal is either very good (for $s_0 > p_1^*$) or very bad (for $s_0 < \hat{s}$). In these cases her optimal holdings of the risky asset in equilibrium are given by eq. (3.11). Instead, she prefers not to disseminate if her private signal is neither very good nor very bad (for $\hat{s} < s_0 < p_1^*$). In these cases her optimal holdings are given by eq. (3.9). Inspection of the raider's optimal holdings indicates that the function $x_R^*(s_0)$ is discontinuous at $\hat{s}$ and p_1^*. In fact, for $s_0 = \hat{s}$,

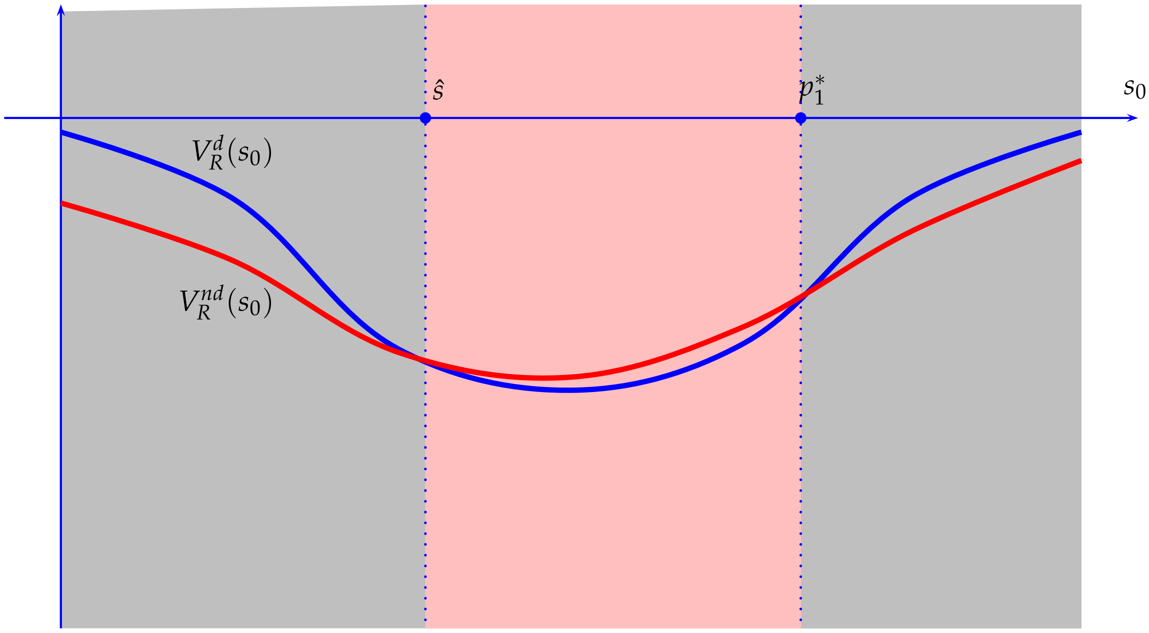


Figure 2: The raider's value function with, $V_R^d(s_0)$, and without, $V_R^{nd}(s_0)$, dissemination.

$$
\begin{aligned}
x_R^{*,nd}(\hat{s}) &= \frac{\tau_R}{\tau}\frac{\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_2^d}}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}+\theta_2}z\,,\\
x_R^{*,d}(\hat{s}) &= -\frac{\tau_R}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}+\theta_2}z\,,
\end{aligned}
$$

so that $x_R^{*,nd}(\hat{s}) > 0 > x_R^{*,d}(\hat{s})$. In addition, for $s_0 = p_1^*$,

$$
\begin{aligned}
x_R^{*,nd}(p_1^*) &= \frac{\tau_R}{\tau}\frac{\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_2^d}}z\,,\\
x_R^{*,d}(p_1^*) &= \frac{\tau_R}{\tau}z\,,
\end{aligned}
$$

so that $0 < x_R^{*,nd}(p_1^*) < x_R^{*,d}(p_1^*)$. As noted above, the raider's optimal holdings are increasing in the private signal, and under dissemination they are increasing at a faster pace. It follows that the dependence of the raider's optimal holdings rule on s_0 can be graphically represented as in Figure 3. This shows that the raider sells short the risky asset only when disseminating her private signal. Once again, this seems coherent with the activity of dedicated short-bias funds which publish damning reports after taking short positions in the securities of the target company.

This discussion delivers the main conclusion of our analysis:

Result 1 *The raider finds it convenient to disseminate her private signal before trading in period 2*

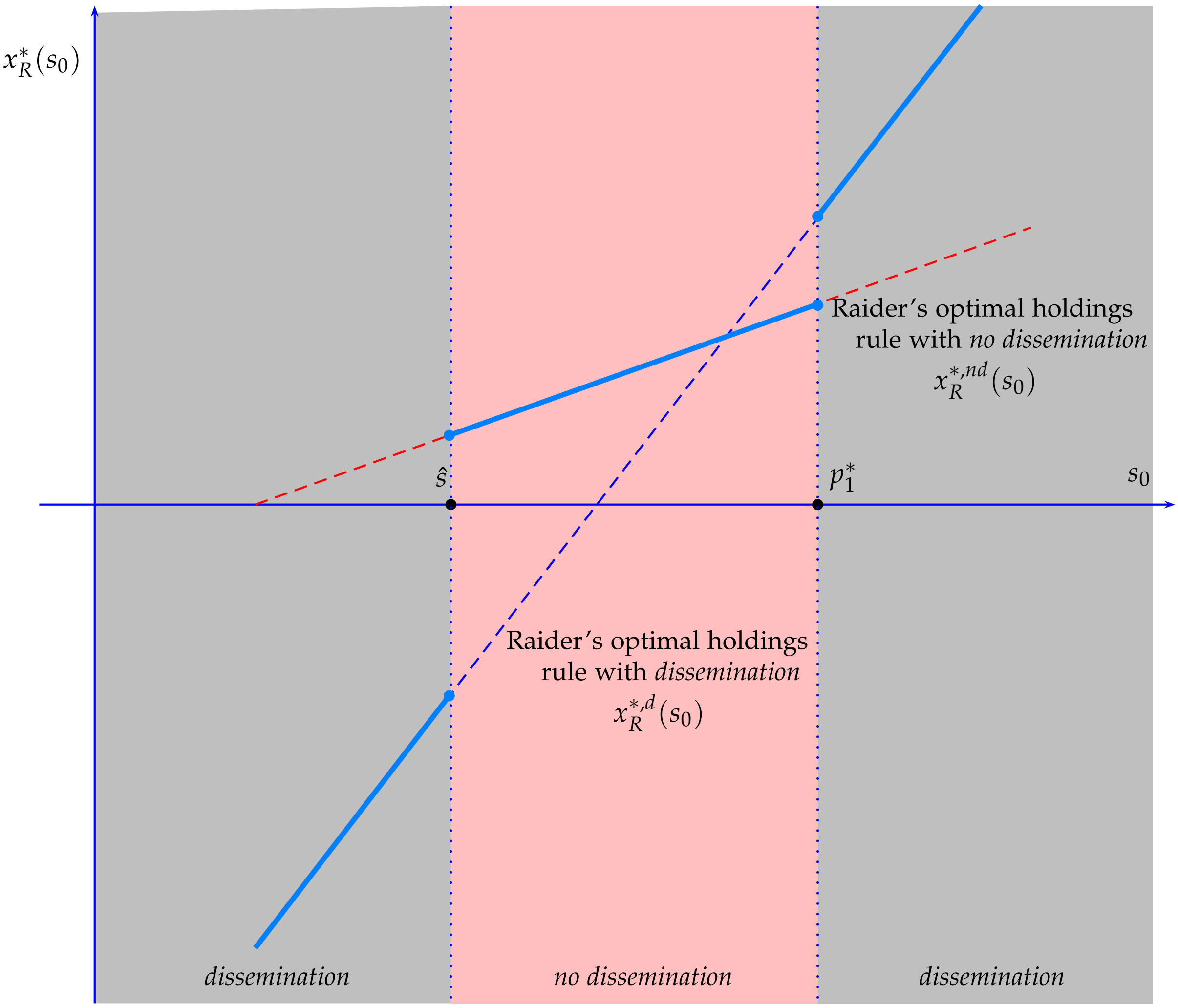


Figure 3: The raider's optimal holdings rule (the azure line).

if her information is either very good or very bad. In the former case she takes a long position in the risky asset and pumps its value by disseminating good news on its fundamental value; in the latter case, viceversa, she takes a short position in the risky asset depressing its valuation by publishing bad news.

Importantly, we impose a degree of bounded rationality, or limited attention, in that the investors do not make full use of the raider's dissemination choice in their assessment of the fundamental value of the risky asset in period 2. Indeed, the fact that the raider does not disseminate her private signal s_0 means that this falls in the interval $(\hat{s}, p_1^*)$. We argue that as they have limited capacity to process information they fail to use this bit of information. This assumption is shared with Kovbasyuk and Pagano.[19]

To develop intuition for Result 1, consider the expression for the raider's value function condition on her information set. This is obtained in the proof of Lemma 4 –see eq. (A.29) in the Appendix,

$$V_R\left(s_0\right) = -\exp\left(-\frac{1}{2}\,\theta_{p_2^*|\Omega_R}\left(\mu_{p_2^*|\Omega_R} - p_1^*\right)^2\right).$$

The raider's payoff reflects the risky asset's price differential from one round to the next –this is because the raider unwinds her position in the second period. Thus, if she observes a negative signal –i.e. if s_0 is low, she sells short the risky asset in period 1 and buys it back in period 2, so that her profits are proportional to $p_1 - p_2$. On the contrary, if her signal is positive –i.e. if s_0 is high, she buys the risky asset in period 1 and sells it back in period 2, so that her profits are proportional to $p_2 - p_1$. As a consequence, in equilibrium, her value function is affected by two terms: the (squared of the) expected price differential, $\left(\mu_{p_2^*|\Omega_R} - p_1^*\right)^2$, and, due to risk-aversion, the precision of such price differential. Since the value function is conditional on period 1 information, the precision of the price differential boils down to the precision of the second period price, $\theta_{p_2^*|\Omega_R}$. Indeed, since $\theta_{p_2^*|\Omega_R} > 0$ and $\left(\mu_{p_2^*|\Omega_R} - p_1^*\right)^2 > 0$ we have that the raider is better off the larger is $\theta_{p_2^*|\Omega_R}$ and/or the 'farer' is $\mu_{p_2^*|\Omega_R}$ from p_1^*. Note that disseminating the signal (viz. not disseminating) affects the value function through the terms $\theta_{p_2^*|\Omega_R}$ and $\mu_{p_2^*|\Omega_R}$ –this is because p_1^* is the same regardless of the dissemination choice. Now we evaluate the two components separately.

[19]Kovbasyuk and Pagano exclude the possibility that the raider's dissemination policy depends on the value of her private signal by assuming that the noise traders' demand for the risky asset is negligible. In our formulation, the same result would be achieved by positing that z, the total supply for the risky asset, is equal to zero.

Considering eqs. (A.31) and (A.33) in the Appendix we have that

$$\theta_{p_2^{*,d}|\Omega_R} > \theta_{p_2^{*,nd}|\Omega_R} \quad \Leftrightarrow \quad \theta^2_{v|\Omega_2^d} > \theta^2_{v|\Omega_2^{nd}},$$

which always holds because $\theta_{v|\Omega_2^d} = \theta_{v|\Omega_2^{nd}} + \theta_0$. Thus, for given (expected) price differential $\mu_{p_2^*|\Omega_R} - p_1^*$, the raider is always better off disseminating her signal (viz. not disseminating). Indeed, in equilibrium, the variability of p_2^* conditional on the raider's information in period 1 depends on the price impact of the public signal the investors observe in period 2, s_2. This price impact is increasing in the investors' uncertainty on the liquidation value v conditional on the public information they possess before observing the public signal in period 2. The dissemination of the raider's private signal reduces such uncertainty and hence the price impact of the public signal s_2 and the variability of p_2^*.

Using eqs. (A.30) and (A.32) in the Appendix and eq. (3.1) we can show that

$$\mu_{p_2^{*,nd}|\Omega_R} - p_1^* = \mu_{p_2^{*,d}|\Omega_R} - p_1^* + \underbrace{\frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_0\left(\mu_{v|\Omega_R} - s_0\right) - \frac{1}{\tau}\frac{\theta_0\left(\theta_1 + \theta_v\right)}{\theta_{v|\Omega_2^d}\,\theta_{v|\Omega_1}}z\right)}_{=\xi}.$$

For the expected price differential without dissemination to be larger (in absolute value) than with dissemination –so that it can counterbalance the precision component, and thus make no dissemination potentially optimal– we need $\xi > 0$ when $\mu_{p_2^{*,d}|\Omega_R} - p_1^* > 0$, or $\xi < 0$ when $\mu_{p_2^{*,d}|\Omega_R} - p_1^* < 0$.[20] Exploiting eqs. (A.30) and (3.1) we can see that, other things equal, $\mu_{p_2^{*,d}|\Omega_R} - p_1^*$ increases in s_0, while ξ decreases in s_0.[21] Therefore one needs the signal to take on somehow "intermediate" values for the expected price differential to be larger without dissemination, and thus to potentially render no dissemination optimal.

From the expressions for eqs. (3.1) and (3.13) we see that

$$p_1^* - \hat{s} = \frac{1}{\tau}\frac{1}{\theta_0}\frac{2\theta_2}{\left(\theta_{v|\Omega_2^d} + \theta_2\right)}z\,. \tag{3.14}$$

Then, we can prove the following Lemma:

Lemma 5 *$p_1^* - \hat{s}$ is decreasing in θ_v, θ_0, θ_1 and τ and increasing in θ_2 and z.*

Proof. See the Appendix.

We can summarize these comparative statics conclusions as follows: *ceteris paribus*, as

[20] The former (resp. latter) case corresponds to a profitable long (resp. short) position.

[21] This is because $\mu_{v|\Omega_R} - s_0 = \frac{1}{\theta_{v|\Omega_R}}\left(\theta_v\mu_v + \theta_1 s_1\right) - \frac{\theta_v+\theta_1}{\theta_{v|\Omega_R}}s_0$.

the investors learn more in period 2 from the public signal–i.e. when θ_2 is larger, or as the overall supply of the risky asset augments –i.e. when z is larger, the incentive for the raider to disseminate her private signal mitigates and the range of values of the private signal s_0 for which no dissemination is preferred expands. The opposite holds when the investors learn more from the public signal in period 1 –i.e. when θ_1 is larger, when the raider observes a more precise private signal in period 0 –i.e. when θ_0 is larger, when there is less ex-ante uncertainty on the liquidation value of the risky asset –i.e. when θ_v is larger, and when the investors are, on average, more risk-tolerant –i.e. when τ is larger.

The expression for $p_1^* - \hat{s}$ also implies the limiting behavior posited in the following Lemma:

Lemma 6 *For either $\theta_0 \uparrow \infty$ or $\theta_1 \uparrow \infty$ or $\theta_2 \downarrow 0$ or $\tau \uparrow \infty$, $p_1^* - \hat{s} \downarrow 0$.*

Proof. See the Appendix.

Thus, the no dissemination interval, $(\hat{s}, p_1^*)$, vanquishes when either the precision of the raider's private signal, θ_0, or that of the public signal in period 1, θ_1, approaches infinity, or when that of the public signal in period 2, θ_2, drops to zero or when the investors' average risk-tolerance, τ, becomes infinite. This indicates that the raider will always disseminate her private signal when either her private signal or the public signal in period 1 presents infinite precision, or when the public signal in period 2 does not convey any information, or when the investors are, on average, infinitely risk-tolerant.

The conclusion pertaining to the raider's dissemination policy for $\theta_2 \downarrow 0$ –i.e. for the "limiting" scenario in which there is no public signal in period 2, is somehow reminiscent of that of Kovbasyuk and Pagano (2021) who show within their formulation that dissemination is preferred to no dissemination when noise trading is "small". Indeed, since they have no public signal (in period 2), then a situation with "small" noise would make prices not to move across time –exactly what happens in our model in the "limiting" scenario when there is no public signal in period 2.

4 Short-sale Constraints

Ljungqvist and Qian (2016) argue that dedicated short-bias funds concentrate their activity on target companies for which limits to short-selling are stringent. In fact, they find that for these companies daily lending fees are (on average) 4 basis points, ie. well above the median of the corresponding distribution for CRSP stocks, while only 5% of shares are available for lending, once again below the median for the distribution for CRSP stocks. Thus, we now discuss the impact of a short-sale constraint on the raider's trading and dissemination strategy. In particular, in a vein similar to Marin and Olivier (2008), we assume

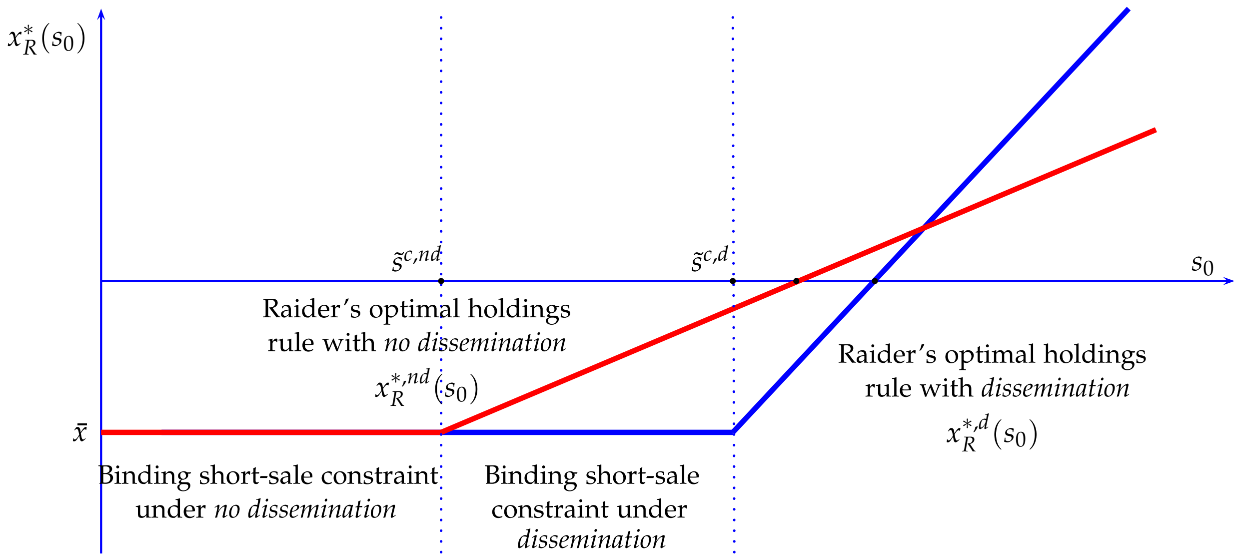


Figure 4: The raider's optimal holdings rule with a short-sale constraint under *no* (red line) and *dissemination* (the blue line).

that x_R must be no smaller than $\bar{x}$, with $\bar{x} \leq 0$. Then, let

$$\tilde{s}^{c,nd} \equiv \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_0}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}} z + \frac{1}{\tau_R}\frac{1}{\theta_0}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}}\bar{x}\,, \tag{4.1}$$

$$\tilde{s}^{c,d} \equiv \mu_{v|\Omega_1} - \frac{1}{\tau}\left(1+\frac{\theta_2}{\theta_0}\right)\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}} z + \frac{1}{\tau_R}\frac{\theta_2}{\theta_0}\frac{1}{\theta_{v|\Omega_2^d}}\bar{x}\,, \tag{4.2}$$

where $\tilde{s}^{c,nd} < \tilde{s}^{c,d}$. Hence, maximizing the raider's expected utility under the short-sale constraint, we prove the following Lemma:

Lemma 7 *Under no dissemination, the short-sale constraint is binding, so that $x_R^c = \bar{x}$, in so far $s_0 < \tilde{s}^{c,nd}$, while x_R^c is equal to $x_R^{*,nd}$, as given in eq. (3.9), for $s_0 \geq \tilde{s}^{c,nd}$.*
Under dissemination, the short-sale constraint is binding in so far $s_0 < \tilde{s}^{c,d}$, while x_R^c is equal to $x_R^{*,d}$, as given in eq. (3.11), for $s_0 \geq \tilde{s}^{c,d}$.

Proof. See the Appendix.

Lemma 7 indicates that for $s_0 = \tilde{s}^{c,d}$ ($s_0 = \tilde{s}^{c,nd}$) the short-sale constraint becomes binding with (without) dissemination. Then, in Figure 4 we have a graphical representation of the dependence on s_0 of the raider's optimal holdings, in the presence of the short-sale constraint, in the two scenarios.

In order to pin down the dissemination policy of the raider with short-sale constraints we need to characterize the raider's value function when the constraint is binding with and without dissemination. In this respect we prove the following Lemma:

Lemma 8 *Under no dissemination, in equilibrium, when the constraint is binding, i.e. for $s_0 < \tilde{s}^{c,nd}$, the raider's value function is*

$$V_R^{c,nd}(s_0) = -\exp\left(-\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^{nd}}}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z - \frac{1}{2}\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\right), \tag{4.3}$$

while it is given by eq. (3.10) for $s_0 > \tilde{s}^{c,nd}$, i.e. when the constraint is not binding.

Under dissemination, in equilibrium, when the constraint is binding, i.e. for $s_0 < \tilde{s}^{c,d}$, the raider's value function is

$$V_R^{c,d}(s_0) = -\exp\left(-\frac{1}{\tau_R}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\frac{\theta_0 + \theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z - \frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\right), \tag{4.4}$$

while it is given by eq. (3.12) for $s_0 > \tilde{s}^{c,d}$, i.e. when the constraint is not binding.

The raider's value is continuous in s_0 both under no dissemination and dissemination.

Proof. See the Appendix.

Let $\gamma = \frac{\tau_R}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}+\theta_2}$. We say the short-sale constraint is *tight* (*lax*) if $\bar{x} > -\gamma z$ ($\bar{x} < -\gamma z$). Then, we can prove the following Lemma:

Lemma 9 *When the short-sale constraint is tight –i.e. for $\bar{x} > -\gamma z$,*

$$\tilde{s}^{c,nd} < \hat{s} < \tilde{s}^{c,d} < p_1^*.$$

When the short-sale constraint is lax –i.e. for $\bar{x} < -\gamma z$,

$$\tilde{s}^{c,nd} < \tilde{s}^{c,d} < \hat{s} < p_1^*.$$

Proof. See the Appendix.

Lemma 9 posits that when the short-sale constraint is tight the value of the private signal s_0 at which the raider finds it optimal to switch from a dissemination policy to a no dissemination policy in the absence of short-sale constraints, $\hat{s}$, falls in between$\tilde{s}^{c,nd}$ and $\tilde{s}^{c,d}$ –i.e. the values of s_0 at which the short-sale constraint becomes binding under respectively no dissemination and dissemination. On the contrary, the Lemma posits that when the short-sale constraint is lax, $\hat{s}$ lies in the interval $(\tilde{s}^{c,d}, p_1^*)$. This means that in the former case for

$s_0 = \hat{s}$ the short-sale is binding under dissemination but not under no dissemination. In the latter case for $s_0 = \hat{s}$ the short-sale is not binding under both scenarios. This leads to the following Proposition:

Proposition 2 *With a tight short-sale constraint –i.e. for* $\bar{x} > -\gamma\, z$*, there is a value* $\check{s}$*, with* $\tilde{s}^{c,nd} < \check{s} < \hat{s}$*, such that the raider will disclose her signal when either* $s_0 < \check{s}$ *or* $s_0 > p_1^*$ *and will not disclose it when* $\check{s} < s_0 < p_1^*$*.*
With a lax short-sale constraint –i.e. for $\bar{x} < -\gamma\, z$*, the raider will disclose her signal when either* $s_0 < \hat{s}$ *or* $s_0 > p_1^*$ *and will not disclose it when* $\hat{s} < s_0 < p_1^*$*.*

Proof. See the Appendix.

From Proposition 2 we conclude that the short-sale constraint imposes a revision of the raider's dissemination policy only when it is stringent. When the constraint is tight the interval of values for the private signal s_0 for which no signal is made public widens. In fact, for $\bar{x} > -\gamma z$, when $s_0 \in (\check{s}, \hat{s})$ the raider will not disseminate her private signal, differently from what she would do if no short-sale constraints existed. In brief, we have the following result:

Result 2 *Tight short-sale constraints induce the raider to revise her dissemination policy. In particular, in the case of bad news, signals will be published only when they are extremely disappointing.*

Result 2 suggests that negative signals are less likely to be published with tight constraints. Interestingly, Bushman and Pinto (2020) analyze the effects of a temporary suspension between 2005 and 2007 by the SEC of short-sale constraints on a randomly selected group of U.S. stocks within the Russell 3000 universe and find that the press coverage for this group of companies was significantly more negative relative to that which applied to those companies for which the constraints were still in place. This is consistent with Result 2, as this implies that the removal of a tight short-sale constraint will increase the probability of dissemination in the public domain of negative signals. However, Result 2 also suggests that when negative signals are published, they tend to represent damning signals.

From Lemma 8 and Proposition 2 we conclude that, in equilibrium,

- when the short-sale constraint is tight, the raider's optimal holdings are equal to

  $\bar{x}$ for $s_0 \leq \check{s}$;

  $x_R^{*,nd}$, as given in eq. (3.9), for $\check{s} < s_0 \leq p_1^*$;

  and $x_R^{*,d}$, as given in eq. (3.11), for $p_1^* < s_0$;

- when the short-sale constraint is lax, the raider's optimal holdings are equal to

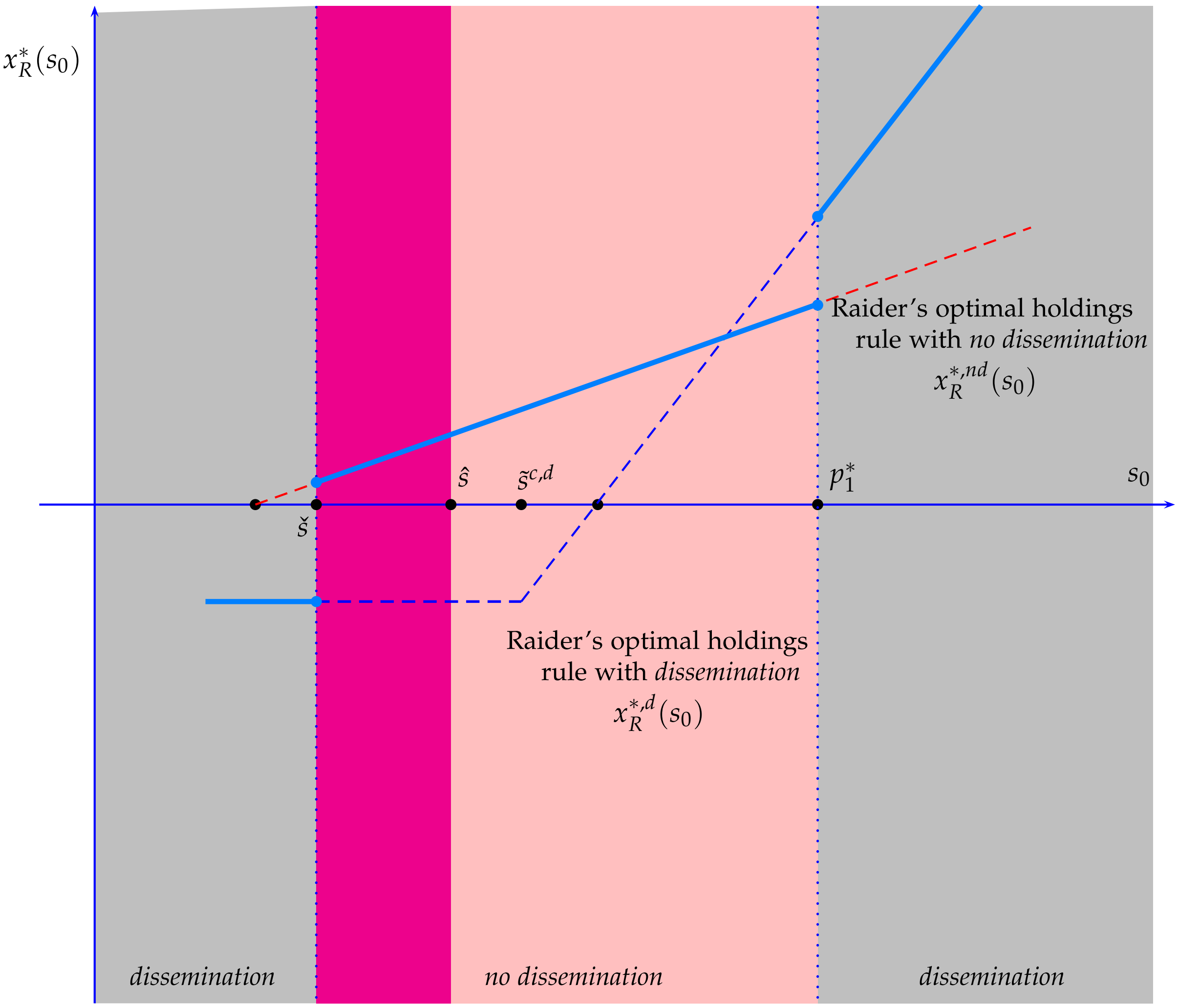


Figure 5: The raider's optimal holdings rule (the azure line) with a tight short-sale constraints, $\bar{x} > -\gamma z$.

$\bar{x}$ for $s_0 \leq \tilde{s}^{c,d}$;

$x_R^{*,nd}$, as given in eq. (3.9), for $\hat{s} < s_0 \leq p_1^*$;

and $x_R^{*,d}$, as given in eq. (3.11), for $\tilde{s}^{c,d} < s_0 \leq \hat{s}$ and for $p_1^* < s_0$.

Figures 5 and 6 provide a graphical representation of the dependence of the raider's optimal holdings on s_0 for respectively $\bar{x} > -\gamma z$ and $\bar{x} < -\gamma z$. In particular, notice that in Figure 5 the area colored in magenta represents the interval of values for which the presence of a tight short-sale constraint induces a revision of the dissemination policy from dissemination of the private signal to no dissemination.

It is noteworthy that with tight short-sale constraints, i.e. when $\bar{x} > -\gamma z$, even if the raider's dissemination policy changes, we see that when s_0 falls below $\check{s}$ the raider moves from a long to a short position as illustrated in Figure 5. This confirms a result we already found when no short-sale constraints were considered (see Figure 4). Thus, we conclude, consistently with the normal practice of dedicated short-bias funds, that when her private signal conveys bad news, the raider will short-sale the risky asset only if she is to release her signal.

Because the dissemination of the raider's private signal makes the market more liquid and efficient and because (tight) short-sale constrains make dissemination less likely (Result 2) we reach the conclusion that tight short-sale constraints i nduce a deterioration of market quality as they provoke a reduction both in market liquidity and efficiency. Importantly, this conclusion is in line with widespread empirical evidence which suggests that limits to short-selling impair market quality. Thus, Saffi and Sigurdsson (2011) investigate the impact of short-sale restrictions employing daily data on 12,600 stocks from 26 countries from 2005 to 2008 and find that stocks subject to higher short-sale constraints present lower price efficiency. Beber and Pagano (2013) study the effects of short-sale bans using daily data for 16,491 stocks in 30 countries from 2008 to 2009 and show that such bans significantly widen bid-ask spreads, increase Amihud's illiquidity measure and slow price discovery. Boehmer, Jones and Zhang (2013) instead concentrate on the analysis of the impact of the short-sale ban imposed by the SEC in 2008 on nearly 1,000 stocks. Using intra-daily data they illustrate how in 2008 effective and quoted spreads and price impacts for the stocks subject to the ban widened significantly more than those of a control group of stocks for which no ban was introduced. Della Corte et al. (2021) confirm earlier conclusions analyzing differences in liquidity across European countries which imposed short-sale bans and those which did not in 2020 and find that for the former bid-ask spreads were on average significantly larger.

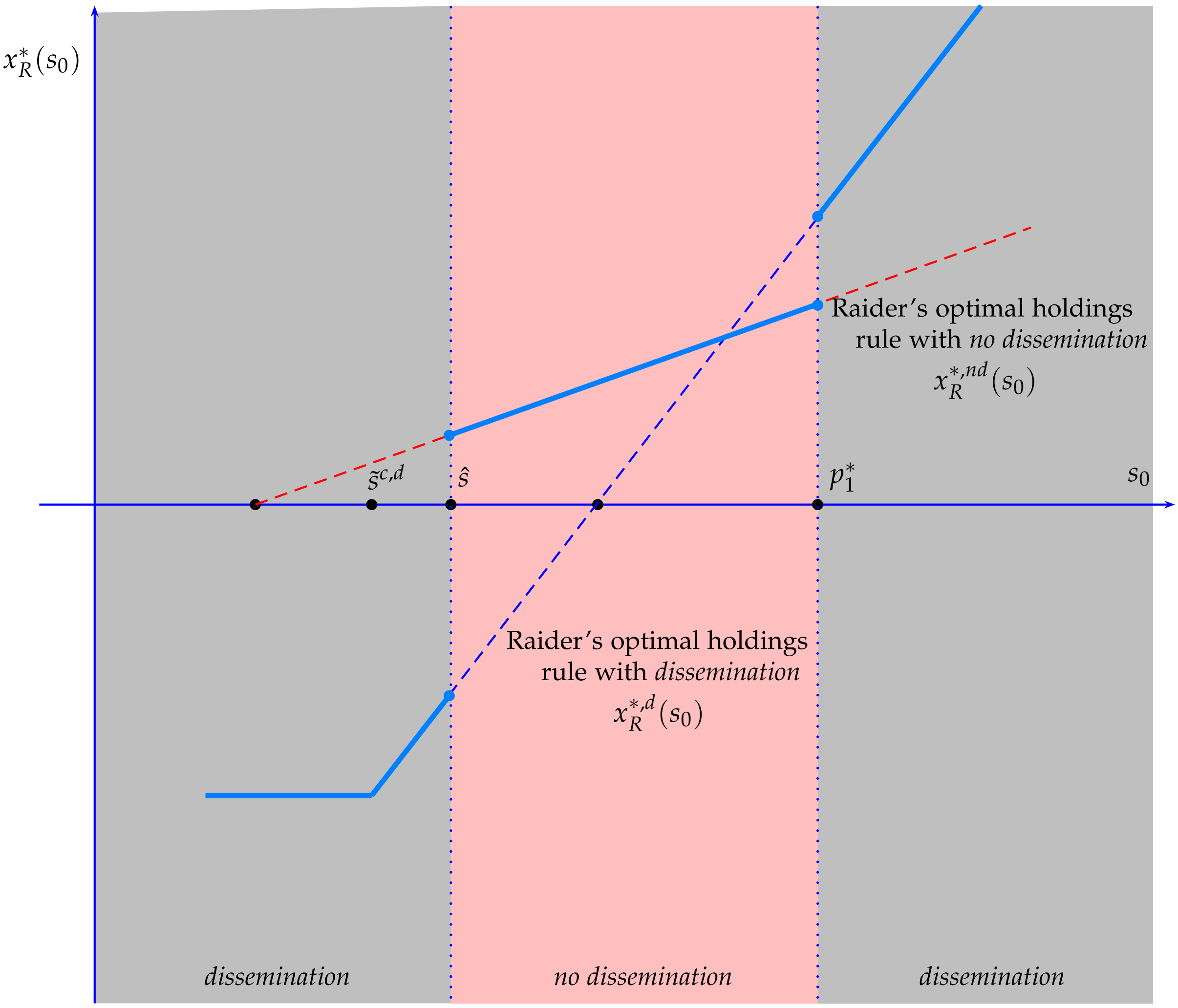


Figure 6: The raider's optimal holdings rule (the azure line) with a lax short-sale constraints, $\bar{x} < -\gamma\, z$.

5 A Study of the Activity of Dedicated Short-bias Funds

In this Section we shed light on the main mechanism highlighted by our model, whereby the raider (may) find it convenient to publicly disseminate her signal in order to induce a price correction. Specifically, we have shown in Section 3 that (see result 1) the raider takes a short position at the first trading round and then disseminates her information to induce a (negative) price correction at the second round. Additionally, result 2 highlights that in the presence of tight short-sale constraints, short-positions and dissemination occur when the raider's information is pretty bad. Taking these predictions to the the data entails taking a stance on various elements. First, who is (are) the raider(s), i.e. those market participants with superior private information. Second, identifying those instances when negative private information is disseminated to the market. Third, making sure that the raider(s) has (have), prior to dissemination, a short-position. Fourth, how to measure the price correction. And lastly, for the second prediction above, when short-sale constraints are binding.

To this end, we concentrate on dedicated short-bias funds which, as described in the Introduction, often take short-sale positions and then disseminate the information they have accumulated for the targeted companies. We identify these funds as the raider(s) in our model in that these are sophisticated investors with superior information, as documented by Jiao, Massa and Zhang (2016) and Huang and Jain (2019).

We first compile a list of dedicated short-bias hedge funds based on Ljungqvist and Qian (2016), Brendel and Ryans (2021) and the recent DOJ's probe on the activity of US short-sellers.[22] Among these funds we select those that, at the time of writing, maintain a publicly available Internet newsletter. This latter requirement is in line with the model assumption that the raider *freely* disseminates her signal. Such requirement drops funds that have suspended their business (e.g. Absaroka Capital Management), those which restrict access to their websites (e.g. GeoInvesting), those which have not published clear-cut selling recommendations during our sample period (e.g. Asensio), and those which currently operate as activist, i.e. long only, investors (e.g. Oasis Management).

For each of these funds we collect, over the period January 2010 to September 2021, those reports that satisfy the following criteria: they target US-listed companies; their target companies are identified as being overvalued, i.e. they constitute sell recommendations; they disclose having a short position in the target company;[23] short-interest data for these com-

[22] "Vast DOJ Probe Looks at Almost 30 Short-Selling Firms and Allies", Bloomberg: February 4, 2022.

[23] This is usually contained in a disclaimer to the report where the fund states that it has taken a short position and that it will benefit from a drop in the price of the target company. Thus, for instance, Spruce Point Capital Management declares in its reports that: "You should assume that as of the publication date

panies are available. For each target company we then know the fund that first targeted it,[24] and the date of the report. To be included in our analysis we further require valid returns. We use daily return data (sourced from CRSP) to carry out our event study, setting the report date as day 0. The pre-event estimation window is defined as $(-245, -6)$, over which we estimate factor loadings via the Fama-French-Carhart model. We require a target company to have complete return series, i.e. 240 observations, during this window. Abnormal returns are then calculated as difference between the (log) realized return and the benchmark (log) return computed using the estimated factor loadings, and then cumulated over three different windows: $(-5, +10)$, $(-5, +20)$ and $(-5, +30)$.[25] Through the lenses of the model in Section 2, we assume, in line with Ljungqvist and Qian (2016), that the funds take a short position (at most) 5 days prior to the report date (corresponding to the first trading round in our model). We then measure the price impact associated with information releases over three alternative windows (which we associate to the second trading round in our model). We use Compustat and CRSP to compute short-interest as the ratio of shares held short (sourced from Compustat-Supplemental Short-Interest File) to outstanding shares (sourced from CRSP). Short-interest is measured one month prior to the report date. Since information on shares held short is reported twice per month (on the 15th, or the last business day prior to that date, and on the last business day of the month) we take the short-interest observed mid-month (resp. at month-end) one month (resp. two months) prior to the event when this occurs in the second (resp. first) half of the month.Our data collection procedure leaves us with a sample of 265 events.[26] Panel (a) in Figure 7 displays the number of events, over time, showing a marked increase in the dissemination of reports

of any short-biased report or letter, Spruce Point Capital Management LLC (possibly along with or through our members, partners, affiliates, employees, and/or consultants) along with our clients and/or investors has a short position in all stocks (and/or options of the stock) covered herein, and therefore stands to realize significant gains in the event that the price of any stock covered herein declines." These statements are crucial in our analysis, as US regulation does not require investment companies to disclose their short-sale positions, no data on the *size* of the short positions of dedicated short-bias funds are available. Angel (2021) discusses the implications of the different disclosure rules on long and short positions in the US.

[24] A target may have follow-on reports, issued by the same fund and/or by different funds. In our sample we have 522 reports for 265 target companies: those with a single report are 159 (representing 60% of all companies), while the remaining 106 have follow-on reports (86 companies from the same fund, and 20 from multiple funds). Consistently with Ljungqvist and Qian (2016) and Brendel and Ryans (2021), we discard follow-on reports. In this respect, Ljungqvist and Qian (2016) claim that these follow-on reports usually do not contain new relevant information, while Angel (2021) argues that they are published to take advantage of fiscal regulation on short-sale gains. Finally, notice that one company is first-targeted, on the same day, by two different funds: MiMedx on September 20, 2017 (Marcus Aurelius Value and Viceroy Research). Our results are unchanged if we exclude this event from the analysis.

[25] In our sample five companies are delisted during the event window(s): one company during the short event window $(-5, +10)$, two companies during the intermediate window $(-5, +20)$, and two more during the long window $(-5, +30)$. For these companies we follow Asad Kausar and Tan (2009) and assume zero abnormal returns post-delisting.

[26] One company, Teavana Holdings, targeted by Glaucus Research Group on November 19, 2012, got acquired by Startbucks on December 31, 2012 (day 28 in event time) and is therefore dropped from the long event window.

during the second half of our sample period.

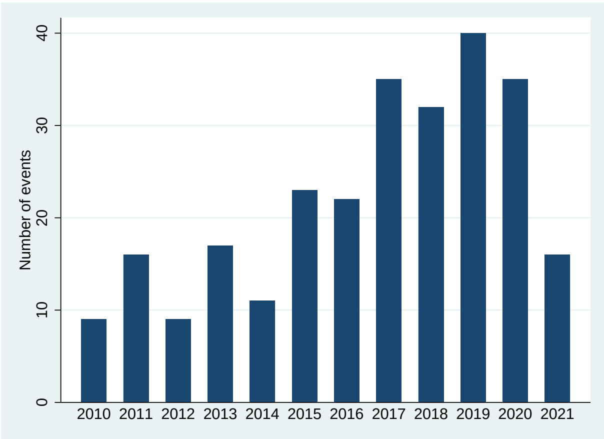
Table 1: Descriptive Statistics for Dedicated Short-bias Funds.

The Table presents, for each fund, summary statistics on the number of target companies, average cumulative abnormal returns (CARs) and number of positive and negative CARs over the (-5,+30) event window. Year started refers to the year in which the fund first published a report on a target. The sample contains 265 first reports on target companies released by 12 dedicated short-bias funds over the period from January 2010 to September 2021. One target company does not enter the (-5,+30) event window since it is taken over prior to day 30. The total number of reports (265) does not coincide with the sum of those published by the individual funds (266), since two funds have first targeted the same company on the same day.

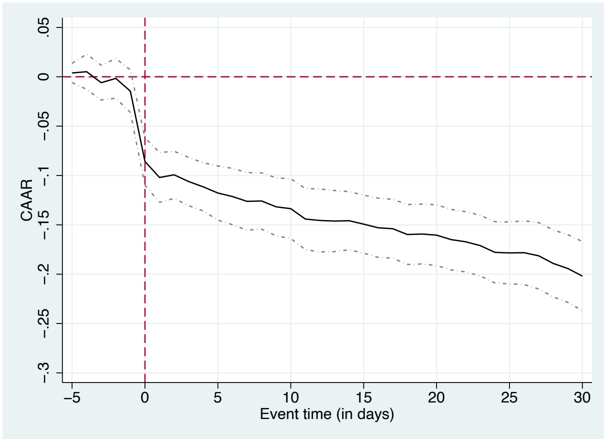
Fund	Year started	Number of reports	CARs (-5,+30)	
			Mean	Positive:Negative
Bleecker Street Research	2014	7	-38.0	1:6
Bonitas Research/Glaucus Research Group	2011	16	-35.5	1:14
Citron Research	2010	46	-22.8	10:36
Gotham City Research	2013	7	-21.5	1:6
Hinderburg Research	2017	22	-13.6	6:16
J Capital Research	2018	15	-24.6	2:13
Kerrisdale Capital Management	2012	12	-3.8	4:8
Marcus Aurelius Value	2016	15	-34.9	1:14
Muddy Waters Research	2010	17	-35.1	1:16
Spruce Point Capital Management	2010	68	-14.8	15:53
Viceroy Research	2016	5	-10.5	1:4
White Diamond Research	2015	36	-12.9	17:19
All funds		265	-20.2	60:204

Table 1 provides summary statistics on the activity of the 12 dedicated short-bias funds in our sample. The most prolific fund is Spruce Point Capital Management with about 25% of reports, followed by Citron Research (about 17% of reports). Both of these funds actively disseminate their research from the very beginning of our sample period. Others (e.g. Hindenburg Research, J. Capital Research, and Viceroy Research) started issuing reports on overvalued companies in the second half of our sample. For all of the funds, share prices (adjusted for the Fama-French-Carhart factors) fall on average during the $(-5, +30)$ event window: Bleecker Street Research has the largest price impact, averaging -38.0%, followed by Glaucus Research Group (-35.5%), Muddy Waters Research (-35.1%) and Marcus Aurelius Value (-34.9%). Across all funds, about 80% of the reports are associated with a negative price reaction 30 trading days after the release date. Looking at the individual funds reveals that for some of them (Glaucus Research Group, Marcus Aurelius Value, and Muddy Waters Research) such percentage is above 90%. At the other end of the spectrum, CARs over the (-5,+30) event window are negative for about 50% of the reports released by White Diamond Research.

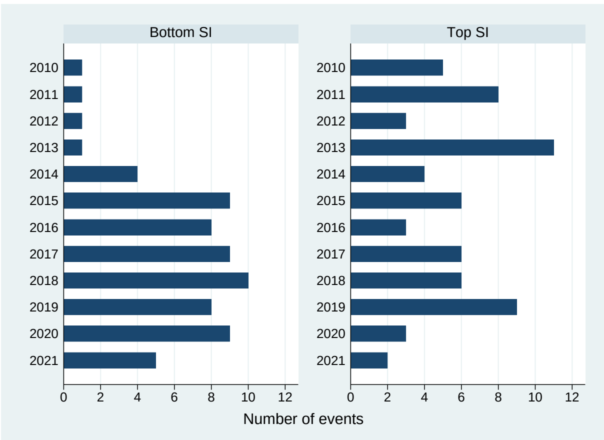
Figure 7: Abnormal Returns and Short-Interest.



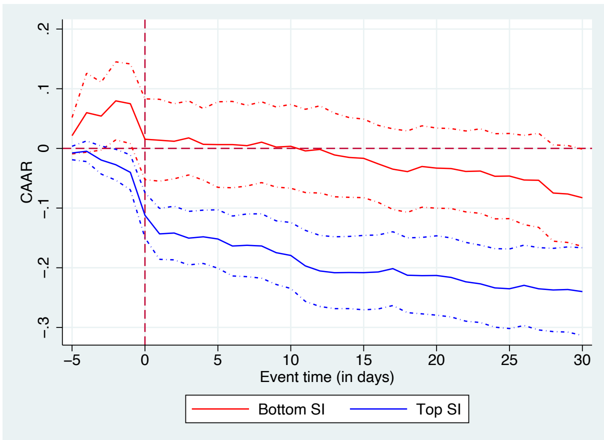
(a) Number of Events by Year



(b) CAARs in the (-5,+30) Window



(c) Number of High and Low SI Events by Year



(d) CAARs in the (-5,+30) Window by SI Groups

Panel (a) presents the number, by years, of the reports published by the dedicated short-bias funds, panel (b) the average CARs in the (-5,+30) event window around the publication of the funds' reports. Panels (c) and (d) refine the former information by considering events pertaining to stocks sorted by short-interest. Bottom (resp. top) SI stocks are those with short-interest (scaled by outstanding shares) one month prior to the event below the 25-th (resp. above the 75-th) percentile. Dotted-dashed lines represent 90% confidence bands.

Panel (b) in Figure 7 shows average CARs over time together with 90% confidence bands. Prior to the event day, average CARs are not statistically different from zero. On the report day, share prices fall on average by -7.1%, and CARs gain statistical significance. From then onwards CARs continue to steadily decrease. Thirty trading days after the report, average CARs equal -20.2%. This pattern is consistent with Figure 3 in Ljungqvist and Qian (2016) –if anything, we document a slightly more pronounced underperformance at thirty days. We then argue that our database offers a solid ground for a study of the impact of short-sale constraints on the activity of sophisticated short sellers in a more recent time period. We conclude that, in line with previous empirical studies as well as our theoretical model, better informed traders that have short-positions, publicly disseminate their private information to induce a price correction.

We now turn to the second empirical prediction of our theoretical model, which brings short-selling constraints into the picture. We view short-interest as a measure of the short-selling constraints, in line with Boehmer, Jones and Zhang (2013), Cohen, Diether and Malloy (2007) and the relevant literature cited therein. Through the lenses of the model, we therefore expect reports on target companies with higher short-interest to be more informative –i.e. to carry a larger price correction– than those on companies with lower short-interest.

Table 2 reports cross-sectional OLS regression results of target companies CARs on short-interest –since we use three different event windows, we have three cross-sections. Huber-White p-values are reported in parentheses, while bootstrap p-values (with 1,000 replications) are in brackets. Panel (a) shows that, for all event windows, short-interest is negatively associated with stock prices at a 5% significance level (or less). In terms of economic significance, a one-standard deviation increase in short-selling costs is associated with a lower stock valuation equal to about -5%. In panel (b) we repeat the same regression after winsorizing 5% in both tails of CARs to mitigate the effect of potential outliers. Again, short-interest is significantly negatively associated with stock prices, although with a smaller economic significance in the range -3.6% to -4.8%. In panels (c) and (d) we exclude, in turn, the two most represented funds –respectively, Citron Research in panel (c) and Spruce Point Capital Management in panel (d). The negative association between short-interest and CARs continues to hold, albeit statistical significance slightly deteriorates, overall, with respect to the baseline results in panel (a).

We carry out two additional empirical exercises to verify the robustness of these findings (results are illustrated in a separate Internet Appendix). First, we relax our requirement that target companies should have a complete return series over the estimation window. To this end, we also estimate factor loadings for those stocks with at least 120 trading days over the estimation window. This gives us 35 reports –typically, for recently IPOed firms– that we add to our sample. Short-interest continues to be negatively associated with stock prices with statistical and economic significances in line with those in panel (a). Second, we assess the informational impact of follow-on *vis-à-vis* first reports. To this end we create an indicator equal to one when a target receives a follow-on report during a given event window (and zero otherwise). We then add to our benchmark regression such indicator variable as well as its interaction with short-interest. The interacted coefficient is never significant at usual levels, confirming that follow-on reports do not convey extra information relative to first reports.[27]

Next, we move to investigate non-linearities in the relation between short-selling costs and stock valuations. To this end, we partition sample firms into those with high short-selling costs, i.e. in the top quartile in the distribution of short-interest, and those with low short-selling costs, i.e. short-interest in the bottom quartile. Panel (c) in Figure 7 displays the number of high and low short-selling targets, over time, and shows that the split we adopt captures both time-series (especially at the beginning of our sample period) as well as cross-sectional variation in short-selling costs. Panel (d) in Figure 7 shows, for each group of companies, average CARs over time together with 90% confidence bands. Although both groups display a similar trend, in that stock prices gradually decline after the event day, the negative CARs for firms with smaller short-selling costs are insignificant for the first three weeks after the report release. Moreover, average CARs are systematically lower for high short-interest firms. Table 3 reports, at various horizons, average CARs in the two groups and results of a two-sided t-test for their significance as well as significant differences between groups. In line with Figure 7-panel (d), average CARs for high short-interest stocks are always significant, and become more and more negative as time goes by –from -18% two weeks after the report to -24% six weeks after. Importantly, the performance wedge between the two groups is statistically significant at all horizons.

6 Concluding Remarks

Within the analytical framework put forward by Kim and Verrecchia (1991) we have proposed an analysis of the incentives a superiorly informed investor (raider) may have to share her private information on a risky asset with other market participants when she is short-sighted and when her investment decisions are subject to limits to short-selling. Our analysis is apt to provide a theoretical underpinnings for the behavior of a particular class of hedge funds, known as dedicated short-bias funds, which target overvalued companies, take limited short-sale positions on their securities and publish extensive reports containing evidence which supports their investment decisions.

We establish that the raider finds it convenient to disseminate her private information only when this is either very good or very bad. We show that when disclosure of private information occurs the efficiency and liquidity of the market and price volatility raise,

[27] Angel (2021) argues that follow-on reports are mostly published for fiscal reasons.

coherently with the empirically evidence associated to the activity of dedicated short-bias funds. With our analysis we also establish that short-sale constraints reduce the chances the raider will disclose her private information, as she will find it optimal to disclose negative signals only when they are extremely disappointing. Thus, an empirical implication of our analysis is that with restrictions to short-selling the campaigns run by dedicated short-bias funds should become sparser but also more aggressive. Because of their impact on the raider's dissemination policy, we also see that restrictions to short-selling reduce market liquidity and efficiency, consistently with a large body of empirical research which associates the introduction of limits to short-selling activity to a deterioration of market quality. Finally, consistently with the normal practice of dedicated short-bias funds, we show that the raider will sell short the risky asset only if she is to publish a disappointing signal on its liquidation value.

Studying the dissemination policy of a group of dedicated short-bias funds we put to the test the main implications of our formulation. Reassuringly in line with this formulation, we find that: i) the publication of damning reports by these sophisticated agents induces a large and significant price correction for the target companies; and ii) such is significantly larger for those companies for which short-sale constraints are more severe.

Some important simplifying assumptions have been introduced in our formulation in order to safeguard simplicity and intuition. Thus, we have considered the possibility that only one raider possesses private information on the risky asset. A relevant issue is what would be the optimal dissemination policy if several short-sighted investors had access to private information on the risky asset. It would be interesting to establish whether, or under which conditions, they would find it convenient to coordinate their campaigns. Similarly, differently from Kim and Verrecchia (1991), we have assumed that only the raider can observe a private signal on the liquidation value of the risky asset. However, potentially heterogenous information on the part of the investors could affect the raider's dissemination policy, because prices act as aggregators of private information. These and other are related issues are all important. However, we leave them to further research.

Table 2: Abnormal Returns and Short-Interest.

The Table presents OLS regression results to examine the relation between cumulative abnormal returns (CARs) and short-interest. For different event windows, CARs are regressed on a constant and short-interest (scaled by outstanding shares). Short-interest is measured one month prior to the report. Panel B winsorizes CARs at the top and bottom 5%; Panel C excludes reports released by Citron Research, while Panel D excludes reports released by Spruce Point Capital. Values in parentheses (brackets) denote Huber-White (bootstrap, with 1,000 replications) p-values. In the last column one observation is dropped because of Teavana Holdings' takeover.

	Panel A: Baseline OLS (265 obs.)		
	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.593	-0.627	-0.624
	(0.005)	(0.003)	(0.021)
	[0.005]	[0.003]	[0.026]
Constant	-0.079	-0.103	-0.144
	(0.007)	(0.000)	(0.000)
	[0.006]	[0.000]	[0.000]
R-squared	0.029	0.031	0.024
	Panel B: Winsorizing outliers (265 obs.)		
	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.421	-0.556	-0.521
	(0.009)	(0.001)	(0.020)
	[0.008]	[0.001]	[0.025]
Constant	-0.104	-0.114	-0.160
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.000]
R-squared	0.027	0.037	0.024
	Panel C: Excluding Citron (219 obs.)		
	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.840	-0.729	-0.625
	(0.002)	(0.007)	(0.060)
	[0.002]	[0.008]	[0.067]
Constant	-0.061	-0.092	-0.144
	(0.068)	(0.003)	(0.000)
	[0.057]	[0.002]	[0.000]
R-squared	0.042	0.032	0.019
	Panel D: Excluding Spruce Point (197 obs.)		
	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.637	-0.655	-0.624
	(0.013)	(0.008)	(0.046)
	[0.014]	[0.009]	[0.054]
Constant	-0.074	-0.106	-0.158
	(0.065)	(0.005)	(0.000)
	[0.070]	[0.005]	[0.000]
R-squared	0.029	0.030	0.022

Table 3: Abnormal Returns and Short-Interest, by Groups.

The Table presents average CARs for stocks sorted by short-interest. Bottom (resp. top) SI stocks are those with short-interest (scaled by outstanding shares) one month prior to the event below the 25-th (resp. above the 75-th) percentile. Difference is top minus bottom SI mean CARs. We perform a two-sided two-sample *t*-test for difference in means (with unequal variances). Values in parentheses (brackets) denote Huber-White (bootstrap, with 1,000 replications) *p*-values. In the last column one observation is dropped because of Teavana Holdings' takeover.

Event Window	(1) (-5,+10)	(2) (-5,+20)	(3) (-5,+30)
Bottom SI	0.004	-0.033	-0.083
	(0.934)	(0.422)	(0.100)
	[0.937]	[0.437]	[0.104]
Top SI	-0.179	-0.213	-0.240
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.000]
Difference	-0.183	-0.180	-0.157
	(0.001)	(0.002)	(0.020)
	[0.001]	[0.002]	[0.023]

References

Admati, Anant, and Paul Pfleiderer. 1986. "A Monopolistic Market for Information." *Journal of Economic Theory*, 39: 400–438.

Admati, Anant, and Paul Pfleiderer. 1988. "Selling and Trading on Information in Financial Markets." *American Economic Review P&P*, 78: 96–103.

Admati, Anant, and Paul Pfleiderer. 1990. "Direct and Indirect Sale of Information." *Econometrica*, 58: 901–928.

Angel, James J. 2021. "GameStonk: What happened and what to do about it." Center For Financial Markets and Policy, Georgetown University McDonough School of Business mieno, Available at SSRN: https://ssrn.com/abstract=3782195.

Appel, Ian, and Vyacheslav Fos. 2020. "Active Short Selling by Hedge Funds." Boston College Finance Working Paper 609/2019, Available at SSRN: https://ssrn.com/abstract=3242516.

Asad Kausar, Richard J. Taffler, and Christine Tan. 2009. "The Going-Concern Market Anomaly." *Journal of Accounting Research*, 47: 213–239.

Bai, Yang, Eric C. Chang, and Jiang Wang. 2006. "Asset Prices Under Short-Sale Constraints." MIT mimeo.

Beber, Alessandro, and Marco Pagano. 2013. "Short-Selling Bans around the World: Evidence from the 2007-09 Crisis." *Journal of Finance*, 68: 343–381.

Benabou, Roland, and Guy Laroque. 1992. "Using Privileged Information to Manipulate Markets: Insiders, Gurus, and Credibility." *The Quarterly Journal of Economics*, 107: 921–958.

Boehmer, Ekkehart, Charles M. Jones, and Xiaoyan Zhang. 2013. "Shackling Short Sellers: The 2008 Shorting Ban." *The Review of Financial Studies*, 26: 1363–1400.

Brendel, Jainja, and James Ryans. 2021. "Responding to Activist Short Sellers: Allegations, Firm Responses, and Outcomes." *Journal of Accounting Research*, 59: 487–528.

Bushman, Robert, and Jedson Pinto. 2020. "The Influence of Short Selling on the Production and Market Consequences of Negative Press Coverage." University of North Carolina Chapel Hill mimeo, Available at SSRN: https://ssrn.com/abstract=3663301.

Cespa, Giovanni. 2008. "Information Sales and Insider Trading with Long-lived Information." *Journal of Finance*, 63: 639–672.

Cohen, Lauren, Karl B. Diether, and Chrisopher J. Malloy. 2007. "Supply and Demand Shifts in the Shorting Market." *The Journal of Finance*, 62: 2061–2096.

Colla, Paolo, and Antonio Mele. 2010. "Information Linkages and Correlated Trading." *Review of Financial Studies*, 23: 203–246.

Della Corte, Pasquale, Robert Kosowski, Dimitris Papadimitriou, and Nikolaos P. Rapanos. 2021. "The Double-Edged Sword of The 2020 European Short-Selling Bans." Imperial College Business School mimeo, Available at SSRN: https://ssrn.com/abstract=3692789.

Diamond, Douglas W., and Robert E. Verrecchia. 1987. "Constraints on Short-selling and Asset Price Adjustment to Private Information." *Journal of Financial Economics*, 18: 277–311.

Glosten, Lawrence R., and Paul R. Milgrom. 1985. "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders." *Journal of Financial Economics*, 14: 71–100.

Grossman, Sanford J., and Joseph E. Stiglitz. 1980. "On the Impossibility of Informationally Efficient Markets." *American Economic Review*, 70: 393–408.

Hellwig, Martin F. 1980. "On the Aggregation of Information in Competitive Markets." *Journal of Economic Theory*, 22: 477–498.

Huang, Qiping, and Pankaj Jain. 2019. "Informed Trading by Hedge Funds." University of Daytona mimeo, Available at SSRN: https://ssrn.com/abstract=3021425.

Jiao, Yawen, Massimo Massa, and Hong Zhang. 2016. "Short Selling Meets Hedge Fund 13F: An Anatomy of Informed Demand." *Journal of Financial Economics*, 122: 544–567.

Kim, Oliver, and Robert E. Verrecchia. 1991. "Trading Volume and Price Reactions to Public Announcements." *Journal of Accounting Research*, 29: 302–321.

Kovbasyuk, Sergey, and Marco Pagano. 2021. "Advertising Arbitrage." CFS Working Paper Series 641.

Lenkey, Stephen L. 2015. "Informed Trading with a Short-Sale Prohibition." Pennsylvania State University mimeo.

Lhabitant, Froncois-Serge. 2006. *Handbook of Hedge Funds.* John Wiley & Sons.

Liu, Ying. 2017. "Why Do Large Investors Disclose Their Information?" Swiss Finance Institute.

Ljungqvist, Alexander, and Wenlan Qian. 2016. "How Constraining Are Limits to Arbitrage?" *The Review of Financial Studies*, 29: 1975–2028.

Luo, Patrick. 2018. "Talking Your Book: Evidence from Stock Pitches at Investment Conferences." Harvard Business School.

Marin, Jose M., and Jacques P. Olivier. 2008. "The Dog That Did Not Bark: Insider Trading and Crashes." *The Journal of Finance*, 63: 2429–2476.

Nezafat, Mahdi, Mark Schroder, and Qinghai Wang. 2017. "Short-sale Constraints, Information Acquisition, and Asset Prices." *Journal of Economic Theory*, 172: 273–312.

Pasquariello, Paolo, and Yifei Wang. 2021. "Speculation with Information Disclosure." University of Michigan mimeo.

Saffi, Pedro A.C. and Kari Sigurdsson. 2011. "Price Efficiency and Short Selling." *Review of Financial Studies*, 24: 821–852.

Schmidt, Daniel. 2020. "Stock Market Rumors and Credibility." *Review of Financial Studies*, 33: 3804–3853.

van Bommel, Jos. 2003. "Rumors." *Journal of Finance*, 58: 1499–1519.

Veldkamp, Laura. 2006. "Media Frenzies in Markets for Financial Information." *American Economic Review*, 96: 577–601.

Yuan, Kathy. 2006. "Asymmetric Price Impacts of Borrowing and Short-Sale Constraints." University of Michigan mimeno.

Appendix A

Preliminaries. For notational convenience, let x be a random variable and Ω be an information set. Define

$$\mu_{x|\Omega} \;=\; E\left[x \mid \Omega\right] \quad \text{and} \quad \theta_{x|\Omega} \;=\; \left(\mathrm{Var}\left[x \mid \Omega\right]\right)^{-1}.$$

We record a number of results that readily obtain from application of the projection theorem. Let v be normally distributed with mean μ_v and precision θ_v and $s_i = v + u_i$ be an additive signal with u_i normally distributed with mean 0 and precision θ_i. Further, assume that $v \perp u_i \perp u_j$ for $i \neq j$. Let Ω include (possibly multiple) additive signals, i.e. $\Omega = \{s_i\}_{i=1}^{I}$. The conditional mean and precision of the fundamental value are

$$\mu_{v|\Omega} \;=\; \frac{1}{\theta_{v|\Omega}}\left(\theta_v \mu_v + \sum_{i=1}^{I} \theta_i s_i\right) \tag{A.1}$$

and

$$\theta_{v|\Omega} \;=\; \theta_v + \sum_{i=1}^{I} \theta_i\,. \tag{A.2}$$

Now consider a single additive signal s_j not included in the information set Ω. Then, for $\Omega' = \Omega \cup s_j$

$$\theta_{s_j|\Omega'} \;=\; \theta_{v|\Omega} \;+\; \theta_j\,. \tag{A.3}$$

In addition, we have that

$$\mu_{s_j|\Omega} \;=\; \mu_{v|\Omega} \tag{A.4}$$

and

$$\theta_{s_j|\Omega} \;=\; \left(\theta_{v|\Omega}^{-1} + \theta_j^{-1}\right)^{-1} \;=\; \frac{\theta_j \theta_{v|\Omega}}{\theta_{v|\Omega'}}\,. \tag{A.5}$$

Moreover for $i \neq j \neq k$

$$\mathrm{Cov}\left[s_k, s_j \mid s_i\right] = \left(\theta_{v|s_i}\right)^{-1}. \tag{A.6}$$

Proof of Lemma 1. In both periods, all investors share the same information sets Ω_1 and Ω_2. Investors differ in their initial endowments of the risky asset, z_i, and in their risk-tolerance τ_i. Investor i final wealth is

$$w_i \;=\; p_1 z_i \;+\; (p_2 - p_1)\, x_{i,1} \;+\; (v - p_2)\, x_{i,2}\,, \tag{A.7}$$

where $x_{i,t}$ is investor i holding of the risky asset in period t.

In period 2 investor i solves the program

$$\max_{x_{i,2}} E\left[-\exp\left(\frac{1}{\tau_i} w_i\right) \mid \Omega_2\right], \tag{A.8}$$

which, since w_i is normally distributed conditional on Ω_2, is equivalent to

$$\max_{x_{i,2}} \left(\mu_{w_i|\Omega_2} - \frac{1}{2}\frac{1}{\tau_i}\frac{1}{\theta_{w_{i,2}|\Omega_2}}\right),$$

where $\mu_{w_i|\Omega_2}$ and $\theta_{w_{i,2}|\Omega_2}$ are the mean and precision of final wealth, conditional on the information set Ω_2. From the expression for final wealth in eq. (A.7) we have that

$$\mu_{w_i|\Omega_2} = p_1 z_i + (p_2 - p_1)\, x_{i,1} + \left(\mu_{v|\Omega_2} - p_2\right) x_{i,2}\,, \tag{A.9}$$

and

$$\theta_{w_{i,2}|\Omega_2} = \frac{\theta_{v|\Omega_2}}{x_{i,2}^2}\,. \tag{A.10}$$

The program (A.8) is then equivalent to

$$\max_{x_{i,2}} \left(\left(\mu_{v|\Omega_2} - p_2\right) x_{i,2} - \frac{1}{2}\frac{1}{\tau_i}\frac{1}{\theta_{v|\Omega_2}} x_{i,2}^2 \right),$$

so that investor i optimal holdings in period 2 are

$$x_{i,2}\left(p_2\right) = \tau_i \theta_{v|\Omega_2} \left(\mu_{v|\Omega_2} - p_2\right)\,. \tag{A.11}$$

In equilibrium the period 2 price satisfies $\int_0^1 x_{i,2}\left(p_2\right) di = z$, which, making use of optimal holdings in eq. (A.11) gives

$$p_2^* = \mu_{v|\Omega_2} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2}} z\,. \tag{A.12}$$

Substituting the equilibrium price (A.12) into optimal holdings (A.11) reveals that, in equilibrium, holdings are

$$x_{i,2}^* = \frac{\tau_i}{\tau} z\,. \tag{A.13}$$

Making use of equilibrium prices (A.12) and holdings (A.13) into the conditional expectation (A.9) and precision (A.10) of final wealth gives

$$\mu_{w_i|\Omega_2} = p_1 z_i + \left(p_2^* - p_1\right) x_{i,1} + \frac{1}{\tau}\frac{\tau_i}{\tau}\frac{1}{\theta_{v|\Omega_2}} z^2\,,$$

and

$$\theta_{w_{i,2}|\Omega_2} = \left(\frac{\tau}{\tau_i}\right)^2 \theta_{v|\Omega_2} \frac{1}{z^2}\,.$$

It therefore follows that

$$\mu_{w_i|\Omega_2} - \frac{1}{2\tau_i \theta_{w_{i,2}|\Omega_2}} = p_1 z_i + \left(p_2^* - p_1\right) x_{i,1} + \frac{1}{2}\frac{1}{\tau}\frac{\tau_i}{\tau}\frac{1}{\theta_{v|\Omega_2}} z^2\,,$$

so that the value function of investor i in period 2 in (A.8) becomes

$$\begin{aligned} E\left[-\exp\left(-\frac{1}{\tau_i} w_i\right) \mid \Omega_2\right] &= -\exp\left[-\frac{1}{\tau_i}\left(p_1 z_i + \left(p_2^* - p_1\right) x_{i,1} + \frac{1}{2}\frac{1}{\tau}\frac{\tau_i}{\tau}\frac{1}{\theta_{v|\Omega_2}} z^2\right)\right] \\ &= -\Psi \exp\left(-\frac{1}{\tau_i}\left(p_2^* - p_1\right) x_{i,1}\right), \end{aligned}$$

where

$$\Psi \equiv \exp\left(-\frac{1}{\tau_i} p_1 z_i - \frac{1}{2}\frac{1}{\tau^2}\frac{1}{\theta_{v|\Omega_2}} z^2\right).$$

In period 1 investor i solves the program

$$\max_{x_{i,1}} \ \Psi\, E\left[-\exp\left(-\frac{1}{\tau_i}\left(p_2^* - p_1\right) x_{i,1}\right) \mid \Omega_1\right],$$

which, since $\Psi > 0$ and p_2^* in (A.12) is normally distributed conditional on Ω_1, is equivalent to

$$\max_{x_{i,2}} \left(\left(\mu_{p_2^*|\Omega_1} - p_1\right) x_{i,1} - \frac{1}{2}\frac{1}{\tau_i}\frac{1}{\theta_{p_2^*|\Omega_1}} x_{i,1}^2\right),$$

so that investor i optimal holdings in period 1 are

$$x_{i,1}\left(p_1\right) \;=\; \tau_i \theta_{p_2^*|\Omega_1}\left(\mu_{p_2^*|\Omega_1} - p_1\right). \tag{A.14}$$

Since $\Omega_1 \subset \Omega_2$, the law of iterated expectations yields $E\left[\mu_{v|\Omega_2} \mid \Omega_1\right] = \mu_{v|\Omega_1}$, so that by (A.12)

$$\mu_{p_2^*|\Omega_1} \;=\; \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2}} z. \tag{A.15}$$

Moreover we have that by (A.12)

$$\theta_{p_2^*|\Omega_1} \;=\; \left(\mathrm{Var}\left[\mu_{v|\Omega_2} \mid \Omega_1\right]\right)^{-1}. \tag{A.16}$$

In equilibrium the period 1 price satisfies $\int_0^1 x_{i,1}\left(p_1\right) di = z$, which, making use of optimal holdings in eq. (A.14) gives

$$p_1^* \;=\; \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2}} z - \frac{1}{\tau}\frac{1}{\theta_{p_2^*|\Omega_1}} z \;=\; \mu_{v|\Omega_1} - \frac{1}{\tau}\left(\frac{1}{\theta_{v|\Omega_2}} + \frac{1}{\theta_{p_2^*|\Omega_1}}\right) z. \tag{A.17}$$

We can now give closed form solution for the prices depending on whether the raider disseminates information or not. In the former case $\Omega_2 = \Omega_2^d$ which includes s_0, s_1 and s_2, while in the latter $\Omega_2 = \Omega_2^{nd}$ which includes s_0 and s_1. In both cases Ω_1 includes s_1.

By means of (A.1) and (A.2) we have that under no dissemination the mean and precision of the fundamental value, conditional on the period 2 information set, are

$$\mu_{v|\Omega_2^{nd}} \;=\; \frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_v \mu_v + \theta_1 s_1 + \theta_2 s_2\right) \tag{A.18}$$

and

$$\theta_{v|\Omega_2^{nd}} \;=\; \theta_v \,+\, \theta_1 \,+\, \theta_2.$$

It follows that the period 2 price in (A.12) becomes

$$p_2^{*,nd} \;=\; \frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_v \mu_v \,+\, \theta_1 s_1 \,+\, \theta_2 s_2 \,-\, \frac{1}{\tau} z\right). \tag{A.19}$$

The conditional precision in (A.16), using (A.18) becomes

$$\theta_{p_2^{*,nd}|\Omega_1} \;=\; \theta^2_{v|\Omega_2^{nd}} \frac{\theta_{s_2|\Omega_1}}{\theta_2^2} \;=\; \frac{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_1}}{\theta_2}, \tag{A.20}$$

where the last term on the RHS follows from (A.5). By means of (A.1) and (A.20), the period 1 price (A.17) becomes

$$
\begin{aligned}
p_1^{*,nd} &= \frac{1}{\theta_{v|\Omega_1}}\left(\theta_v\mu_v + \theta_1 s_1\right) - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_1}}\left(\theta_{v|\Omega_1} + \theta_2\right) z \\
&= \frac{1}{\theta_{v|\Omega_1}}\left(\theta_v\mu_v + \theta_1 s_1 - \frac{1}{\tau} z\right). \qquad \text{(A.21)}
\end{aligned}
$$

By means of (A.1) and (A.2) we have that under dissemination the mean and precision of the fundamental value, conditional on the period 2 information set, are

$$
\mu_{v|\Omega_2^d} = \frac{1}{\theta_{v|\Omega_2^d}}\left(\theta_v\mu_v + \theta_0 s_0 + \theta_1 s_1 + \theta_2 s_2\right) \qquad \text{(A.22)}
$$

and

$$
\theta_{v|\Omega_2^d} = \theta_v + \theta_0 + \theta_1 + \theta_2 \,,
$$

which allow to write the period 2 price in (A.12) as

$$
p_2^{*,d} = \frac{1}{\theta_{v|\Omega_2^d}}\left(\theta_v\mu_v + \theta_0 s_0 + \theta_1 s_1 + \theta_2 s_2 - \frac{1}{\tau} z\right). \qquad \text{(A.23)}
$$

The conditional precision in (A.16), using (A.22) becomes

$$
\begin{aligned}
\theta_{p_2^{*,d}|\Omega_1} &= \theta^2_{v|\Omega_2^d}\left(\frac{\theta_0^2}{\theta_{s_0|\Omega_1}} + \frac{\theta_2^2}{\theta_{s_2|\Omega_1}} + 2\theta_0\theta_2 \mathrm{Cov}\left[s_0, s_2 \mid \Omega_1\right]\right)^{-1} \\
&= \theta^2_{v|\Omega_2^d}\left(\frac{\theta_0\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}} + \frac{\theta_2\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_1}} + \frac{2\theta_0\theta_2}{\theta_{v|\Omega_1}}\right)^{-1} \\
&= \frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}{\theta_0 + \theta_2}, \qquad \text{(A.24)}
\end{aligned}
$$

where the second line follows from (A.5) and (A.6). By means of (A.1) and (A.24), the period 1 price (A.17) becomes

$$
\begin{aligned}
p_1^{*,d} &= \frac{1}{\theta_{v|\Omega_1}}\left(\theta_v\mu_v + \theta_1 s_1\right) - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}\left(\theta_{v|\Omega_1} + \theta_0 + \theta_2\right) z \\
&= \frac{1}{\theta_{v|\Omega_1}}\left(\theta_v\mu_v + \theta_1 s_1 - \frac{1}{\tau} z\right). \qquad \text{(A.25)}
\end{aligned}
$$

Considering that eqs. (A.21) and (A.25) coincide with eq. (3.1), while eqs. (A.19) and (A.23) coincide respectively with eqs. (3.2) and (3.3) the proof is complete. □

Proof of Lemma 2. Just consider the inverse of the expressions for the corresponding precisions given in eqs. (A.20) and (A.24). □

Proof of Lemma 3. In the proof of Lemma 1 we have already established, see eq. (A.13), that $x^*_{i,2} = \frac{\tau_i}{\tau} z$. In addition, we see that substituting the conditional expectation of period 2 prices (A.15) and the period 1 price (A.17) into period 1 optimal holdings (A.14) reveals that, in equilibrium, investor i's holdings are

$$x_{i,1}^{*} = \tau_i \, \theta_{p_2^*|\Omega_1} \left(\mu_{v|\Omega_1} - \frac{1}{\tau} \frac{1}{\theta_{v|\Omega_2}} z - \left(\mu_{v|\Omega_1} - \frac{1}{\tau} \left(\frac{1}{\theta_{v|\Omega_2}} + \frac{1}{\theta_{p_2^*|\Omega_1}} \right) z \right) \right) = \frac{\tau_i}{\tau} z \,. \tag{A.26}$$

Finally, by means of the conditional expectation of period 2 prices (A.15), the period 1 price (A.17), and the period 1 equilibrium holdings (A.26) we have that

$$\begin{aligned} \left(\mu_{p_2^*|\Omega_1} - p_1 \right) x_{i,1} - \frac{1}{2} \frac{1}{\tau_i} \frac{1}{\theta_{p_2^*|\Omega_1}} x_{i,1}^2 &= \frac{1}{\tau} \frac{1}{\theta_{p_2^*|\Omega_1}} z \frac{\tau_i}{\tau} z - \frac{1}{2} \frac{1}{\tau_i} \frac{1}{\theta_{p_2^*|\Omega_1}} \left(\frac{\tau_i}{\tau} z \right)^2 \\ &= \frac{1}{2} \frac{1}{\tau} \frac{\tau_i}{\tau} \frac{1}{\theta_{p_2^*|\Omega_1}} z^2 , \end{aligned}$$

and investor i value function becomes

$$V_i^{\{d,nd\}} = \Psi \left[- \exp \left(- \frac{1}{2} \frac{1}{\tau^2} \frac{1}{\theta_{p_2^*|\Omega_1}} z^2 \right) \right] = \exp \left(- \frac{1}{\tau_i} p_1^* z_i - \frac{1}{2} \frac{1}{\tau^2} \left(\frac{1}{\theta_{p_2^*|\Omega_1}} + \frac{1}{\theta_{v|\Omega_2}} \right) z^2 \right) . \tag{A.27}$$

Under no dissemination, we see, using the definition of $\theta_{v|\Omega_2^{nd}}$ and eq. (A.20), that

$$\frac{1}{\theta_{p_2^{*,nd}|\Omega_1}} + \frac{1}{\theta_{v|\Omega_2^{nd}}} = \frac{1}{\theta_{v|\Omega_2^{nd}}} \left(1 + \frac{\theta_2}{\theta_{v|\Omega_1}} \right) = \frac{1}{\theta_{v|\Omega_1}} .$$

Similarly, under dissemination, we see, using the definition of $\theta_{v|\Omega_2^{d}}$ and eq. (A.24), that

$$\frac{1}{\theta_{p_2^{*,d}|\Omega_1}} + \frac{1}{\theta_{v|\Omega_2^{d}}} = \frac{1}{\theta_{v|\Omega_2^{d}}} \left(1 + \frac{\theta_0 + \theta_2}{\theta_{v|\Omega_1}} \right) = \frac{1}{\theta_{v|\Omega_1}} .$$

Substituting these two expressions into eq. (A.27) we see that $V_i^d = V_i^{nd}$. □

Proof of Lemma 4. The raider's information set Ω_R in period 1 includes the private signal s_0 and the period 1 public signal s_1. Since the raider has a zero endowment in the risky asset and is short-sigthed, her final wealth is

$$w_R = (p_2 - p_1) \, x_R \, .$$

Considering her CARA preferences, the value function in period 1 is

$$V_R(s_0) \equiv \max_{x_R} - \exp \left(- \frac{1}{\tau_R} \left(\mu_{w_R|\Omega_R} - \frac{1}{2 \tau_R \theta_{w_R|\Omega_R}} \right) \right) .$$

Since $\mu_{w_R|\Omega_R} = \left(\mu_{p_2|\Omega_R} - p_1 \right) x_R$ and $\theta_{w_R|\Omega_R} = \frac{\theta_{p_2|\Omega_R}}{x_R^2}$, we have that the raider's optimal holdings are

$$x_R(p_1) = \tau_R \theta_{p_2|\Omega_R} \left(\mu_{p_2|\Omega_R} - p_1 \right) . \tag{A.28}$$

It therefore follows that the raider's value function, in equilibrium, rewrites as

$$
\begin{aligned}
V_R\left(s_0\right) &= -\exp\left(-\frac{1}{\tau_R}\left(\underbrace{\left(\mu_{p_2^*|\Omega_R} - p_1^*\right) x_R}_{=\mu_{w_R|\Omega_R}} - \frac{1}{2}\frac{1}{\tau_R}\frac{x_R^2}{\underbrace{\theta_{p_2^*|\Omega_R}}_{=\theta_{w_R|\Omega_R}}}\right)\right) \\
&= -\exp\left(-\frac{1}{2}\theta_{p_2^*|\Omega_R}\left(\mu_{p_2^*|\Omega_R} - p_1^*\right)^2\right) \\
&= -\exp\left(-\frac{1}{2}\theta_{p_2^*|\Omega_R}\left(\mu_{p_2^*|\Omega_R} - \mu_{v|\Omega_1} + \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}} z\right)^2\right), \qquad \text{(A.29)}
\end{aligned}
$$

where the second line follows from (A.28) and the third line obtains from (A.17) and the fact that, as shown above, $\left(\theta^{-1}_{p_2^*|\Omega_1} + \theta^{-1}_{v|\Omega_2}\right) = \theta^{-1}_{v|\Omega_1}$. We then turn to determine the conditional mean and precision of period 2 price, which depend on the investors' information set in period 2 –i.e. they depend on the raider's dissemination choice.

Let assume the raider decides not to make public her private signal. Starting from the period 2 equilibrium price in (A.19) we have that

$$
\begin{aligned}
\mu_{p_2^{*,nd}|\Omega_R} &= \frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_v\mu_v + \theta_1 s_1 + \theta_2\mu_{s_2|\Omega_1} - \frac{1}{\tau} z\right) \\
&= \frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_v\mu_v + \theta_1 s_1 + \theta_2\frac{1}{\theta_{v|\Omega_R}}\left(\theta_v\mu_v + \theta_0 s_0 + \theta_1 s_1\right)\right) - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}} z \\
&= \frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_{v|\Omega_2^d}\mu_{v|\Omega_R} - \theta_0 s_0\right) - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}} z, \qquad \text{(A.30)}
\end{aligned}
$$

where (A.1) and (A.4) yield the second line. As for the conditional precision, note that

$$
\theta_{s_2|\Omega_R} = \left(\theta^{-1}_{v|\Omega_R} + \theta_2^{-1}\right)^{-1} = \frac{\theta_2\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}},
$$

so that from (A.19) we obtain

$$
\theta_{p_2^{*,nd}|\Omega_R} = \left(\frac{\theta_{v|\Omega_2^{nd}}}{\theta_2}\right)^2 \theta_{s_2|\Omega_R} = \frac{\theta^2_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}. \qquad \text{(A.31)}
$$

We then substitute (A.17), (A.30) and (A.31) into the raider's optimal holdings in (A.28) and obtain that, in equilibrium, the raider's holdings are

$$
\begin{aligned}
x_R^{*,nd} &= \tau_R \frac{\theta^2_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}} \left(\underbrace{\frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_{v|\Omega_2^d}\mu_{v|\Omega_R} - \theta_0 s_0\right) - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}} z}_{=\mu_{p_2^{nd}|\Omega_R}} - \underbrace{\left(\mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}} z\right)}_{=p_1^*} \right) \\
&= \tau_R \frac{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}} \left(\theta_0 s_0 \left(\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_R}} - 1 \right) + \left(\theta_{v|\Omega_2^d}\theta_{v|\Omega_1} - \theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R} \right) \frac{\mu_{v|\Omega_1}}{\theta_{v|\Omega_R}} \right) + \frac{\tau_R}{\tau} \frac{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}} z \\
&= \tau_R \frac{\theta_{v|\Omega_2^{nd}}}{\theta_2\theta_{v|\Omega_2^d}} \left(\theta_2\theta_0 s_0 + \theta_0 \left(\theta_{v|\Omega_1} - \theta_{v|\Omega_2^{nd}} \right) \mu_{v|\Omega_1} \right) \; + \; \frac{\tau_R}{\tau} \frac{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}} z \\
&= \tau_R\, \theta_0 \frac{\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_2^d}} \left(s_0 - \mu_{v|\Omega_1} \right) \; + \; \frac{\tau_R}{\tau} \frac{\theta_{v|\Omega_2^{nd}}}{\theta_{v|\Omega_2^d}} \frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}} z \,,
\end{aligned}
$$

which coincides with eq. (3.9).

Then, assume the raider decides to disseminate her private signal. In this case $\Omega_R \subset \Omega_2^d$. By the law of iterated expectations we then have that $E\left[\mu_{v|\Omega_2^d} \mid \Omega_R\right] = \mu_{v|\Omega_R}$ so that by (A.12) we obtain

$$
\mu_{p_2^{*,d}|\Omega_R} \;=\; \mu_{v|\Omega_R} \;-\; \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^d}} z \,. \tag{A.32}
$$

As for the conditional precision $\theta_{p_2^{*,d}|\Omega_R}$, we use (A.23) and get

$$
\theta_{p_2^{*,d}|\Omega_R} \;=\; \frac{\theta^2_{v|\Omega_2^d}}{\theta_2^2 \left(\theta^{-1}_{v|\Omega_R} + \theta_2^{-1} \right)} \;=\; \frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}{\theta_2} \,. \tag{A.33}
$$

We then substitute (A.17), (A.32) and (A.33) into the raider's optimal holdings in (A.28) and obtain that, in equilibrium, the raider's holdings are

$$
\begin{aligned}
x_R^{*,d} &= \tau_R \frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}{\theta_2} \left(\underbrace{\mu_{v|\Omega_R} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^d}} z}_{=\mu_{p_2^{*,d}|\Omega_R}} - \underbrace{\left(\mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}} z \right)}_{=p_1^*} \right) \\
&= \tau_R \frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}{\theta_2} \left(\theta_v\mu_v + \theta_1 s_1 \right) \left(\frac{1}{\theta_{v|\Omega_R}} - \frac{1}{\theta_{v|\Omega_1}} \right) + \tau_R \frac{\theta_{v|\Omega_2^d}}{\theta_2}\theta_0 s_0 - \frac{\tau_R}{\tau} \frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}{\theta_2} \left(\frac{1}{\theta_{v|\Omega_2^d}} - \frac{1}{\theta_{v|\Omega_1}} \right) z \\
&= \tau_R \frac{\theta_0}{\theta_2} \theta_{v|\Omega_2^d} \left(s_0 - \mu_{v|\Omega_1} \right) \; + \; \frac{\tau_R}{\tau} \left(1 + \frac{\theta_0}{\theta_2} \right) \frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}} z \,,
\end{aligned}
$$

which coincides with eq. (3.11).

Plugging into the raider's value function (A.29) her optimal holdings under no dissemination

–i.e. the expression in eq. (3.9), we find that in equilibrium, under no dissemination,

$$
\begin{aligned}
V_R^{nd}(s_0) &= -\exp\left(-\frac{1}{2}\underbrace{\frac{\theta^2_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}}_{=\theta_{p_2^{*,nd}|\Omega_R}}\left(\underbrace{\frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_{v|\Omega_2^d}\mu_{v|\Omega_R}-\theta_0 s_0\right)-\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}}z}_{=\mu_{p_2^{*,nd}|\Omega_R}}-\mu_{v|\Omega_1}+\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z\right)^2\right) \\
&= -\exp\left(-\frac{1}{2}\frac{\theta^2_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left(\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}}\mu_{v|\Omega_R}-\mu_{v|\Omega_1}-\frac{\theta_0}{\theta_{v|\Omega_2^{nd}}}s_0+\frac{1}{\tau}\frac{\theta_2}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_1}}z\right)^2\right) \\
&= -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left(\theta_{v|\Omega_2^d}\mu_{v|\Omega_R}-\theta_{v|\Omega_2^{nd}}\mu_{v|\Omega_1}-\theta_0 s_0+\frac{1}{\tau}\frac{\theta_2}{\theta_{v|\Omega_1}}z\right)^2\right). \qquad \text{(A.34)}
\end{aligned}
$$

Plugging into the raider's value function (A.29) her optimal holdings under dissemination –i.e. the expression in eq. (3.11), we find that in equilibrium, under dissemination,

$$
\begin{aligned}
V_R^d(s_0) &= -\exp\left(-\frac{1}{2}\underbrace{\frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}{\theta_2}}_{=\theta_{p_2^{*,d}|\Omega_R}}\left(\underbrace{\mu_{v|\Omega_R}-\frac{1}{\theta}\frac{1}{\theta_{v|\Omega_2^d}}z}_{=\mu_{p_2^{*,d}|\Omega_R}}-\mu_{v|\Omega_1}+\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z\right)^2\right) \\
&= -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}{\theta_2}\left(\mu_{v|\Omega_R}-\mu_{v|\Omega_1}+\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z\right)^2\right) \\
&= -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left(\theta_{v|\Omega_2^d}\left(\mu_{v|\Omega_R}-\mu_{v|\Omega_1}\right)+\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_1}}z\right)^2\right). \qquad \text{(A.35)}
\end{aligned}
$$

To complete the proof we manipulate, in the above expressions (A.34) and (A.35), those terms that do not depend on z. By (A.1) we have that

$$
\begin{aligned}
\mu_{v|\Omega_R}-\mu_{v|\Omega_1} &= \frac{1}{\theta_{v|\Omega_R}}\left(\theta_v\mu_v+\theta_0 s_0+\theta_1 s_1\right)-\frac{1}{\theta_{v|\Omega_1}}\left(\theta_v\mu_v+\theta_1 s_1\right) \\
&= -\frac{\theta_0}{\theta_{v|\Omega_R}\theta_{v|\Omega_1}}\left(\theta_v\mu_v+\theta_1 s_1\right)+\frac{\theta_0}{\theta_{v|\Omega_R}}s_0 \\
&= \frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0-\mu_{v|\Omega_1}\right), \qquad \text{(A.36)}
\end{aligned}
$$

where the second line obtains from $\theta_{v|\Omega_R}=\theta_{v|\Omega_1}+\theta_0$. Moreover we have that

$$
\begin{aligned}
\theta_{v|\Omega_2^d}\mu_{v|\Omega_R}-\theta_{v|\Omega_2^{nd}}\mu_{v|\Omega_1}-\theta_0 s_0 &= \theta_{v|\Omega_2^d}\left(\mu_{v|\Omega_R}-\mu_{v|\Omega_1}\right)+\left(\theta_{v|\Omega_2^d}-\theta_{v|\Omega_2^{nd}}\right)\mu_{v|\Omega_1}-\theta_0 s_0 \\
&= \theta_{v|\Omega_2^d}\left(\mu_{v|\Omega_R}-\mu_{v|\Omega_1}\right)+\theta_0\left(\mu_{v|\Omega_1}-s_0\right),
\end{aligned}
$$

where the second line follows from $\theta_{v|\Omega_2^d} = \theta_{v|\Omega_2^{nd}} + \theta_0$. Substitution of (A.36) into the latter then yields

$$\begin{aligned}
\theta_{v|\Omega_2^d}\mu_{v|\Omega_R} - \theta_{v|\Omega_2^{nd}}\mu_{v|\Omega_1} - \theta_0 s_0 &= \theta_{v|\Omega_2^d}\underbrace{\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right)}_{=\mu_{v|\Omega_R}-\mu_{v|\Omega_1}} + \theta_0\left(\mu_{v|\Omega_1} - s_0\right) \\
&= \frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right)\left(\theta_{v|\Omega_2^d} - \theta_{v|\Omega_R}\right) \\
&= \frac{\theta_0\theta_2}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right). \qquad \text{(A.37)}
\end{aligned}$$

By means of (A.36) and (A.37) the value functions (A.34) and (A.35) rewrite as eq. (3.10) and eq. (3.12) respectively. □

Proof of Proposition 1. Making use of (3.10) and (3.12) the condition $V_R^d(s_0) > V_R^{nd}(s_0)$ becomes

$$\left(\frac{\theta_0\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_1}}z\right)^2 > \left(\frac{\theta_0\theta_2}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\frac{\theta_2}{\theta_{v|\Omega_1}}z\right)^2,$$

or equivalently

$$\left(\frac{\theta_0\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}{\theta_2\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\left(1+\frac{\theta_0}{\theta_2}\right)z\right)^2 > \left(\frac{\theta_0\theta_{v|\Omega_1}}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}z\right)^2.$$

From (A.2) we also have that $\theta_{v|\Omega_2^d} = \theta_{v|\Omega_R} + \theta_2$ so that $\frac{\theta_{v|\Omega_2^d}}{\theta_2} = 1 + \frac{\theta_{v|\Omega_R}}{\theta_2}$ and the latter becomes

$$\left(\frac{\theta_0\theta_{v|\Omega_1}}{\theta_{v|\Omega_R}}\left(1+\frac{\theta_{v|\Omega_R}}{\theta_2}\right)\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}\left(1+\frac{\theta_0}{\theta_2}\right)z\right)^2 > \left(\frac{\theta_0\theta_{v|\Omega_1}}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}z\right)^2,$$

which allows to rewrite $V_R^d(s_0) > V_R^{nd}(s_0)$ as

$$(a+b)^2 > a^2,$$

with

$$a = \frac{\theta_0\theta_{v|\Omega_1}}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}z \quad \text{and} \quad b = \frac{\theta_0}{\theta_2}\left(\theta_{v|\Omega_1}\left(s_0 - \mu_{v|\Omega_1}\right) + \frac{1}{\tau}z\right). \qquad \text{(A.38)}$$

For the raider to disseminate her signal, it must therefore be that either $b > 0$ and $a > -\frac{1}{2}b$ or $b < 0$ and $a < -\frac{1}{2}b$. Consider the first case. By means of (A.38) the inequality $b > 0$ is equivalent to

$$s_0 > \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z = p_1^*. \qquad \text{(A.39)}$$

By means of (A.38) the restriction $a > -\frac{1}{2}b$ is the same as

$$\theta_0\theta_{v|\Omega_1}\left(s_0 - \mu_{v|\Omega_1}\right)\left(\frac{1}{\theta_{v|\Omega_R}} + \frac{1}{2\theta_2}\right) + \frac{1}{\tau}\left(1 + \frac{\theta_0}{2\theta_2}\right) > 0 \qquad \Leftrightarrow$$

$$s_0 > \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}\frac{(2\theta_2+\theta_0)\,\theta_{v|\Omega_R}}{\theta_0\left(\theta_{v|\Omega_2^d}+\theta_2\right)}z = \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}\frac{(2\theta_2+\theta_0)\,(\theta_v+\theta_0+\theta_1)}{\theta_0\,(\theta_v+\theta_0+\theta_1+2\theta_2)}z \quad \Leftrightarrow$$

$$s_0 > \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}\left(1 + 2\frac{\theta_2\theta_{v|\Omega_1}}{\theta_0\left(\theta_{v|\Omega_2^d}+\theta_2\right)}\right)z = \hat{s}\,. \tag{A.40}$$

We conclude that $\hat{s} < p_1^*$. Therefore $V_R^d(s_0) > V_R^{nd}(s_0)$ when $s_0 > p_1^*$.

We now turn to the second case. The restriction $b < 0$ is equivalent to $s_0 < p_1^*$, and $a < -\frac{1}{2}b$ is equivalent to $s_0 < \hat{s}$. Since we have shown above that $\hat{s} < p_1^*$ we conclude that $V_R^d(s_0) > V_R^{nd}(s_0)$ when $s_0 < \hat{s}$. $\square$

Proof of Lemma 5. It is immediate to see from the expression for $p_1^* - \hat{s}$ in eq. (3.14) that

$$\frac{d\left(p_1^*-\hat{s}\right)}{d\theta_v} = -\frac{2}{\tau}\frac{\theta_2}{\theta_0\left(\theta_{v|\Omega_2^d}+\theta_2\right)^2}z < 0\,,$$

$$\frac{d\left(p_1^*-\hat{s}\right)}{d\theta_1} = \frac{d\left(p_1^*-\hat{s}\right)}{d\theta_v} < 0\,,$$

$$\frac{d\left(p_1^*-\hat{s}\right)}{d\theta_0} = -\frac{2}{\tau}\frac{\theta_2}{\theta_0^2\left(\theta_{v|\Omega_2^d}+\theta_2\right)^2}\left(\theta_{v|\Omega_2^d}+\theta_0+\theta_2\right)z < 0\,,$$

$$\frac{d\left(p_1^*-\hat{s}\right)}{d\theta_2} = \frac{2}{\tau}\frac{\theta_{v|\Omega_2^{nd}}}{\theta_0\left(\theta_{v|\Omega_2^d}+\theta_2\right)^2}z > 0\,,$$

$$\frac{d\left(p_1^*-\hat{s}\right)}{d\tau} = -\frac{1}{\tau^2}\frac{1}{\theta_0}\frac{2\theta_2}{\left(\theta_{v|\Omega_2^d}+\theta_2\right)}z < 0\,,$$

$$\frac{d\left(p_1^*-\hat{s}\right)}{dz} = \frac{1}{\tau}\frac{1}{\theta_0}\frac{2\theta_2}{\left(\theta_{v|\Omega_2^d}+\theta_2\right)} > 0\,.\,\square$$

Proof of Lemma 6. From the expression for $p_1^* - \hat{s}$ in eq. (3.14) we also immediately see that

$$\lim_{\theta_0\uparrow\infty}\left(p_1^*-\hat{s}\right) = 0\,, \quad \lim_{\theta_1\uparrow\infty}\left(p_1^*-\hat{s}\right) = 0\,, \quad \lim_{\theta_2\downarrow 0}\left(p_1^*-\hat{s}\right) = 0 \quad \lim_{\tau\uparrow\infty}\left(p_1^*-\hat{s}\right) = 0\,.\,\square$$

Proof of Lemma 7. Firstly, note that short-selling constraints do not affect equilibrium prices nor investors' trades in equilibrium, since these reflect public information only and not the raider's trades. With short-selling constraints the raider's optimal holdings are

$$x_R^c(p_1) = \max\left\{\tau_R\theta_{p_2|\Omega_R}\left(\mu_{p_2|\Omega_R}-p_1\right), \bar{x}\right\}.$$

It follows that in equilibrium short-sale constraints are binding iff

$$\mu_{p_2^*|\Omega_R} < p_1^* + \frac{1}{\tau_R}\frac{1}{\theta_{p_2^*|\Omega_R}}\bar{x} = \underbrace{\mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z}_{=p_1^*} + \frac{1}{\tau_R}\frac{1}{\theta_{p_2^*|\Omega_R}}\bar{x}\,. \tag{A.41}$$

Depending on whether dissemination occurs (or not), the date 2 prices are affected. We therefore analyze the two cases separately.

Under no dissemination date 2 price is as in (A.19) with conditional mean as in (A.30) and conditional precision as in (A.31), so that the inequality (A.41) becomes

$$\begin{aligned}
\frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_{v|\Omega_2^d}\mu_{v|\Omega_R} - \theta_0 s_0\right) - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}}z &< \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z + \frac{1}{\tau_R}\frac{\theta_2\theta_{v|\Omega_2^d}}{\theta^2_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x} && \Leftrightarrow\\
\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) &< -\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z + \frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x} && \Leftrightarrow\\
s_0 &< \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_0}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}}z + \frac{1}{\tau_R}\frac{1}{\theta_0}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}}\bar{x} = \tilde{s}^{c,nd}\,,
\end{aligned}$$

where the second line follows from (A.37) and $\theta_{v|\Omega_2^{nd}} = \theta_{v|\Omega_1} + \theta_2$, while the expression for $\tilde{s}^{c,nd}$ coincides with that in eq. (4.1).

Under dissemination date 2 price is as in (A.23) with conditional mean as in (A.32) and conditional precision as in (A.33), so that the inequality (A.41) becomes

$$\begin{aligned}
\mu_{v|\Omega_R} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^d}}z &< \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z + \frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x} && \Leftrightarrow\\
\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) &< -\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z + \frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x} && \Leftrightarrow\\
s_0 &< \mu_{v|\Omega_1} - \frac{1}{\tau}\left(1+\frac{\theta_2}{\theta_0}\right)\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z + \frac{1}{\tau_R}\frac{\theta_2}{\theta_0}\frac{1}{\theta_{v|\Omega_2^d}}\bar{x} = \tilde{s}^{c,d}\,,
\end{aligned}$$

where (A.36) and $\theta_{v|\Omega_2^d} = \theta_{v|\Omega_1} + \theta_0 + \theta_2$ yield the second line and the expression for $\tilde{s}^{c,d}$ coincides with that in eq. (4.2). □

Notice that since $0 < \frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}} < 1$ and

$$\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}} = 1 + \frac{\theta_0}{\theta_v+\theta_1+\theta_2} > \frac{\theta_2}{\theta_v+\theta_0+\theta_1+\theta_2} = \frac{\theta_2}{\theta_{v|\Omega_2^d}}\,,$$

we have that, for and $\bar{x} \leq 0$, $\tilde{s}^{c,nd} < \tilde{s}^{c,d}$ that is to say that the short-selling constraint, under dissemination, kicks in "before" it does without dissemination –i.e. for a larger set of values for s_0. □

Proof of Lemma 8. The raider's value functions under no dissemination and dissemination are identical, respectively, to (3.10) and (3.12) when the short-selling constraint does not bind. However, when the short-sale constraint binds we have from the previous analysis that

$$V^{c}\left(s_0\right) \;=\; -\exp\left(-\frac{1}{\tau_R}\left[\mu_{p_2^*|\Omega_R}-p_1^*-\frac{1}{2}\frac{1}{\tau_R}\frac{1}{\theta_{p_2^*|\Omega_R}}\bar{x}\right]\bar{x}\right).$$

Clearly, since the date 2 prices are different with and without dissemination, we separately deal with the two cases.

Under no dissemination, making use of the date 1 price in (A.21) and the conditional moments in (A.30) and (A.31) we obtain

$$\begin{aligned}
V_R^{c,nd}\left(s_0\right) &= -\exp\Bigg(-\frac{1}{\tau_R}\Bigg[\frac{1}{\theta_{v|\Omega_2^{nd}}}\left(\theta_{v|\Omega_2^d}\mu_{v|\Omega_R}-\theta_0 s_0\right)-\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^{nd}}}z-\left(\mu_{v|\Omega_1}-\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z\right) \\
&\qquad -\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2\theta_{v|\Omega_2^d}}{\theta^2_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x}\Bigg]\bar{x}\Bigg) \\
&= -\exp\left(-\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^{nd}}}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0-\mu_{v|\Omega_1}\right)+\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z-\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\,,\right)
\end{aligned}$$

where the last line follows from (A.37) and $\theta_{v|\Omega_2^{nd}}=\theta_{v|\Omega_1}+\theta_2$. This expression coincides with (4.3).

Under dissemination, making use of the conditional moments in (A.32) and (A.33) as well as the date 1 price in (A.25) we obtain

$$\begin{aligned}
V_R^{c,d}\left(s_0\right) &= -\exp\left(-\frac{1}{\tau_R}\left[\mu_{v|\Omega_R}-\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_2^d}}z-\left(\mu_{v|\Omega_1}-\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z\right)-\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\right) \\
&= -\exp\left(-\frac{1}{\tau_R}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0-\mu_{v|\Omega_1}\right)+\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z-\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\,,\right)
\end{aligned}$$

where the last line follows from (A.36) and $\theta_{v|\Omega_2^d}=\theta_{v|\Omega_1}+\theta_0+\theta_2$. This expression coincides with (4.4).

Moreover it is immediate to check that, both with and without dissemination, the value functions are continuous. To show this we consider their values at $\tilde{s}^{c,h}$ for $h=\{nd,d\}$. Considering the no dissemination case first, substituting (4.1) into (3.10) gives

$$\begin{aligned}
V_R^{nd}\left(\tilde{s}^{c,nd}\right) &= -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left(\frac{\theta_0\theta_2}{\theta_{v|\Omega_R}}\underbrace{\left(-\frac{1}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_0\theta_{v|\Omega_1}}z+\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_0\theta_{v|\Omega_2^{nd}}}\bar{x}\right)}_{=\tilde{s}^{c,nd}-\mu_{v|\Omega_1}}+\frac{1}{\tau}\frac{\theta_2}{\theta_{v|\Omega_1}}z\right)^2\right) \\
&= -\exp\left(-\frac{1}{2}\frac{1}{\tau_R^2}\frac{\theta_2\theta_{v|\Omega_2^d}}{\left(\theta_{v|\Omega_2^{nd}}\right)^2\theta_{v|\Omega_R}}\bar{x}^2\right),
\end{aligned}$$

and evaluating (4.3) at $s_0 = \tilde{s}^{c,nd}$ yields

$$
\begin{aligned}
V_R^{c,nd}\left(\tilde{s}^{c,nd}\right) &= -\exp\left(-\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^{nd}}}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\underbrace{\left(-\frac{1}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_0\theta_{v|\Omega_1}}z+\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_0\theta_{v|\Omega_2^{nd}}}\bar{x}\right)}_{=\tilde{s}^{c,nd}-\mu_{v|\Omega_1}}+\frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z\right.\right.\\
&\qquad\left.\left.-\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\right)\\
&= -\exp\left(-\frac{1}{2}\frac{1}{\tau_R^2}\frac{\theta_2\theta_{v|\Omega_2^d}}{\left(\theta_{v|\Omega_2^{nd}}\right)^2\theta_{v|\Omega_R}}\bar{x}^2\right). \qquad (A.42)
\end{aligned}
$$

Thus we have that $V_R^{nd}\left(\tilde{s}^{c,nd}\right) = V_R^{c,nd}\left(\tilde{s}^{c,nd}\right)$. Similarly, from substituting (4.2) into (3.12) we have

$$
\begin{aligned}
V_R^{d}\left(\tilde{s}^{c,d}\right) &= -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left(\frac{\theta_0\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_R}}\underbrace{\left(-\frac{1}{\tau}\frac{(\theta_0+\theta_2)\,\theta_{v|\Omega_R}}{\theta_0\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z+\frac{1}{\tau_R}\frac{\theta_2}{\theta_0\theta_{v|\Omega_2^d}}\bar{x}\right)}_{=\tilde{s}^{c,d}-\mu_{v|\Omega_1}}+\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_1}}z\right)^2\right)\\
&= -\exp\left(-\frac{1}{2}\frac{1}{\tau_R^2}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}^2\right),
\end{aligned}
$$

and into (4.4) we have

$$
\begin{aligned}
V_R^{c,d}\left(\tilde{s}^{c,d}\right) &= -\exp\left(-\frac{1}{\tau_R}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\underbrace{\left(-\frac{1}{\tau}\frac{(\theta_0+\theta_2)\,\theta_{v|\Omega_R}}{\theta_0\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z+\frac{1}{\tau_R}\frac{\theta_2}{\theta_0\theta_{v|\Omega_2^d}}\bar{x}\right)}_{=\tilde{s}^{c,d}-\mu_{v|\Omega_1}}+\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z\right.\right.\\
&\qquad\left.\left.-\frac{1}{\tau_R}\frac{\theta_2}{2\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x}\right)\\
&= -\exp\left(-\frac{1}{2}\frac{1}{\tau_R^2}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}^2\right).
\end{aligned}
$$

Thus $V_R^{d}\left(\tilde{s}^{c,d}\right) = V_R^{c,d}\left(\tilde{s}^{c,d}\right)$. $\square$

Proof of Lemma 9. We have already shown that $\tilde{s}^{c,nd} < \tilde{s}^{c,d}$ and that $\hat{s} < p_1^*$. Then, consider that from eqs. (4.2) and (3.1) $\tilde{s}^{c,d} < p_1^*$ since $\bar{x} < 0$ and

$$
\left(1+\frac{\theta_2}{\theta_0}\right)\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}} > 1 \Leftrightarrow \theta_2\theta_{v|\Omega_R} > \theta_0\theta_2 \Leftrightarrow \theta_2\left(\theta_v+\theta_1\right) > 0.
$$

Moreover, making use of eq. (4.1) allows to rewrite $\hat{s}$ in eq. (3.13) as

$$\begin{aligned}\hat{s} &= \mu_{v|\Omega_1} - \frac{1}{\tau}\left(\frac{1}{\theta_{v|\Omega_1}} + \frac{1}{\theta_0}\frac{2\theta_2}{\theta_{v|\Omega_2^d}+\theta_2}\right) z \\ &= \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{(2\theta_2+\theta_0)\,\theta_{v|\Omega_R}}{\theta_0\left(\theta_{v|\Omega_2^d}+\theta_2\right)\theta_{v|\Omega_1}} z\,.\end{aligned}$$

It follows from the latter and eq. (4.1) that $\tilde{s}^{c,nd} < \hat{s}$ since $\bar{x} < 0$ and

$$\frac{(2\theta_2+\theta_0)\,\theta_{v|\Omega_R}}{\theta_0\left(\theta_{v|\Omega_2^d}+\theta_2\right)} < \frac{\theta_{v|\Omega_R}}{\theta_0} \quad\Leftrightarrow\quad \frac{2\theta_2+\theta_0}{\theta_v+\theta_0+\theta_1+2\theta_2} < 1\,.$$

Finally, inspection of eqs. (4.2) and (3.13) reveals that $\tilde{s}^{c,d} > \hat{s}$ when

$$\begin{aligned}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}}\bar{x} &> \frac{1}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_1}}\left(\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}} - \frac{2\theta_2+\theta_0}{\theta_{v|\Omega_2^d}+\theta_2}\right) z && \Leftrightarrow \\ \frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}}\bar{x} &> \frac{1}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}\left(\theta_{v|\Omega_2^d}+\theta_2\right)\theta_{v|\Omega_1}}\left((\theta_0+\theta_2)\left(\theta_{v|\Omega_2^d}+\theta_2\right) - (2\theta_2+\theta_0)\,\theta_{v|\Omega_2^d}\right) z \Leftrightarrow \\ \bar{x} &> -\frac{\tau_R}{\tau}\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}+\theta_2} z\,. && \text{(A.43)}\end{aligned}$$

When this inequality holds (resp. does not hold), we refer to tight (resp. lax) short-selling constraints. Summing up the above results we have that $\tilde{s}^{c,nd} < \hat{s} < \tilde{s}^{c,d} < p_1^*$ with tight short-selling constraints, and $\tilde{s}^{c,nd} < \tilde{s}^{c,d} < \hat{s} < p_1^*$ with lax short-selling constraints. □

Before we can prove Proposition 2 we derive two preliminary results.

Remark/1. For later use, note that the value functions (3.10) and (3.12) are of the form

$$V_R^h(s_0) = -\exp\left(-\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left[\alpha_h\left(s_0-\mu_{v|\Omega_1}\right) + \frac{1}{\tau}\beta_h z\right]^2\right), \quad h = \{nd, d\}\,,$$

with

$$\begin{aligned}\alpha_{nd} &= \frac{\theta_0\theta_2}{\theta_{v|\Omega_R}} \quad\text{and}\quad \beta_{nd} = \frac{\theta_2}{\theta_{v|\Omega_1}} \\ \alpha_d &= \frac{\theta_0\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_R}} \quad\text{and}\quad \beta_d = \frac{\theta_0+\theta_2}{\theta_{v|\Omega_1}}\,.\end{aligned}$$

It follows that the value functions have their global minimum at $\tilde{s}^h = \mu_{v|\Omega_1} - \frac{1}{\tau}\frac{\beta_h}{\alpha_h}z$ and are monotonically decreasing (resp. increasing) for $s_0 < \tilde{s}^h$ (resp. $s_0 > \tilde{s}^h$). The closed form expression for $\tilde{s}^h$ is

$$\tilde{s}^{nd} \equiv p_1^* - \frac{1}{\tau}\frac{1}{\theta_0} z\,, \tag{A.44}$$

and

$$\tilde{s}^{d} \equiv p_1^* - \frac{1}{\tau}\frac{1}{\theta_0}\frac{\theta_2}{\theta_{v|\Omega_2^d}} z \,, \tag{A.45}$$

It is immediate to check that $\tilde{s}^{nd} < \tilde{s}^{d}$.

Remark/2. For later use, note that the value functions (4.3) and (4.4) are of the form

$$V_R^{c,h}(s_0) = -\exp\left(-a_h\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0 - \mu_{v|\Omega_1}\right) + b_h\right]\bar{x}\right)\,, \quad h = \{nd, d\}\,, \tag{A.46}$$

with

$$a_{nd} = \frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^{nd}}} \quad \text{and} \quad b_{nd} = \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}} z - \frac{1}{2}\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^{nd}}\theta_{v|\Omega_R}}\bar{x}$$

$$a_d = \frac{1}{\tau_R} \quad \text{and} \quad b_d = \frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}} z - \frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\,.$$

Taking the derivative of (A.46) with respect to s_0 yields

$$\frac{dV_R^{c,h}(s_0)}{ds_0} = \frac{\theta_0}{\theta_{v|\Omega_R}} a_h \bar{x} \exp\left(-\frac{a_h\bar{x}}{\theta_{v|\Omega_R}}\left[\theta_0\left(s_0 - \mu_{v|\Omega_1}\right) + \theta_{v|\Omega_R} b_h\right]\right)\,,$$

which is non-positive because $a_h > 0$ and $\bar{x} \le 0$. Moreover, since $a_{nd} < a_d$, we have that $\frac{dV_R^{c,d}(s_0)}{ds_0} < \frac{dV_R^{c,nd}(s_0)}{ds_0}$. Therefore the value functions with short-sale constraints are monotonically decreasing in s_0 and, under dissemination, the value function decreases with s_0 at a faster pace than the value function without dissemination.

Proof of Proposition 2. We consider now three intervals for s_0.

1) $s_0 \in (-\infty, \tilde{s}^{c,nd}]$: here the raider is constrained regardless of his dissemination choice. We first show that at $s_0 = \tilde{s}^{c,nd}$ the value function $V_R^{c,d}(s_0)$ is larger that $V_R^{c,nd}(s_0)$. Evaluating (4.3) at $s_0 = \tilde{s}^{c,nd}$ gives eq. (A.42).

Note that since $\theta_{v|\Omega_2^d} > \theta_{v|\Omega_2^{nd}}$ we have that $V_R^{c,nd}\left(\tilde{s}^{c,nd}\right) < V_R^{c,d}\left(\tilde{s}^{c,d}\right)$. It follows from $\tilde{s}^{c,nd} < \tilde{s}^{c,d}$ and the above discussion on the slope of the value functions with short-selling constraints (see Remark 2) that $V_R^{c,d}\left(\tilde{s}^{c,nd}\right) > V_R^{c,nd}\left(\tilde{s}^{c,nd}\right)$ and, a fortiori, $V_R^{c,d}(s_0) > V_R^{c,nd}(s_0)$ when $s_0 < \tilde{s}^{c,nd}$.

2) $s_0 \in (\tilde{s}^{c,nd}, \hat{s}]$. Here the raider is unconstrained without dissemination. We split our discussion depending on whether (A.43) holds or not, since this affects the location of $\tilde{s}^{c,d}$ with respect to $\hat{s}$ –and thus the region where the raider is constrained under dissemination.

2.a) tight short-selling constraint, i.e. (A.43) holds: the raider is constrained under dissemination. We establish that there is a unique $\check{s} \in (\tilde{s}^{nd}, \hat{s}]$ such that $V_R^{c,d}(s_0) > V_R^{nd}(s_0)$ for $s_0 \in (\tilde{s}^{c,nd}, \check{s}]$ while $V_R^{c,d}(s_0) < V_R^{nd}(s_0)$ for $s_0 \in (\check{s}, \hat{s}]$. We show this in a number of steps: 1) at the left endpoint of the segment the value function $V_R^{c,d}(s_0)$ is larger than $V_R^{nd}(s_0)$; 2) at the right endpoint of the segment the value function $V_R^{c,d}(s_0)$ is smaller than $V_R^{nd}(s_0)$; 3) the value functions $V_R^{c,d}(s_0)$ and $V_R^{nd}(s_0)$ cross only once in the interval $\tilde{s}^{c,nd} < s_0 < \hat{s}$. First, by the continuity of the value functions (see Remark/2) we have that $V_R^{c,nd}\left(\tilde{s}^{c,nd}\right) = V_R^{nd}\left(\tilde{s}^{c,nd}\right)$, and, since we have shown above that $V_R^{c,d}\left(\tilde{s}^{c,nd}\right) > V_R^{c,nd}\left(\tilde{s}^{c,nd}\right)$ we have that $V_R^{c,d}\left(\tilde{s}^{c,nd}\right) > V_R^{nd}\left(\tilde{s}^{c,nd}\right)$. Second, we have shown above (See the Proof of Proposition 1) that $V_R^{d}(\hat{s}) = V_R^{nd}(\hat{s})$ and, since $V_R^{c,d}(s_0) < V_R^{d}(s_0)$ for $s_0 < \tilde{s}^{c,d}$, we have that $V_R^{c,d}(\hat{s}) < V_R^{nd}(\hat{s})$. For the third step, inspection of (A.44) and (4.1) reveals that $\tilde{s}^{c,nd} = \tilde{s}^{nd} + \frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^{nd}}}{\theta_0\theta_{v|\Omega_2^{nd}}}\bar{x} \leq \tilde{s}^{nd}$ because $\bar{x} \leq 0$. Moreover, inspection of (A.44) and (3.13) yields that $\tilde{s}^{nd} < \hat{s}$ since $0 < \frac{2\theta_2+\theta_0}{\theta_{v|\Omega_2^d}+\theta_2} < 1$. Since we have shown above that $V_R^{nd}(s_0)$ is increasing for $s_0 > \tilde{s}^{nd}$ (see Remark/1) and $V_R^{c,d}(s_0)$ is decreasing for $s_0 < \tilde{s}^{c,d}$ (see Remark 2) we conclude that there exists a point $\check{s} \in (\tilde{s}^{nd}, \hat{s}]$ where the value functions cross, and $V_R^{c,d}(s_0) > V_R^{nd}(s_0)$ for $s_0 \in (\tilde{s}^{nd}, \check{s})$ while $V_R^{c,d}(s_0) < V_R^{nd}(s_0)$ for $s_0 \in (\check{s}, \hat{s})$. It remains to be shown that $\check{s}$ is the *only* crossing point over the interval $(\tilde{s}^{c,nd}, \hat{s}]$, i.e. we have to rule out that the value functions $V_R^{nd}(s_0)$ and $V_R^{c,d}(s_0)$ cross twice over the interval $(\tilde{s}^{c,nd}, \tilde{s}^{nd}]$ where they are both decreasing. Making use of the value functions (3.10) and (4.4) allows to write the condition $V_R^{c,d}(s_0) > V_R^{nd}(s_0)$ as

$$\frac{1}{\tau_R}\left[\frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0-\mu_{v|\Omega_1}\right)+\frac{1}{\tau}\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_1}}z-\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x} >$$
$$\frac{1}{2}\frac{\theta_{v|\Omega_R}}{\theta_2\theta_{v|\Omega_2^d}}\left(\frac{\theta_0\theta_2}{\theta_{v|\Omega_R}}\left(s_0-\mu_{v|\Omega_1}\right)+\frac{1}{\tau}\frac{\theta_2}{\theta_{v|\Omega_1}}z\right)^2,$$

which is equivalent to

$$\frac{1}{\tau_R}\left[y+\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}}w-\frac{1}{2}\frac{1}{\tau_R}\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\bar{x}\right]\bar{x} > \frac{1}{2}\frac{\theta_2\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}}(y+w)^2 \qquad \Leftrightarrow$$
$$y^2+2\left(w-\frac{1}{\tau_R}\frac{\theta_{v|\Omega_2^d}}{\theta_2\theta_{v|\Omega_R}}\bar{x}\right)y+w^2-\frac{2}{\tau_R}\frac{\theta_0+\theta_2}{\theta_2\theta_{v|\Omega_R}}w\,\bar{x}+\frac{1}{\tau_R^2}\frac{1}{\left(\theta_{v|\Omega_R}\right)^2}\bar{x}^2 < 0, \tag{A.47}$$

with
$$y \equiv \frac{\theta_0}{\theta_{v|\Omega_R}}\left(s_0-\mu_{v|\Omega_1}\right) \quad \text{and} \quad w \equiv \frac{1}{\tau}\frac{1}{\theta_{v|\Omega_1}}z.$$

Note that the equation associated to (A.47) describes a (concave upward) parabola in y. Since $\bar{x} \leq 0$ we also have that the coefficient on the linear term is positive. Therefore, by the rule of signs the parabola is always strictly positive, or it has two roots (both negative, or one positive and one negative). Since we have already established before that $V_R^{c,d}(\check{s}) = V_R^{nd}(\check{s})$ so that $y = \frac{\theta_0}{\theta_{v|\Omega_R}}\left(\check{s}-\mu_{v|\Omega_1}\right)$ is a root to the parabola, we can rule out that the parabola is always strictly positive. It follows that $V_R^{c,d}(s_0)$ and $V_R^{nd}(s_0)$ cross at *at most* another point *only* –corresponding to the other root of the second order equation in y– ruling out the possibility t hat they cross twice over the interval $(\tilde{s}^{c,nd}, \tilde{s}^{nd}]$. We therefore have that $V_R^{c,d}(s_0) > V_R^{nd}(s_0)$ for $s_0 \in \left(\tilde{s}^{c,nd}, \tilde{s}^{nd}\right)$. Thus dissemination is optimal for $s_0 \in (\tilde{s}^{c,nd}, \check{s}]$ while no dissemination is optimal for $s_0 \in (\check{s}, \hat{s}]$.

2.b) lax short-selling constraint, i.e. (A.43) does not hold: the raider, under dissemination, is constrained for $s_0 \in (\tilde{s}^{c,nd}, \tilde{s}^{c,d}]$ and unconstrained for $s_0 \in (\tilde{s}^{c,d}, \hat{s}]$. Dissemination is clearly optimal for $s_0 \in (\tilde{s}^{c,d}, \hat{s}]$ since we have shown above (aggiungere numerazione alla sezione di confronto tra le value functions without s-s constraint) that $V_R^{d}(s_0) > V_R^{nd}(s_0)$ for $s_0 \leq \hat{s}$. We now establish that dissemination is also optimal for $s_0 \in (\tilde{s}^{c,nd}, \tilde{s}^{c,d}]$. Since we know from the previous case that $V_R^{c,d}(s_0) > V_R^{nd}(s_0)$ for $s_0 \in (\tilde{s}^{c,nd}, \check{s}]$, we have to show that $\tilde{s}^{c,d}$ belongs to this interval. This is equivalent to show that $V_R^{c,d}\left(\tilde{s}^{c,d}\right) > V_R^{nd}\left(\tilde{s}^{c,d}\right)$. Evaluating (A.47) at $s_0 = \tilde{s}^{c,d}$ yields

$$\left(-\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}}\,w + \frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\,\bar{x}\right)^2 + 2\left(w - \frac{1}{\tau_R}\,\frac{\theta_{v|\Omega_2^d}}{\theta_2\theta_{v|\Omega_R}}\,\bar{x}\right)\left(-\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}}\,w + \frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\,\bar{x}\right)$$

$$+\, w^2 - \frac{2}{\tau_R}\,\frac{\theta_0+\theta_2}{\theta_2\theta_{v|\Omega_R}}\,w\,\bar{x} + \frac{1}{\tau_R^2}\,\frac{1}{\left(\theta_{v|\Omega_R}\right)^2}\bar{x}^2 \;<\; 0 \qquad \Leftrightarrow$$

$$\left(\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}}\right)^2 w^2 + \left(\frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\right)^2 \bar{x}^2 - \frac{2}{\tau_R}\,\frac{\theta_2\left(\theta_0+\theta_2\right)}{\left(\theta_{v|\Omega_2^d}\right)^2\theta_{v|\Omega_R}}\,w\,\bar{x} - 2\frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}}\,w^2 + \frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\,w\,\bar{x}$$

$$+\,\frac{2}{\tau_R}\,\frac{\theta_0+\theta_2}{\theta_2\theta_{v|\Omega_R}}w\bar{x} - \frac{2}{\tau_R^2}\,\frac{1}{\left(\theta_{v|\Omega_R}\right)^2}\,\bar{x}^2 + w^2 - \frac{2}{\tau_R}\,\frac{\theta_0+\theta_2}{\theta_2\theta_{v|\Omega_R}}\,w\,\bar{x} + \frac{1}{\tau_R^2}\,\frac{1}{\left(\theta_{v|\Omega_R}\right)^2}\,\bar{x}^2 \;<\; 0 \qquad \Leftrightarrow$$

$$\frac{1}{\left(\theta_{v|\Omega_2^d}\right)^2}\left(\left(\theta_{v|\Omega_2^d}\right)^2 + \left(\theta_0+\theta_2\right)^2 - 2\left(\theta_0+\theta_2\right)\theta_{v|\Omega_2^d}\right) w^2$$

$$+\,\frac{1}{\tau_R^2}\,\frac{1}{\left(\theta_{v|\Omega_R}\right)^2}\left(\left(\frac{\theta_2}{\theta_{v|\Omega_2^d}}\right)^2 - 1\right)\bar{x}^2 + \frac{2}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_2^d}\theta_{v|\Omega_R}}\left(1 - \frac{\theta_0+\theta_2}{\theta_{v|\Omega_2^d}}\right) w\bar{x} \;<\; 0 \qquad \Leftrightarrow$$

$$\left(\frac{\theta_{v|\Omega_1}}{\theta_{v|\Omega_2^d}}\right)^2 w^2 - \frac{1}{\tau_R^2}\,\frac{\theta_{v|\Omega_R}\left(\theta_{v|\Omega_2^d}+\theta_2\right)}{\left(\theta_{v|\Omega_R}\right)^2\left(\theta_{v|\Omega_2^d}\right)^2}\,\bar{x}^2 + \frac{2}{\tau_R}\,\frac{\theta_2\theta_{v|\Omega_1}}{\left(\theta_{v|\Omega_2^d}\right)^2\theta_{v|\Omega_R}}\,w\,\bar{x} \;<\; 0 \qquad \Leftrightarrow$$

$$\frac{1}{\tau^2}\,z^2 - \frac{1}{\tau_R^2}\,\frac{\theta_{v|\Omega_2^d}+\theta_2}{\theta_{v|\Omega_R}}\,\bar{x}^2 + \frac{2}{\tau}\,\frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_R}}\,\bar{x}\,z \;<\; 0\,. \tag{A.48}$$

The equation associated to the LHS describes a concave downward parabola in $\bar{x}$ with roots

$$\bar{x}_{1/2} \;=\; -\,\frac{\frac{1}{\tau}\,\frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_R}}\,z \;\pm\; \sqrt{\left(\frac{1}{\tau}\,\frac{1}{\tau_R}\,\frac{\theta_2}{\theta_{v|\Omega_R}}\,z\right)^2 + \frac{1}{\tau^2}\,\frac{1}{\tau_R^2}\,\frac{\theta_{v|\Omega_2^d}+\theta_2}{\theta_{v|\Omega_R}}\,z^2}}{-\frac{1}{\tau_R^2}\,\frac{\theta_{v|\Omega_2^d}+\theta_2}{\theta_{v|\Omega_R}}}$$

$$=\; \frac{\tau_R}{\tau}\,\frac{\theta_2 \pm \theta_{v|\Omega_2^d}}{\theta_{v|\Omega_2^d}+\theta_2}\,z\,.$$

Therefore the inequality (A.48) holds for

$$\bar{x} \;<\; -\,\frac{\tau_R}{\tau}\,\frac{\theta_{v|\Omega_R}}{\theta_{v|\Omega_2^d}+\theta_2}\,z \quad \text{and} \quad \bar{x} \;>\; \frac{\tau_R}{\tau}\,z\,.$$

Since the first inequality coincides with the lax short-selling constraint condition, we conclude that $V_R^{c,d}\left(\tilde{s}^{c,d}\right) > V_R^{nd}\left(\tilde{s}^{c,d}\right)$ when (A.43) does not hold.

3) $s_0 \in (\hat{s}, +\infty)$: here the raider is unconstrained without dissemination, and, again, we split our discussion depending on whether (A.43) holds (or not).

3.a) tight short-selling constraint, i.e. (A.43) holds: the raider, under dissemination, is constrained for $s_0 \in (\hat{s}, \tilde{s}^{c,d}]$, and unconstrained for $s_0 > \tilde{s}^{c,d}$. We have previously shown that, without short-selling constraints (see the Proof of Proposition 1), $V_R^{nd}(s_0) > V_R^d(s_0)$ for $s_0 \in (\hat{s}, p_1^*]$ and $V_R^{nd}(s_0) < V_R^d(s_0)$ for $s_0 > p_1^*$. Moreover recall that $\tilde{s}^{c,d} < p_1^*$. Since we know that $V_R^{c,d}(s_0) < V_R^d(s_0)$ for $s_0 \leq \tilde{s}^{c,d}$, it follows that no dissemination is optimal for $s_0 \in (\hat{s}, p_1^*]$ while dissemination is optimal for $s_0 > p_1^*$.

3.b) lax short-selling constraint, i.e. (A.43) does not hold: the raider, under dissemination, is unconstrained. Owing to Proposition 1 we have that no dissemination is optimal for $s_0 \in (\hat{s}, p_1^*]$ while dissemination is optimal for $s_0 > p_1^*$. □

The raider's dissemination of bad news and her optimal holdings in equilibrium. We have already seen that in the absence of short-sale constraints the dependence of the raider's optimal holdings is discontinuous at $\hat{s}$ (see Figure 3), so that as she moves from the dissemination to the no dissemination policy at $\hat{s}$ she also switches from a short to a long position. The same holds in the presence of lax short-sale constraints, i.e. for $\bar{x} < -\gamma z$. This is because we know that: i) the raider's dissemination policy is identical to that without constraints (Proposition 2); ii) the raider is unconstrained for $s_0 > \tilde{s}^{c,d}$; and iii) $\tilde{s}^{c,d} < \hat{s}$ by Lemma 9. Therefore the raider's optimal holdings are given by $\bar{x} \leq 0$ for $s_0 \in \left(-\infty, \tilde{s}^{c,d}\right)$, $x_R^{*,d}$ for $s_0 \in \left(\tilde{s}^{c,d}, \hat{s}\right)$, and $x_R^{*,nd}$ for $s_0 \in \left(\hat{s}, p_1^*\right)$. It remains to be shown that with tight short-selling constraints, i.e. for $\bar{x} > -\gamma z$, the raider switches at $\check{s}$ from a short to a long position in the risk asset. We know from Proposition 2 that the raider optimally publicizes her signal for $s_0 \in (-\infty, \check{s})$. Moreover, from Lemma 9 we have that $\hat{s} < \tilde{s}^{c,d}$ and, again, from Proposition 2, $\check{s} < \hat{s}$. Taken together, these inequalities imply that $\check{s} < \hat{s} < \tilde{s}^{c,d}$ and therefore the raider's optimal holdings are given by $\bar{x} \leq 0$ for $s_0 < \check{s}$. We now show that the raider's holdings are discontinuous at $\check{s}$ in that $x_R^{*,nd}(\check{s}) > 0$. To establish this result, note from eqs. (3.9) and (A.44) that $x_R^{*,nd}(\tilde{s}^{nd}) = 0$ and recall from the proof of Proposition 2 that $\tilde{s}^{nd} < \check{s}$. Then, it follows that $x_R^{*,nd}(\check{s}) > 0$ because, owing to eq. (A.44), optimal holdings are increasing in s_0.

Internet Appendix: Supplementary Tables and Figures

Table A.1: Descriptive Statistics for Dedicated Short-bias Funds (Revised).

The Table presents, for each fund, summary statistics on the average cumulative abnormal returns (CARs) and number of positive and negative CARs over the (-5,+10) and (-5,+20) event windows. Year started refers to the year in which the fund first published a report on a target. The sample contains 265 first reports on target companies released by 12 dedicated short-bias funds over the period from January 2010 to September 2021. The total number of reports (265) does not coincide with the sum of those published by the individual funds (266), since two funds have first targeted the same company on the same day.

Fund	Number of reports	CAR (-5,+10)		CAR (-5,+20)	
		Mean	Positive:Negative	Mean	Positive:Negative
Bleecker Street	7	-18.2	2:5	-32.5	1:6
Bonitas/Glaucus	16	-25.0	2:14	-27.6	2:14
Citron	46	-14.3	6:40	-19.4	6:40
Gotham City	7	-20.3	0:7	-21.1	0:7
Hinderburg	22	-5.4	7:15	-9.4	8:14
J Capital	15	-21.2	2:13	-19.7	3:12
Kerrisdale	12	2.5	6:6	2.8	5:7
Marcus Aurelius	15	-27.7	1:14	-29.2	1:14
Muddy Waters	17	-28.4	1:16	-32.8	2:15
Spruce Point	68	-12.0	11:57	-12.7	15:53
Viceroy	5	-14.4	0:5	-10.8	0:5
White Diamond	36	-1.0	12:24	-4.8	15:21
All funds	265	-13.4	50:215	-16.0	58:207

Table A.2: Descriptive Statistics for CARs and Short-interest.

The Table presents summary statistics for the average cumulative abnormal returns (CARs) over the (-5,+10), (-5,+20) and (-5,+30) event windows and for the percentage of shares held short for the stocks in our data sample.

	average	median	5-th percentile	95-th percentile	standard deviation	skewness	kurtosis
	CAR (percentage)						
window							
(-5,+10)	-13.4	-13.2	-56.1	36.6	30.0	1.205	9.157
(-5,+20)	-16.0	-13.4	-62.8	33.1	30.5	0.372	5.780
(-5,+30)	-20.2	-15.6	-81.4	29.9	34.6	0.056	4.913
	Short-interest (percentage)						
	9.2	6.9	0.7	26.0	8.5	2.062	9.536

Table A.3: Abnormal Returns and Short-Interest (Revised).

The Table presents OLS regression results to examine the relation between cumulative abnormal returns (CARs) and short-interest. For different event windows, CARs are regressed on a constant and short-interest (scaled by outstanding shares). Short-interest is measured one month prior to the report. Panel E excludes reports released by Citron and Spruce Point Capital. Values in parentheses (brackets) denote Huber-White (bootstrap, with 1,000 replications) p-values. In the last column one observation is dropped because of Teavana Holdings' takeover.

	Panel E: Excluding Citron and Spruce (151 obs.)		
	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.973	-0.816	-0.648
	(0.005)	(0.016)	(0.107)
	[0.007]	[0.021]	[0.126]
Constant	-0.048	-0.091	-0.159
	(0.328)	(0.042)	(0.002)
	[0.328]	[0.044]	[0.002]
R-squared	0.046	0.034	0.018

Table A.4: Abnormal Returns and Short-Interest (Revised).

The Table presents OLS regression results to examine the relation between cumulative abnormal returns (CARs) and short-interest with abnormal returns obtained using factor loadings estimated with at least 120 trading days observations. For different event windows, CARs are regressed on a constant and short-interest (scaled by outstanding shares). Short-interest is measured one month prior to the report. Values in parentheses (brackets) denote Huber-White (bootstrap, with 1,000 replications) p-values. In the last column one observation is dropped because of Teavana Holdings' takeover.

	Panel F: 120 Trading Days Factor Loadings Estimation (300 obs.)		
	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.513	-0.525	-0.490
	(0.011)	(0.009)	(0.058)
	[0.016]	[0.012]	[0.063]
Constant	-0.091	-0.116	-0.163
	(0.001)	(0.000)	(0.000)
	[0.001]	[0.000]	[0.000]
R-squared	0.021	0.021	0.014

Table A.5: Abnormal Returns, Short-Interest and Follow-on Reports.

The Table presents OLS regression results to examine the impact of follow-on reports on the relation between cumulative abnormal returns (CARs) and short-interest. For different event windows, CARs are regressed on a constant, short-interest (scaled by outstanding shares), a dummy variable for follow-on reports and a interaction term between short-interest and the follow-on dummy. Short-interest is measured one month prior to the report. The follow-on dummy variable takes a value of 1 when one (or more than one) follow-on report is published during a given event window and zero otherwise. Values in parentheses (brackets) denote Huber-White (bootstrap, with 1,000 replications) p-values. In the last column one observation is dropped because of Teavana Holdings' takeover.

	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Short-interest	-0.509	-0.594	-0.745
	(0.029)	(0.066)	(0.077)
	[0.036]	[0.072]	[0.093]
Follow-on$\times$Short-interest	-0.323	-0.099	0.265
	(0.560)	(0.813)	(0.621)
	[0.586]	[0.833]	[0.654]
Follow-on	0.011	0.018	-0.015
	(0.896)	(0.775)	(0.835)
	[0.901]	[0.788]	[0.839]
Constant	-0.082	-0.107	-0.138
	(0.011)	(0.001)	(0.001)
	[0.011]	[0.001]	[0.001]
R-squared	0.031	0.031	0.025

Table A.6: Abnormal Returns and Short-Interest, by Groups (Revised).

The Table presents median CARs for stocks sorted by short-interest. Bottom (resp. top) SI stocks are those with short-interest (scaled by outstanding shares) one month prior to the event below the 25-th (resp. above the 75-th) percentile. Difference is top minus bottom SI median CARs. We perform a two-sample Wilcoxon test for difference in medians. Values in parentheses denote p-values.

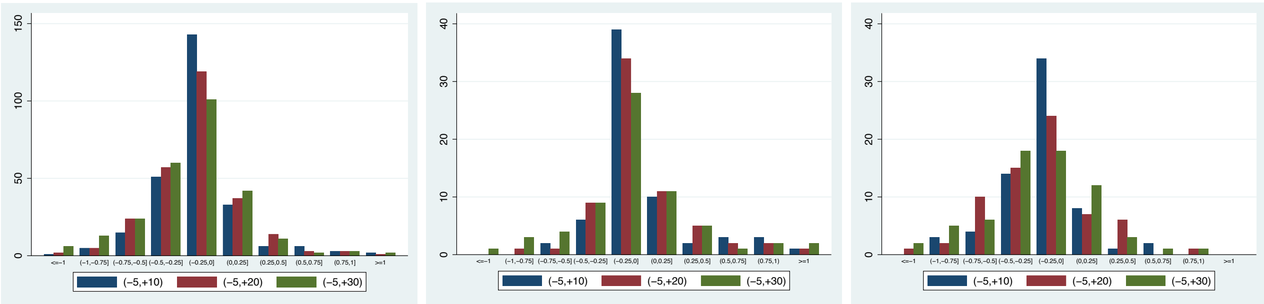
	Event window		
	(1)	(2)	(3)
	(-5,+10)	(-5,+20)	(-5,+30)
Bottom SI	-0.081	-0.089	-0.099
	(0.026)	(0.026)	(0.009)
Top SI	-0.142	-0.186	-0.206
	(0.000)	(0.000)	(0.000)
Difference	-0.061	-0.097	-0.107
	(0.004)	(0.003)	(0.041)

Table A.7: Abnormal Returns and Short-Interest, by Groups.

The Table presents average CARs for stocks sorted by short-interest with abnormal returns obtained using factor loadings estimated with at least 120 trading days observations. Bottom (resp. top) SI stocks are those with short-interest (scaled by outstanding shares) one month prior to the event below the 25-th (resp. above the 75-th) percentile. Difference is top minus bottom SI mean CARs. We perform a two-sided two-sample t-test for difference in means (with unequal variances). Values in parentheses (brackets) denote Huber-White (bootstrap, with 1,000 replications) p-values. In the last column one observation is dropped because of Teavana Holdings' takeover.

	(1)	(2)	(3)
Event Window	(-5,+10)	(-5,+20)	(-5,+30)
Bottom SI	-0.017	-0.055	-0.115
	(0.672)	(0.164)	(0.023)
	[0.671]	[0.158]	[0.018]
Top SI	-0.176	-0.202	-0.230
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.000]
Difference	-0.159	-0.147	-0.115
	(0.002)	(0.007)	(0.073)
	[0.002]	[0.007]	[0.080]

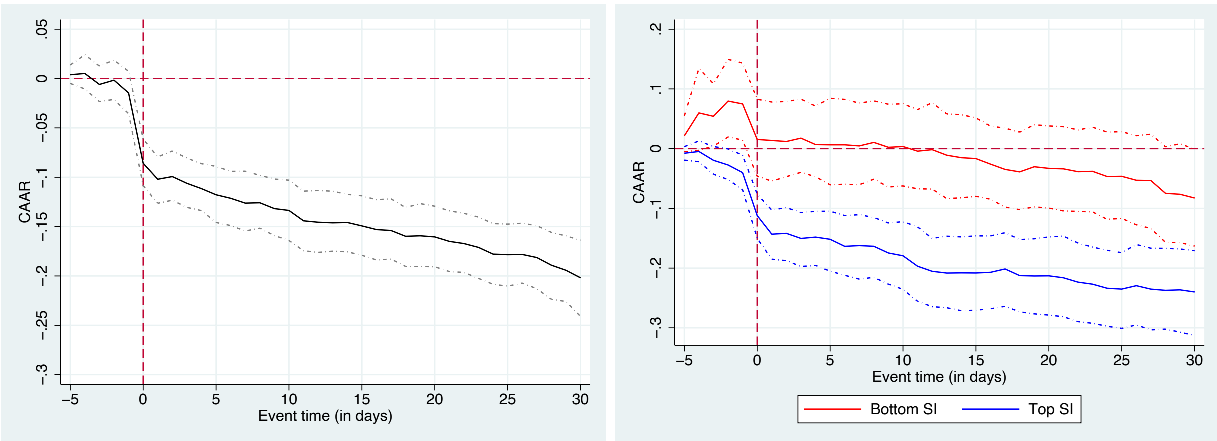
Figure A.1: Cumulative Abnormal Return Distribution.



(a) All Stocks (b) Bottom SI Stocks (c) Top SI Stocks

Panel (a) plots the histograms of the cumulative abnormal returns over the (-5,+10), (-5,+20) and (-5,+30) event windows for all the stocks in our data sample. Panel (b) (Panel (c)) plots the same histograms for the bottom (top) SI stocks.

Figure A.2: Abnormal Returns and Short-Interest (Revised).



(a) CAARs in the (-5,+30) Window (b) CAARs in the (-5,+30) Window by SI Groups

Panel (a) plots the average CARs in the (-5,+30) event window around the publication of the funds' reports alongside the corresponding bootstrapped 90% confidence interval. Panel (b) refines the former information by considering events pertaining to stocks sorted by short-interest. Bottom (resp. top) SI stocks are those with short-interest (scaled by outstanding shares) one month prior to the event below the 25-th (resp. above the 75-th) percentile. Dotted-dashed lines represent 90% confidence bands.