Trading Ahead of Barbarians' Arrival at the Gate: Insider Trading on Non-Inside Information☆

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Abstract

This paper formalizes a novel form of corporate insider trading based on non-insider information. In our model, insiders make trading decisions in anticipation of activist intervention. Because insiders have access to private information about firm fundamentals, they can better separate activism-motivated trades from those by speculators based on signals about firm fundamentals. We validate this prediction empirically by showing that when activists (privately) accumulate shares ahead of Schedule 13D filings, insiders are less likely to sell shares and are more likely to buy shares. Consistently with the proposed mechanism, insiders respond to activist trading more decisively precisely when there is an absence of positive news about the firm's fundamentals—so that insiders are able to attribute high buy order flow to activist interest instead of speculation on positive fundamentals.

Informed trading is a key force to market efficiency (in that value relevant information gets impounded into price) and real efficiency (in that market signals direct resource allocation). At the same time, there is also a consensus that unbridled trading of a public company's stock or other securities by people who possess material, nonpublic information about the company is inherently unfair to other investors. Significant presence of such trades drains market participation and liquidity, and eventually stunts economic growth as outside investors lose confidence in the leveling of the play field (Bhattacharya and Daouk, 2002). For this reason, all major securities markets have developed laws, rules, and systems that regulate trades by insiders (which usually include senior management, directors of the board, controlling shareholders, among others) and their affiliates who have privileged access to material nonpublic information, and criminalize insider trades that are based on, or misappropriate, such information.

While the theory and practice of insider trading law and regulation have involved over time, the boundary of insider trading remains blurry and becomes more so with new developments of the market. In this study, we explore the possibility of insider trading on non-insider information in a setting where an insider (i.e., a CEO) makes trading decisions on their firm's stock based on assessed possibilities of trading by activist shareholders. Shareholder activism aggressively pursued by hedge funds or hedge fund-like institutional investors has become a mainstream venue of non-control based corporate governance (see a recent review by Brav, Jiang, and Li, 2021). Though the insider does not have direct information about the arrival of the "barbarians at the gate,"[1] privileged information about their own firm's fundamentals helps the insider to filtrate public information and eventually trade on public information with a distinct advantage. We elaborate the set-up as follows.

[1] The term was coined in the namesake book by Burrough and Helyar (1990) for corporate raiders. More recently media have likened hedge fund activists to a new class of barbarians at the gate. See, e.g., "The Barbarians Return to the Gate," in Financial Times, April 24, 2014.

Activist hedge funds accumulate a minority, usually $5-10\%$, stake in target companies (usually via open-market purchase) and then agitate changes in operations, governance, and asset reallocation. In recent decades, real-time trades/orders have essentially become public information, and it has been common in the theoretical literature to assume that agents observe order flows at the same level as market makers. Modern "tape readers" specialize in looking at electronic order and trade books to hypothesize the motives underlying any unusual trading patterns and to analyze where a stock price may be headed. Compared to other forms of informed trading by outsiders (such as those betting on takeover prospects or earnings surprises), activists are better positioned to camouflage their trades due to their ability to spread the trades to time market liquidity. This is because the deadline of the private information, in the form of a Schedule 13D,[2] is largely self-imposed. However, given the concentration of trades in the last 60 days prior to filing (Collin-Dufresne and Fos, 2015), and a hard deadline of ten calendar days after the 5% crossing-date (the disclosure triggering event), it becomes increasingly difficult for activists to hide their trades in market liquidity as they approach Schedule 13D filing. Now the question becomes: Are insiders better equipped to detect activist trading than outsider investors and the market makers prior to Schedule 13D filing?

We hypothesize that the answer is a "yes" based on both incentives and capabilities. First, insiders have stronger incentives than general investors to get informed of activist plans. The information about an upcoming Schedule 13D filing is valuable to general investors due to the significantly positive average announcement return[3]. However, the

[2]Schedule 13D is a SEC form serving as a disclosure of beneficial ownership that is above 5% of shares outstanding, mandated within ten days after the investor crosses the threshold.

[3]Brav, Jiang, Partnoy, and Thomas (2008) documented an average of 5-6% return in excess of the market during the 20-day window around announcement. A similar pattern and magnitude has since been confirmed for the U.S. market (e.g. Clifford, 2008; Greenwood and Schor, 2009; Klein and Zur, 2009; Boyson and Mooradian, 2011) and for activism events in Europe (e.g. Becht et al., 2008).

information is of additional value to incumbent managers. Because job turnover increases and compensation drops for senior executives at the targeted firms, hedge fund activism often meets defense from the management.[4] Being prepared is a premise to an effective defense. As activism goes mainstream, firms have, with the help of financial advisories and other intermediaries, adapted by deploying defensive strategies ahead of the barbarians' arrival at the gate. In short, companies that recognize their vulnerability from activist targeting are incentivized to detect activist movement ahead of the public.

Second, insiders enjoy an information advantage in an indirect way. Conditional on both insiders and outsiders observing the same order flows and trades, insiders have a more refined information filtration to isolate trades potentially generated by activist interests from those motivated by leakage of or speculations on firm fundamentals, such as earnings or sales growth. Suppose a piece of public information is the union of two disjoint components, i.e., $\mathcal{F} = \mathcal{F}_1 + \mathcal{F}_2$, where $\mathcal{F}$ is public information but not its composition. If $\mathcal{F}_2$ is in the information set of insiders, then observing $\mathcal{F}$ reveals $\mathcal{F}_1$ to insiders alone. More importantly, if insiders trade based on inferred $\mathcal{F}_1$ they do not run afoul of the insider trading rule because the material, nonpublic information $\mathcal{F}_2$ serves as information filtration but would not have motivated any trade on its own. In our context, when investors observe abnormal buy orders, they could attribute them to either strong firm fundamentals (such as higher than expected earnings to be announced) or activist interests. The insiders, on the other hand, can rule in the latter if they are able to rule out the former. Interestingly, if they buy to counter activist, the insiders do so precisely because of a lack of private positive information about firm fundamentals.

In a motivating empirical diagnostic test (presented in Section 1.2), we show that

[4] According to Brav et al. (2008), activists were outright "hostile" or openly confrontational in about one-quarter of the cases; and managers of the target firm accommodated activist request without a major push back in fewer than 30% of the cases.

corporate insiders engage in share purchase, at frequencies significantly above normal, on the same day when activists trade, and three days afterwards (corresponding to the $T+3$ settlement). Such a coincidence is intriguing given that activist trading is not observable in real time. We thus present a stylized theoretical model that demonstrates a mechanism that could give rise to the pattern. In our model, a simple economy, lasting three dates, is populated by an activist, a company insider, the market makers, and a "stock picker" (who speculates based on a noisy but informative signal about firm fundamental). The activist can increase firm cash flows at date 2 in some but not all states of the economy, and buys shares at date 0 when they can. The order flow at date 0 is comprised of the demands of the activist and stock picker. The latter demand is imperfectly correlated with firm cash flows, and hence, complicates the inference for the market maker who is not informed about firm fundamentals. The insiders derive disutility under activist ownership dominance and trade at date 1 after observing the order flow at date zero. Importantly, they have informational advantage over the market maker because they know the fundamentals of their own company and are better able to filtrate activist trading from the total order flow.

For tractability, we assume that the strategies of activists and insiders are binary, so that activists can only buy or abstain from buying whereas insiders can sell or continue to hold. Such assumptions are consistent with the empirical regularities that activists *become* shareholders to profit from their intervention as opposed to pre-existing shareholders who voice their discontent (Brav et al., 2008), and that insiders sell far more than buying of the stock of their own firm for diversification reasons (which we document in Section 3.2). We solve the inference problem of the market maker and the insiders and, consequently, stock prices at dates 0 and 1. We find that the insider tends to abstain from selling shares when the possibility of activist trading is high. Relaxing the modeling restriction that insiders are only choosing between selling and keeping their shares, we interpret the result more generally as high net buying or low net selling, corresponding to acquisition or preservation of shares, by insiders after discerning activist interest. Such a trading strategy is part of the defense tactic, in addition to financial calculations about trading gains. This is because both insiders and dissident shareholders typically own similar percentage of the outstanding target stock,[5] hence marginal change in ownership on either side could be potentially pivotal.

We empirically investigate whether and to what extent insiders trade ahead of Schedule 13D filings, and whether the trading pattern is related to insiders' ability to gleam the information from both unusual trading volumes and forward-looking information about their own firms. Several patterns and relations arise. First, we document a significant relationship between activist trading and insider trading during the 60-day window prior to Schedule 13D filings.[6] We begin from comparing insider trading during the 60-day window prior to 13D filings with those outside the time window. We find that the likelihood of insider buying (selling) is 13 (78) basis points higher (lower), relative to days outside the time window. The difference, statistically significant, amounts to 15% (37%) of the normal pace of insider buying (selling). The combination of more buying and less selling leave more shares, and hence voting and control power, in the hand of the management at the dawn of an activist campaign.

Second, we discover a significant concurrence between activist and insider buy during the ten-day window prior to 13D filing. If we view the ownership at filings, on average of 7.5% (Collin-Dufresne and Fos, 2015), as a proxy for the ownership level activists desired before making their intention public, activists on average need to acquire an additional

[5]Fos and Jiang (2016) report that the activist and insider blocks at proxy contests are 9.6% and 10.9%, respectively, on average.

[6]The 60-day window is dictated by the SEC rule that Schedule 13D filers are required to respectively disclose trading during the previous 60 days. However, Collin-Dufresne and Fos (2015) show that shares accumulated during this window constitute the 51% of the total activist stake.

2.5%. It becomes a challenge for the activists to continue to camouflage their trades given the limited opportunity to time market liquidity facing a hard deadline of ten days triggered by crossing the 5% ownership threshold. We find that while selling during the ten-day period remains substantially lower than the normal level, insiders further make significantly more purchase. The combined results indicate that insiders both refrain from selling when there is a threat of activism (during the 60-day window), and further engage in buying when the footprint of the barbarians becomes clearer (during the last ten-day window).

Third, we rule out the alternative hypothesis that the concurrence of activist and insider trading could be due to activists piggybacking on insider buying as the latter might be motivated by private positive information about the firm. To separate insider defensive trading against activist interest, from activist trading on insider information, we need to step back and ask the question as how insider information could transmit in the market place. There are two potential sources. The first is "tape watching," that is, the real-time order flow could contain information about informed trading. If insiders or activists can "watch" the real-time order flows and trades, and detect trades that appear to be deliberate and purposeful, they can piggyback almost instantly. Information flow in either direction could produce the correlation of trades by two parties on the same day. The second is via record change. Under the T+3 settlement rule prevailing during most of our sample period (till 2017), a transaction will finish the ownership record change three days after the trade. If companies or investors actively monitor ownership changes—with the help of the intermediaries such as proxy solicitors—then they might get informed three days after the trade. If insiders buy in response to activist trades, we should observe a significant response on T+3. In the reverse direction, activists could potentially be informed of the trades place by insiders after just two days given that insider trading requires disclosure within 48 hours. If activists trade in response to insider trades, then we should observe abnormal activist trading two days after insider trading. Importantly, we further find that insider buy is significantly (at the 5% level) higher than usual on T+3 days relative to activist trading; but there is no significant correlation between activist trading and insider trading two days (or any days) prior. Therefore, results attribute the "source" trades to be placed by the activists and insiders trade in response.

Finally, we empirically test the mechanism that insiders are better positioned to isolate unusual trade flows from activist interests from those motivated by speculation on firm fundamentals. A key model prediction built on the mechanism is that insiders are able to respond to activist trading more decisively precisely when there is an absence of upcoming positive news about the firm's performance. We test the hypothesis in the context of earnings surprise, about which insiders are most likely to be informed ahead of the public. We find that the abnormal insider buying on the days with activist trading is solely driven by the subsample without positive earning surprises. In fact, within the subsample of positive earning surprises, there is no significant insider trade (buy or sell) on days when activist trade. This test affirmatively differentiates insider buy (and not selling) in response to activist interest in our set-up from the conventional insider trading based on private information about firm fundamentals.

Because affirming the mechanism of information filtration is the key to identify the causal relations in the data, we design an additional test leveraging the unique features of shareholder activism. Another piece of fundamental information insiders potentially have is the room for improvement if the company undergoes operational and governance reforms under activist pressure. Under this hypothesis, insiders may also be able to predict the stock market reaction to the public disclosure of a Schedule 13D, which in turn implies that insiders purchase prior to Schedule 13D filing has predictive power on the Schedule 13D announcement returns. Using the cross section of the stock return in excess of the market around the 11-day window centered on Schedule 13D filing, we show that the announcement return is significantly higher when insiders engage in excess share repurchase, and when they exhibit shortfall from normal selling, after controlling for other firm- and event-related variables. Under such a strategy, insiders benefit in two ways: They benefit from the price appreciation on their holdings and they counter activist power with higher insider stakes.

While the main contribution of this study is to present, solve, and test a model of a novel form of insider trading without insider information regarding the direct motive to trade, we also aim to achieve a better understanding of corporate strategies facing activist attacks – a relatively understudied corner of the activism literature, as most of the activism literature carries the perspective of activist investors and other institutional investors, as estimates the impact on the target firms. A few studies adopt the lens of the defensive side. Fos and Jiang (2016) show that CEOs of firms that are targets of proxy contests change their option exercise patters to preserve voting power. Bourveau and Schoenfeld (2017) show how firms vulnerable to activist attack increase and strategize voluntary disclosure. Fos (2018) and Gantchev et al. (2018) both show that firms start to take corrective measures after their peers were targeted by activists. Our study differs from these earlier papers in that we model insider response to activist plan that is not yet public and cannot be predicted from public information, and presents new evidence that corporate defense starts before the opponents' arrival at the gate.

1. Institutional Background

1.1. Informed and insider trading around Schedule 13D filings

In the United States, Sections 16(b) and 10(b) of the Securities Exchange Act of 1934 serve as the base for regulating insider trading. The country is generally viewed as making the most serious efforts in enforcement. Under the current interpretation of the law, anyone who misappropriates material non-public information and trades while in possession of such information may be guilty of insider trading. Where illegal insider trading is concerned, "insiders," despite the term, are not just limited to corporate officials/directors and large shareholders but can include any individual who trades shares while in possession of material non-public information about the firm (issuer) obtained in some direct or imputed duty of trust.

Activist investing introduces novel nuances to insider trading. The first new question is whether information about an activist's plan to target a company constitutes as material and nonpublic information relevant for insider trading. On the surface, such information predicts stock return (hence its materiality) and is not known to the public until the filing of a Schedule 13D (hence its nonpublic nature).[7] For this reason, there has been advocacy for extending insider information to activists even before the Schedule 13D filing. However, in this setting the private information does not originate from the firm and is not obtained due to or with any breach of a trust or duty; instead, the information is about activist investors' ability to potentially move markets by marking their views public. In other words, the information is created by the activists, who are outsiders themselves, rather than being proprietary about the firm.[8]

The second new issue, which this study exposes, is that corporate insiders may have an advantage in filtrating public information with the help of private information about firm fundamentals. Even if insiders and outside speculators observe the same trade flows, the private knowledge of firm fundamental information (such as earnings and sales growth) allows insiders to rule in or rule out trades motivated by fundamentals and therefore to

[7]Schedule 13D is a SEC form serving as a disclosure of beneficial ownership that is above 5% of shares outstanding, mandated within ten days after the investor crosses the threshold.

[8]See Back, Collin-Dufresne, Fos, Li, and Ljungqvist (2018) for a theory model for such a setting.

achieve better estimation of the likelihood of activist interests. In this case, because the information insiders trade on (or change pre-existing trading plans for) is about activist interests, which is not insider information as we discussed above, such trades are innocent in the conventional lens of insider trading. This situation is compounded by the "safe harbour" for insiders to cancel pre-committed trades (e.g., via 10b-5 Plans which allow insiders to buy and sell (usually sell) shares according to a pre-set plan in order to be clear of insider trading liabilities, reflecting the U.S. Supreme Court's holding that there can be no liability for insider trading without an actual securities transaction. Lenkey (2019) and Fos and Jiang (2016) provide theoretical predictions and empirical evidence of insiders' informed cancellation of planned trading. Our setting incorporates both "insider trading on public information" (i.e., insider information advantage allows them to better filtrate public information) and "informed non-trading" (i.e., insiders restrain from the routine selling based on information).

1.2. Motivating empirical pattern

Figure 1, shown below, serves as motivating evidence that corporate insiders seem to trade in response to activist trading, though the latter is not public information in real time. Because the ensuing Schedule 13D filing requires that the filer retrospectively discloses all transactions in the firm's securities during the six-day window leading to the filing, we are able to trace out activist trading ex post for research purposes. Merging this data with insider trading data from Form-4 filings, we are able to juxtapose transactions from both groups. Section 3 will describe the data sources and sample construction in more detail, while we highlight the finding herein.

The figure shows the probability that an insider will buy shares of their own firm from five days prior to a activist purchase as disclosed in Schedule 13D ("Schedule 13D trading") to five days afterwards, in excess of the unconditional average levels: insiders

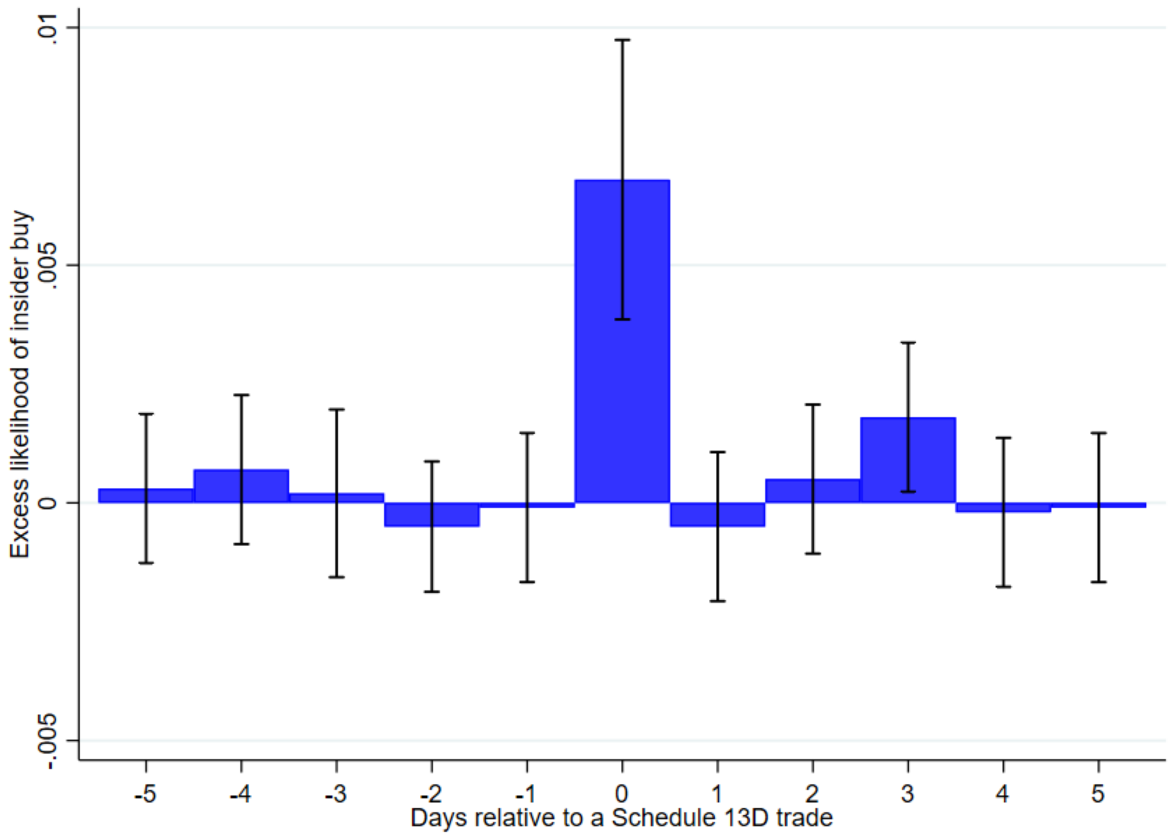

Figure 1: **Concurrence of insider and Schedule 13D trading.**

buy (sell) shares in their own firms on 0.80% (2.16%) of the days, and conduct a trade in either direction on 2.97%. It turns out that there is no abnormal trading by insiders during the ten-day window, except on two days: The same day that activist trades; and three days later. On these two days, the probabilities of insider buy is 0.68 and 0.18 basis points higher than the normal level, with both differences being significant at the 5% level. The three-day interval also looks fortuitous as it coincides with the $T + 3$ settlement prevailing till 2017, which covers most of our sample. The pattern suggests, *as if*, insiders are able to discern activist trades out of the total order flow though they do not receive the information in real time.[9]

[9]Several studies have suggested that an activist may "tip" other traders about their plan prior to

2. Model

2.1. Model setup: Players, incentives, and information structure

In this section, we present a parsimonious theoretical model that shows how the informational advantage of firm insiders allows them to timely detect and optimally respond to stock buying by activists. The model explains the main empirical finding, as shown in Figure 1, that insiders learn about activist trades ahead of the public. The model specifies the information sets of the insiders, activists, and market makers, such that insiders are not directly informed about the activist plans. The informational advantage that the insiders have over the market makers is restricted to that about firm fundamentals (in the absence of activist intervention). The model shows how the information about activist trades is incorporated into aggregate order flow, and how this information can be learned by insiders and market makers before it becomes publicly available. Unlike in most models of informed trading in which value of the securities or cash flows are exogenously determined, the value of the firm in our model is endogenous in the presence of the conflict of interests between activists and insiders, determined by the optimal trading strategies of insiders and activists which impact equilibrium stock prices. Finally, we summarize the empirical implications after solving the model.

The model sets up a two-period economy with three dates, $t = 0, 1, 2$, and three types of investors (the activist (with subscript A), the insider (I), the stock picker (N)), and the market maker (M). The firm, in the absence of activist intervention, pays final dividend D_2 at date $t = 2$, where D_2 equals $D_H > 0$ with probability π_D or $D_L = 0$ with probability $1-\pi_D$. The insider represents agents who run the firm and who enjoy the benefits of control;

Schedule 13D and before the stock price fully reflects the potential value improvement, especially after the lead activist reached the desire level of ownership stake (Wong, 2020). Sharing information helps the activist accumulate more voting power by like-minded investors who, in turn, can benefit from the expected increase in the target firm stock price. In such a scenario, insiders of the target firms are the least desired "tippees" by the activists.

such agents include firm managers and board members. The activist can acquire shares in the firm and boost its output by bringing new skills, reducing inefficiencies, or monitoring the performance of the insiders. Specifically, by acquiring stock holding θ_A in the firm, the activist increases the firm's output by $\psi\nu\theta_A$, where ν is a random variable representing their ability to increase output that takes values 0 and 1 with some probabilities, and ψ is a constant. Consequently, the cash flow of the firm in the presence of activism is $D_2+\psi\nu\theta_A$.[10] Finally, the stock picker receives an informative but noisy signal of D_2.

The type of the firm $s \in \{L, H\}$, that is, whether it generates high or low dividends, is known at $t = 0$ to both the activist and the insider,[11] but not to the stock picker and market maker. The ability to improve the firm, ν, is known only to the activist. Thus the private information cannot be competed away (Holden and Subrahmanyam (1992)). The market maker attempts to filter out the information about D_2 and ν while the insider focuses on learning about ν from the observables. Based on the model set-up, we observe that $\mathcal{F}_M \subset \mathcal{F}_I \subset \mathcal{F}_A$, where $\mathcal{F}_A$, $\mathcal{F}_I$, and $\mathcal{F}_M$ denote the information sets of the different groups of investors. That is, the information set of the activist strictly dominates that of the insider (because the former is privately informed about their own ability to enhance firm value, ν), which in turn dominates that of the market maker (because the latter does not have any direct information about firm fundamentals).

[10] The assumption that activists enhance the values of targeted firms in expectation is supported by the prevailing evidence across different time periods and markets, see a survey of existent evidence as well as an updated analysis provided by Brav et al. (2021).

[11] Activist investors engage in intensive research over candidates of target companies. Prominent activists such as Trian Partners and Starboard Value, are known for presenting in-depth reports running hundreds of pages at the launching of campaigns and for uncovering issues that even the mangers were not aware of. For simplicity, we assume that activists have the same level of information as the insiders about the firm fundamentals.

The joint distribution of the activist improvement ν and dividend D_2 is given by

$$\begin{aligned} \text{Prob}(\nu = 1, D_2 = D_H) &= \eta_1, & \text{Prob}(\nu = 0, D_2 = D_H) &= 0, \\ \text{Prob}(\nu = 1, D_2 = D_L) &= \eta_2, & \text{Prob}(\nu = 0, D_2 = D_L) &= \eta_3. \end{aligned} \tag{1}$$

The "upper triangular" structure specifying $\text{Prob}(\nu = 0, D_2 = D_H) = 0$ serves as a simplifying normalization and is without loss of generality. It is equivalent to $\text{Prob}(\nu = 1|D_2 = D_H) = 1$, that is, the activist can always create additional value for a "good" firm, but may not be able to save a fundamentally "bad" firm. Such a structure of probabilities captures a realistic situation, as argued by Brav et al. (2008), that activists create value by bringing expertise and by mitigating agency problems, but cannot rescue a firm from distress due to fundamental business issues such as obsolete technology or sun-setting markets. The inferences from the model would be materially the same if we normalize $\text{Prob}(\nu = 1, D_2 = D_L)$ to be zero in a "lower triangular" structure.

In terms of trading strategies, we assume that the activist only buys or abstains from trading, so that their trading strategy is constrained to $\theta_A \in \{0, \bar{\theta}\}$. Such an assumption is motivated by the fact that activist investors tend not be pre-exiting shareholders but choose to acquire most of their stakes in firms within a few months prior to targeting (Brav et al. (2008) and Collin-Dufresne and Fos (2015). Moreover, we are analyzing activists who benefit from value improvement and therefore they would not short the stock in equilibrium.[12] On the insider's side, we assume that their trading strategy takes two possible values $\theta_I \in \{-\tilde{\theta}, 0\}$. That is, the insider either sells some of their shares or stays

[12]The alternative for the activist fund, when firm underperformance is not yet public knowledge, is to short the firm's shares before publicizing the inefficiency, in which case the short-seller benefits from the decline in the share price to its fundamental value. Such "activist shorts" are a different genre from what we study in this paper. Readers may refer to Zhao (2020), Appel and Fos (2021), and Molk and Partnoy (2021) for detailed analyses.

put. Restricting the trading strategy of the insider to be either $-\tilde{\theta}$ or 0 captures the empirical regularity that insiders routinely sell but infrequently buy the stocks of their own firm. This is because managers and board members receive a significant portion of their compensation in the form of shares and options such that insiders are significant net sellers for liquidity and diversification. The activist and the insider trade with the market maker. The trading is sequential in that the activist trades with the market maker at date $t = 0$, and then the insider trades at date $t = 1$ after observing prices and order flows at date $t = 0$. Such sequential trading allows us to model the optimal response of the insider to the informed trading by activist, which is the focus of this study.

A functioning market (in which order flows are not fully revealing) requires the presence of investors who are not perfectly informed of the fundamental value of the security. The stock picker, N, plays this role in our model. The stock picker trades along with the activist and the insider and obfuscates the order flow. The stock picker's trades take the full range of values, $\theta_{N,0} \in \{-\bar{\theta}, 0, \bar{\theta}\}$ at date $t = 0$ and $\tilde{\theta}_{N,1} \in \{-\tilde{\theta}, 0, \tilde{\theta}\}$ at date $t = 1$. Following the model developed in Lambert, Ostrovsky, and Panov (2018), we assume that the orders submitted by these traders are not completely uninformative, and are (imperfectly) correlated with the dividend D_2. One interpretation is that the stock picker, as the name suggests, trades on some noisily informative signals about D_2, which are not endogenized here for tractability. In particular, the conditional probabilities of observing orders at date $t = 0, 1$, are given by

$$\begin{aligned}
\mathrm{Prob}(\theta_{N,0} &= \bar{\theta}|D_s) &&= \pi_1^s; &\quad \mathrm{Prob}(\tilde{\theta}_{N,1} &= \tilde{\theta}|D_s) &&= \tilde{\pi}_1^s; \\
\mathrm{Prob}(\theta_{N,0} &= 0|D_s) &&= \pi_0^s; &\quad \mathrm{Prob}(\tilde{\theta}_{N,1} &= 0|D_s) &&= \tilde{\pi}_0^s; \\
\mathrm{Prob}(\theta_{N,0} &= -\bar{\theta}|D_s) &&= \pi_{-1}^s, &\quad \mathrm{Prob}(\tilde{\theta}_{N,1} &= -\tilde{\theta}|D_s) &&= \tilde{\pi}_{-1}^s,
\end{aligned} \tag{2}$$

where $s \in \{L, H\}$ is the type of the firm.

To capture the idea that the stock pickers possess some information about the underlying type $s \in \{L, H\}$, we assume that when the firm type is good, $s = H$, they buy more frequently than sell, so that $\pi_1^H \geq \pi_0^H \geq \pi_{-1}^H$ and $\tilde{\pi}_1^H \geq \tilde{\pi}_0^H \geq \tilde{\pi}_{-1}^H$, and vice versa when type is bad, $s = L$. Moreover, they are more likely to buy in a good state and are more likely to sell in a bad state so that $\pi_1^H \geq \pi_1^L$ and $\pi_{-1}^L \geq \pi_{-1}^H$, and similarly in the second period $\tilde{\pi}_1^H \geq \tilde{\pi}_1^L$ and $\tilde{\pi}_{-1}^L \geq \tilde{\pi}_{-1}^H$. Such a structure essentially combines noisy traders and (outside) informed traders in the typical microstructure model so that our model remains tractable with the addition of an activist trader. It is essential that informed trading among non-activists exists which gives the insider an advantage over the market maker regarding the presence of activism. Because the insider observes type s they can better filter out the information about the trading of the activist from the aggregate flow than the market maker. If stock picker trades are pure noise then any abnormal buying could be attributed to a heightened probability of activist arrival, and in which case the insider and the market maker would be on the same level in period 0.

By $p_1(\theta_A + \theta_{N,0})$ we denote the first-stage stock price at date $t = 0$ as a function of the combined order flow $\theta_A + \theta_{N,0}$ in the eyes of the market maker. The activist solves the following optimization at date $t = 0$:

$$\max_{\theta_A \in \{0, \bar{\theta}\}} \mathbb{E}\Big[(D_2 + \psi\nu\theta_A)\theta_A - \theta_A p_1(\theta_A + \theta_{N,0}) | \mathcal{F}_A\Big], \tag{3}$$

where $\mathcal{F}_A$ is the information set of the activist, which includes the information about D_2 and ν. We assume that the initial stock holding of the activist is 0 as supported by the empirical evidence.

By $p_2(\theta_I + \tilde{\theta}_{N,1}, \theta_A^* + \theta_{N,0})$ we denote the second stage stock price at date $t = 1$ as a function of the combined order flow $\theta_I + \tilde{\theta}_{N,1}$. We also model that the insider has a disutility from activism which aims at reducing private benefits through monitoring.[13] The insider solve the following optimization problem:

$$\max_{\theta_I \in \{-\tilde{\theta}, 0\}} \mathbb{E}\left[(D_2 + \psi\nu\theta_A)\theta_I - \phi\theta_A(-\theta_I) - \theta_I p_2(\theta_I + \tilde{\theta}_{N,1}, \theta_A^* + \theta_{N,0})|\mathcal{F}_I\right], \tag{4}$$

where $\mathcal{F}_I$ is the information set of the insider. The insider has positive initial endowment of shares so that the total wealth from the holding should be $(D_2 + \psi\nu\theta_A)(X_I + \theta_I)$. However, initial position X_I does not affect other terms nor optimization, and hence is simplified to the first term in (4), $(D_2 + \psi\nu\theta_A)\theta_I$.

The second term in (4), $-\phi\theta_A(-\theta_I)$, is related to the insider's disutility from activism—hence the negative sign in front of the term. Such disutility is larger when activist acquires a higher stake (θ_A) and when the insider sell more shares (i.e., if $\theta_I = -\bar{\theta}$). In other words, the insider disutility is related to the relative ownership power (hence influence over the firm) between the activists and insiders.[14] It is worth noting that insiders, being significant shareholders themselves, benefit from value improvement brought by activism. Therefore insiders, when facing the threat of activism, fight more to retain their jobs and benefits, instead of thwarting value-enhancing plans, in their negotiation or settlements with the activists (Corum (2020)). Moreover, Bebchuk et al. (2020) provide empirical evidence that high insider ownership significantly reduces the likelihood that an activism campaign will escalate to a proxy contest (and favors an outcome more "friendly" to the

[13]Brav et al. (2008) show that CEO turnover rates more than double and their compensation experiences significant downsizing after the firm was targeted by activist. Fos and Jiang (2016) discover that in extreme cases insiders of firms targeted by activists exercise options out-of-money in order to boost up their voting power prior to a proxy contest, a sufficient evidence for private benefits of control.

[14]Fos and Jiang (2016) show that both insiders and dissident shareholders typically own similar and strict minority percentage of the outstanding target stock, around 10 percent on average. Hence marginal change in ownership on either side could be potentially pivotal.

incumbent management). Based on these findings from the earlier literature, we adopt the simple specification that insider trading does not impact the value improvement created by activism (ψ) but does impact the insider's disutility from activism.

The market maker, who observes neither D_2 nor ν, filters out the information about these variables from order flows. Following the standard literature, we assume that the market maker is risk-neutral, and behaves competitively and sets the first-stage and second-stage prices to the expected values

$$p_1(\theta_A + \theta_{N,0}) \;=\; \mathbb{E}\Big[D_2 + \psi\nu\theta_A | \theta_A + \theta_{N,0}\Big], \tag{5}$$

$$p_2(\theta_I + \tilde{\theta}_{N,1}, \theta_A + \theta_{N,0}) \;=\; \mathbb{E}\Big[D_2 + \psi\nu\theta_A | \theta_I + \tilde{\theta}_{N,1}, \theta_A + \theta_{N,0}\Big]. \tag{6}$$

2.2. Trading strategies and equilibrium

The feasible trading strategies of the investors restrict the aggregate order flow observed by the market maker to be one of the four values $-\bar{\theta};\ 0;\ \bar{\theta};\ 2\bar{\theta}$ at dates $t = 0$ and $-\tilde{\theta};\ 0;\ \tilde{\theta};\ 2\tilde{\theta}$ at $t = 2$. The limited discrete set of values is necessary to make the updating of beliefs tractable and to solve for asset prices, especially given the fact that at date $t = 1$ the market maker updates using two order flows, from date 0 and date 1.

We start with solving the first-stage equilibrium at date $t = 0$ when the activist trades with the market maker, with the presence of the stock picker. We conjecture a certain trading strategy of the activist, verify that it is an equilibrium strategy under certain conditions, and then derive the equilibrium stock prices. Proposition 1 summarizes our results.

Proposition 1. *Consider the following trading strategy of the activist at date $t = 0$:*

$$\theta_A^*(D_2, \nu) = \begin{cases} \bar{\theta}, & \textit{if} \quad D_2 = D_H; \\ \bar{\theta}, & \textit{if} \quad D_2 = D_L, \ \nu = 1; \\ 0, & \textit{if} \quad D_2 = D_L, \ \nu = 0. \end{cases} \tag{7}$$

Then, for sufficiently large $\bar{\theta} \geq d$, where d is given by equation (A6) *in the Appendix, θ_A^* is the unique equilibrium strategy, and the equilibrium first-stage price $p_1(x)$ is given by*

$$p_1(x) = \begin{cases} 0, & x = -\bar{\theta}; \\ D_H \dfrac{\pi_{-1}^H \pi_D}{\pi_{-1}^H \pi_D + \pi_{-1}^L \eta_2 + \pi_0^L \eta_3} + \psi\bar{\theta} \dfrac{\pi_{-1}^H \eta_1 + \pi_{-1}^L \eta_2}{\pi_{-1}^H \eta_1 + \pi_{-1}^L \eta_2 + \pi_0^L \eta_3}, & x = 0; \\ D_H \dfrac{\pi_0^H \pi_D}{\pi_0^H \pi_D + \pi_0^L \eta_2 + \pi_1^L \eta_3} + \psi\bar{\theta} \dfrac{\pi_0^H \eta_1 + \pi_0^L \eta_2}{\pi_0^H \eta_1 + \pi_0^L \eta_2 + \pi_1^L \eta_3}, & x = \bar{\theta}; \\ D_H \dfrac{\eta_1}{\eta_1 + \eta_2} + \psi\bar{\theta}, & x = 2\bar{\theta}. \end{cases} \tag{8}$$

While the proof is provided in the Appendix, we outline the intuition herein which paves the way to the next proposition. First, activist trading strategy is straightforward. Because they can always increase the value of a "good" firm (see condition (1)), the activist always buys when firm type is $s = H$. However, if the firm is of type $s = L$, the activist can improve the firm only with some probability and, consequently, buys only when they can implement the improvement ($\nu = 1$).

Second, we note that the realization of the order flow $\theta_A + \theta_{N,0} = -\bar{\theta}$ is fully revealing. Specifically, given the structure of the trading strategy (7), the latter order flow implies that $\theta_A = 0$, and hence, $s = L$. Consequently, the market maker infers that $\theta_A = 0$ and $D_2 = 0$ and sets price to zero. Similarly, the order flow $\theta_A + \theta_{N,0} = 2\bar{\theta}$ reveals that $\theta_A = \bar{\theta}$. However, there is remaining uncertainty about whether the firm type is L or H. When $\theta_A + \theta_{N,0} \in \{0, \bar{\theta}\}$, the market maker needs to make inference both about the firm type and the activist's trading taking into account the structure of θ_A in (7) and the conditional probabilities (2) describing the trading activity of the stock picker. Consequently, even zero order flow $\theta_A + \theta_{N,0} = 0$ causes the insider and the market maker to update their information sets.

Next, in the second stage starting at date $t = 1$, the insider observes the date $t = 0$ order flow $\theta_A + \theta_{N,0}$. The insider then filters out the information about θ_A using the information contained in the order flow, the fundamental D_2, and the structure of the distribution of stock picker demands conditional on value D_2, given by equations (2). Then, the insider chooses the trading strategy θ_I that maximizes the objective function (4).[15] In Proposition 2 below, we conjecture a trading strategy of the insider and derive the stock price implied by that strategy. We then show that the conjectured strategy is an equilibrium under some model parameters.

[15]From the equation for the first-stage price (8), we observe that the probabilities π_k can be chosen such that there is one-to-one mapping between prices and order flows $\theta_A + \theta_{N,0}$ at date $t = 0$. Hence, the insider effectively observes $\theta_A + \theta_{N,0}$ via their observation of the stock price.

Proposition 2. *Consider the trading strategy of the insider, given by*

$$\theta_I^* = \begin{cases} 0, & D_2 = D_H; \\ -\widetilde{\theta}, & D_2 = D_L, \quad \theta_A^* + \theta_{N,0} = -\bar{\theta}; \\ -\tilde{\theta}, & D_2 = D_L, \quad \theta_A^* + \theta_{N,0} = 0; \\ 0, & D_2 = D_L, \quad \theta_A^* + \theta_{N,0} = \bar{\theta}; \\ -\tilde{\theta}, & D_2 = D_L, \quad \theta_A^* + \theta_{N,0} = 2\bar{\theta}. \end{cases} \tag{9}$$

Given this strategy, the second-stage stock price is $p_2(\theta_I + \tilde{\theta}_{N,1}, \theta_A + \theta_{N,0})$*, where function* $p_2(x, y)$ *is given by equation* (A7) *in the Appendix. Moreover, the strategy* (9) *is the equilibrium if and only if conditions* (A21) *in the Appendix are satisfied.*

As before, we provide the economic intuition underlying the insider's strategy θ_I^*. When the firm type is good, $s = H$, the insider knows that the activist will be present and unambiguously prefers to keep shares (and do not sell). By keeping their shares, the insider enjoys the high dividend, benefits financially from the value improvement brought by the activist, and at the same time counters activist control by preserving ownership stake and, hence, also the voting power.

In the alternative situation, both the insider and the activist know that the firm type is $s = L$. Unconditionally, the insider knows that with probability η_2 activist will buy; but insider's belief could be further refined by observing the order flow from stage 1, combined with their knowledge that $s = L$. If the order flow is $\theta_A^* + \theta_{N,0} = -\bar{\theta}$, then the equilibrium is fully revealing. Both the insider and the market maker infer that $\theta_A^* = 0$. Further, the market maker learns with certainty that $s = L$, because $\theta_A^* = 0$ is only possible for the bad firm type, as can be seen from the activist strategy (7). Consequently, the firm value and the price are equal to zero, $p_2 = D_2 + \psi\widehat{\theta}_A = 0$, where $\widehat{\theta}_A$ represents the insider's best estimate of the activist's strategy. In this case, the insider is indifferent between keeping shares or selling because the price is fair. For modelling simplicity, we assume that the insider sells when they are indifferent with respect to trading profits due to the motive to diversify their portfolio which is not formally modeled in our setup. The selling motive in this situation can also be attributed to investor's general desire to avoid (unmodelled) costs of carrying on with a bad firm.

The cases in which $\theta_A^* + \theta_{N,0} = \bar{\theta}$ or $\theta_A^* + \theta_{N,0} = 0$ are not fully revealing, as in both cases there is an interior probability that the activist has arrived to both the insider and the market maker. If the insider infers that $\theta_A^* = \bar{\theta}$ is likely, this is good news as activism will increase the final dividend. It is also bad news because the insider suffers disutility from activism due to the loss of private benefits of control. Both economic forces (captured by the first and the second terms in the insider's optimization (4)) discourage the insider from selling—in order to financially benefit from the value improvement as well as to counter activist dominance. To the market maker who does not have the knowledge of firm fundamental (that $s = L$), the inference of activist presence is less precise. Hence the price set by the market maker is under-valued, conditional on the insider's knowledge that $s = L$, when $\theta_A^* + \theta_{N,0} = \bar{\theta}$, further support the insider's restraint from selling. Market maker also over-prices when $\theta_A^* + \theta_{N,0} = 0$, prompting the insider to sell, provided that disutility of selling parameter ϕ is not too large.[16]

Here comes the highlight of the model: The strategy (9) demonstrates how the informational advantage of the insider regarding own firm fundamentals allows them to detect and optimally respond to activist trading, on which the insider has no more direct

[16] Subsection A1 in the Appendix provides the calibration in which the insider strategy (9) is the equilibrium for wide ranges of model parameters.

information compared to any other non-activists. Such a filtration manifests itself in the contingency of insider trading on the realization of the aggregate order flow even when the insider already knows that the firm fundamental is weak, i.e., $D_2 = D_L$. In such situation, the insider sells when $\theta_A^* + \theta_{N,0} = 0$ and does not sell when $\theta_A^* + \theta_{N,0} = \bar{\theta}$. The intuition is that the insider deduces that the activist is more likely to be present in the latter case. Knowing that the firm fundamental is weak, the insider down-weights the probability that a buy order could be from the stock picker (who has an informative albeit noisy signal), leaving a higher chance that the positive order flow was from the activist (who buys in case the firm is fixable, i.e., $\nu = 1$). Activist buy in this scenario is more likely than in the scenario of zero aggregate order flow which could be due to either activist's buy order being offset by the bearish stock picker (when the activist has the ability to improve the firm and the stock picker draws negative signal) or no action by both (when activist knows they cannot fix the firm; and the stock picker did not receive a directional signal).

Finally, when the insider and the market maker observe $\theta_A^* + \theta_{N,0} = 2\bar{\theta}$ and the type is $s = L$, they both can infer that $\theta_A^* = \bar{\theta}$ but they nevertheless have different valuations of the firm. The market maker, who does not know the true state of the firm, would set the price to $\mathbb{E}[D_2|\mathcal{F}_M] + \psi\bar{\theta}$. On the other hand, the insider's valuation is $D_L + \psi\bar{\theta} < \mathbb{E}[D_2|\mathcal{F}_M] + \psi\bar{\theta}$, because the insider knows that the firm's type is L. Consequently, the firm is overvalued from the insider's point of view, and hence, the insider prefers to sell in this case, despite the activist buying. We observe that the market maker overvalues the fundamental value D_2 but prices correctly the additional value $\psi\bar{\theta}$ created by the activist. Consequently, by selling, the insider gains due to the mispriced fundamental value D_2 and is fairly compensated for the additional value $\psi\bar{\theta}$.[17]

[17] The investor may abstain from selling if parameter ϕ capturing the disutility of selling is very large. However, for the ranges of ϕ considered in our calibrations in subsection A1, the investor chooses to sell shares. The situation in which the insider buys shares when $\theta_A^* + \theta_{N,0} = 2\bar{\theta}$ requires unrealistically large

Admittedly, the fully revealing cases in the model arise due to our restriction that trading strategies take only two values for both the activist (who can stay put or buy) and the insider (who can stay put of sell) for tractability. Though the parameterization is motivated by institutional features and empirical regularities in the setting of insider trading and activism, we acknowledge that the fully revealing states are unlikely to arise in a more general setting with full-range trading strategies. Lemma A1 in the Appendix formally shows that the fully revealing order flow $\theta_A^* + \theta_{N,0} = 2\bar{\theta}$ has a smaller probability of occurrence than the order flows $\theta_A^* + \theta_{N,0} = 0$ and $\theta_A^* + \theta_{N,0} = \bar{\theta}$ under the assumption that the stock picker's signal is informative so that they are more likely to sell than buy or do nothing when the firm type is bad.

2.3. Economic and empirical implications

We now provide the summary of the main economic and empirical implications of the model. First, the model highlights two (related) sources of the informational advantage of insiders over the market makers, the knowledge of firm fundamental, D_2, and the ability to efficiently separate the activist trades from the trades by the stock picker, given by equations (2), because the latter trades are correlated with D_2, which the market maker does not observe.

Second, the model predicts that the insider trades in response not only to observed total order flows (which is public information), but also to activist buy (which is not publicly observable) as shown in Figure 1. Naturally, the order flow $\theta_A + \theta_{N,0}$ contains information about the activist trading; but the filtration by the insider is much more refined due to the insider knowledge about firm fundamental D_2, as long as the trades by the stock picker is at least somewhat informative about firm fundamental.[18] Moreover, in reality, activist trades

values of ϕ.

[18]Assume the stock picker's signal is pure noise such that the stock picker degenerates into a noise trader.

typically stay under 30% of the total daily trading volume (Collin-Dufresne and Fos, 2015) and hence the pattern revealed in Figure 1 requires a help from the additional filtration.

Third, the model predicts that the insider's trading strategy is determined by the trade-off between exploiting mispricing by the less-informed market maker (about firm fundamental) and mitigating their disutility from activism (taking advantage of their filtered information about activist presence). Insiders sell when they believe that activists are less likely to be present than the estimate by the market maker, and refrain from selling when order flow signals the threat of activism, in line with our empirical findings below.

3. Data and Overview

3.1. Data sources

The construction of the key data sample of this study follows the methodology developed in Collin-Dufresne and Fos (2015). We start with a universe of Schedule 13D filings from the SEC EDGAR website spanning 1996-2018. We begin from the universe of all Schedule 13D filings available on EDGAR. We then exclude filings by corporate insiders as well as filings that result from non-market transactions (e.g., conversion of pre-held securities, private placements, negotiated block transactions, and gift of shares), and require that investor must cross the 5% threshold by purchasing shares in the open market. Finally, we exclude cases when derivatives (such as options) count toward the 5% ownership because our set-up focus on trades by activists and insiders in the public equity market. Our preliminary sample contains about 3,100 Schedule 13D filings.

For each event, we have the usual information on the identity of the activist, the filing

Then, $\text{Prob}(\theta_{N,0} = \bar{\theta}|D_s) = \text{Prob}(\theta_{N,0} = 0|D_s) = \text{Prob}(\theta_{N,0} = -\bar{\theta}|D_s) = 1/3$. In such a limit, equation (7) for the activist trading strategy θ_A and equation (A19) in the Appendix imply that, for example, $\text{Prob}(\theta_A = \bar{\theta}|D_L, \theta_A + \theta_{N,0} = x) = \text{Prob}(\theta_A = \bar{\theta}|D_L)$, where $x \in \{0, \bar{\theta}\}$, and hence the information in the order flow is redundant for predicting the probability of activist buying.

date, the disclosure trigger date (the 5% crossing date), and the disclosed ownership stake. The key input from the 13D filings for this project is the information on all trades made by filers during 60-day period prior to the filing. We are left with 2,847 Schedule 13D filings for which there is disclosed information of activist trading. The sample corresponds to 115,841 observations (2,847 times the number of trading days during the 60-calendar-day window). For each trade disclosed on Schedule 13D, we know the date of the trading (and hence we also know the dates without activist trading), and the number of shares in transaction (which could be either buy or sell, the great majority being buy), and the average daily price paid or received.

We then merge the manually collected data with standard databases to obtain stock and firm level information (CRSP and Compustat), as well as insider trading information (Thomson Reuters). We use purchase and sell transactions reported in form 4 for directors (role codes CB, D, DO, H, OD, and VC) and officers (role codes AV, CEO, CFO, CI, CO, CT, EVP, O, OB, OP, OT, OS, OX, P, S, SVP, and VP).

3.2. Sample overview and summary statistics

Our Schedule 13D trading sample consists of 2,847 Schedule 13D filing with information on activist trades ("events"). Figure 2 shows the time-series distribution of events. The number of events ranges from 64 during 2004 to 185 during 2007, averaging at 124 events per year. During a typical event, Schedule 13D filers trade on 29.2% of trading days (out of the 60-day window), suggesting that they trade on selective days rather than in a continuous way. Moreover, because activists tend to trade in a way that best conceals their actions (Collin-Dufresne and Fos, 2015), it is hard to predict when a Schedule 13D filing event occurs or on which days the Schedule 13D filers trades, based on public information including order flows.

When Schedule 13D filers trade, they constitute a large fraction of trading activity.

Specifically, the average number of shares traded is 26% of daily turnover. The vast majority of these trades, 94.4%, are purchases, suggesting that trades by Schedule 13D filers usually have exert upward price impacts. Indeed, in the sample of 115,841 observations, the average daily returns are -0.01% (indistinguishable from zero) on days without trades by Schedule 13D filers. In contrast, the average daily return is 0.25% (significantly different from zero at 1%) on days when Schedule 13D filers trade. Thus, an investor with private information about the timing of trades by Schedule 13D filers could gain in trading.

[Insert Figure 2 here.]

We next turn our attention to data from Thomson Reuters on trading by corporate insiders. Our sample contains 31.9 million firm-trading day observations. The summary statistics are reported in Table 2, after Table 1 which defines all variables. Panel A shows that the average probability of an insider trade on a given day is 2.97%. The average probability of insider sell is 2.16% and of insider buy is 0.80%, suggesting that majority of insider trades are sell transactions as insiders cash out their equity-based compensation for liquidity and diversification. In panel B of Table 2, we restrict the sample to days when Schedule 13D filers trade. Results indicate that insider buy is 1.22% on days when activists trade, as compared to 0.80% on an average day (Panel A); on the selling front, the probability is 1.64% on activist trading days, lower than the 2.15% unconditional average. Thus, the descriptive statistics provide the first indication of a relationship between insider and activist trades, that is, insiders buy more and sell less on days activists trade.

[Insert Table 1 here.]

[Insert Table 2 here.]

Panel C reports summary statistics for days with insider trading. Consistently with our earlier discussion, we find that insiders are more likely to sell (73%) than to buy (27%)

when they trade. Daily returns are higher on days when insiders trade than in the full sample. Finally, we note that insider no-trade could be due to choice to restrictions. For this reason in our empirical analysis we control for the limitations imposed on trading by the common "blackout windows" during which insiders are not allowed to conduct discretionary trades due to upcoming release of material information (e.g., earnings). The blackout windows for individual firms are not publicly disclosed in filings. We thus calibrate the upper bound and lower bound based on the survey by Bettis et al. (2000). Specifically, we code [t+4,t+14] relative to quarterly disclosure as the "Free trade" window and [t-14,t+2] as the "Not free trade" window. Panel C shows that trading intensity is 20.4% during the $Free\ trade$ window and 6.9% during the $Not\ free\ trade$ window, indicating that insider trading restrictions affect the likelihood of insider trading in an expected way.[19]

4. Empirical Tests and Results

4.1. Univariate Analyses

Taking all daily observations for firms in our sample for the period of 1996-2018, Table 2 shows that, based on information from Form 4, insiders buy (sell) shares in their own firms on 0.80% (2.16%) of the days. These numbers set the benchmark for detecting unusual activities in trading. The average value of *Insider net sell*, defined as *Insider buy* minus *Insider Sell*, is 1.36%.

We present three sets of results signifying the abnormal insider trading prior to Schedule 13D filings in Table 3. First, we compare insider trading during the 60-day window prior to 13D filings with those outside the time window, and results are reported in Panel

[19]Insider trading still occurs during the $Not\ free\ trade$ window for two reasons. First, our construction of the variable is based on survey and best practice instead of being based on information from individual firms. Second, pre-committed trades especially those authorized by plans compliant with Rule 10b5-1 are not restricted, but are cancellable (see Fos and Jiang, 2016; Lenkey, 2019).

B. Insider buy frequency increases by 12 basis points, or a 15% increase over the usual level. In contrast, insider selling slows down by 0.78 percentage points, or by 36%. Both differences are statistically significantly at less than 1% level. The combination of more buying and less selling prior to Schedule 13D filings leaves more shares, and hence voting and control power, in the hand of the management at the dawn of an activist campaign.

[Insert Table 3 here.]

Panel C of Table 3 further partitions the 60-day window into the last ten and the first 50 days. Note that during most of the 10-day window, activists likely have passed the 5% ownership triggering level because activists have ten days before having to disclose their block.[20] If we view the ownership at filings, on average of 7.5% (Collin-Dufresne and Fos, 2015), as a proxy for the ownership level activists desired before making their intention public (and hence the price fully reflect the value impact of their effort), activists on average need to acquire an additional 2.5% against a hard deadline of ten days. Because of the limit of ten days, it is a challenge for the activists to continue to camouflage their trades as they lose the discretion to time market liquidity.

We thus hypothesize that the pattern we observed in Panel B should be most profound during the last 10 ten days of the 60-day window. Results in Panel C confirm such a hypothesis. While selling in both sub-periods is substantially lower than the normal level, the abnormal insider buying mostly concentrates during the last ten days. The daily buying frequency is 1.27% during the ten-day window, significantly higher (at less than the 1% level) than the 0.86% frequency during the previous 50 days.

Next we partition the 60-day window into two subsets: Days on which Schedule 13D filers buy shares; and those they do not. Recall that such information is not publicly

[20] Bebchuk et al. (2013) report the detailed distribution of the interval between 5% crossing and 13D filing. Over 80% of Schedule 13D filings are filed six or more days after the triggering transaction.

observable or predictable. It turns out that insider buying frequency remains normal on days when Schedule 13D filers do not trade; but the frequency is 0.43 percentage points higher (or 53% higher) on the set of days with Schedule 13D filers' trades. The difference is again significant at the 1% level. Selling rate is also higher by 0.37 percentage points, indicating that in some cases insiders consume the liquidity provided by activist buying. We will therefore control for daily turnover to mitigate the effect of stock liquidity on the estimates.

4.2. Main Results

In this section, we present the analyses in the regression framework so as to better control for firm and stock characteristics relevant for trading. Fixed effects are deployed to subsume unobserved firm and market heterogeneity. We begin by comparing insider trading during the 60-day window prior to Schedule 13D filings with those outside the time window, using the following regression:

$$y_{it} = \alpha_i + \alpha_{ym} + \gamma_1 \mathit{SC13D\ 60\text{-}day\ window}_{it} + \gamma_2 \mathit{Return}_{it} + \gamma_3 \mathit{Turnover\ rate}_{it} + \varepsilon_{it}, \quad (10)$$

where y_{it} is a measure of insider trading activity on day t for firm i, α_i represents firm fixed effects and α_{ym} for year-month fixed effects. Among the independent variables, *SC13D 60-day window* is an indicator of the 60-day window prior to Schedule 13D filings, Return_{it} is stock return on day t for firm i, and $\mathit{Turnover\ rate}_{it}$ is share turnover rate on day t for firm i. Standard errors are clustered at the firm level. Because the regressions incorporate firm-month fixed effects, unobserved, and potentially time varying (up to the monthly frequency) firm characteristics are controlled for, and so are the real-time market conditions at the monthly level. Results are reported in Table 4.

[Insert Table 4 here.]

When we consider insider stock purchases (columns 1 and 2) and sales (columns 3 and 4), we find that the change in the likelihood of insider trading is driven by insider sells. Specifically, we find that insider buy during the 60-day window is on par with the level in other times; however, insider selling slows down considerably by 0.91 percentage points (relative to the normal level of 2.16%). Connecting to the model in Section 2 in which insiders are choosing between selling and not selling, we examine the outcome of "Insider net sell" (i.e., the difference between sell and buy) in columns (5) and (6). Again the results show that during the 60-day window prior to schedule 13D filing, insiders significantly (at the 1% level) reduce selling their holdings, net of their buying.

The slowdown of insider selling of shares corroborates theoretical predictions of Levit et al. (2021) that there is an equilibrium "voting premium," and empirical findings in Fos and Jiang (2016) showing that CEOs decrease option exercise after proxy contests are announced. Both results indicate insiders' desire to preserve their stock holdings (hence voting rights or controlling power in general) when they face the challenge from activist shareholders. Nevertheless, the two settings are critically different: The earlier papers show insider responses after public announcement of activism (proxy contests) while in the setting of this paper we discover that some insiders seem to respond to information about activist arrival which is not supposed to be observable.

Based on the finding in previous regression that the 60-day window prior to Schedule 13D filings is where the action is, we next restrict the analysis to trading days during this window. We estimate the following regression:

$$y_{it} = \alpha_i + \alpha_{ym} + \alpha_{iym} + \gamma_1 SC13D\ trade_{it} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}, \quad (11)$$

where y_{it}, α_i, and α_{ym}, as well as the two control variables, are same as before. The new key independent variable, *SC13D trade*, is an indicator of days when Schedule 13D filers trade. Standard errors are clustered at firm level. Because the regressions incorporate firm-month fixed effects, unobserved, and potentially time varying (up to the monthly frequency) firm characteristics are controlled for, and so is real-time market conditions at the monthly level. Results are reported in Table 5.

[Insert Table 5 here.]

In Table 5, columns 1 and 4 show that insiders are more likely to trade on days when Schedule 13D filers trade. Specifically, the likelihood of insider buy (sell) is 0.77% (0.27%) higher on days when Schedule 13D filers trade than on days when Schedule 13D filers do not trade. When we control for stock returns and turnover rates in columns 2 and 5, we find that the likelihood of insider sell becomes similar on days when Schedule 13D filers trade and on days when they do not trade. In contrast, change the likelihood of insider buy remains positive and significant at 1% level. Finally, insider net selling is significantly lower on days with 13D trades (columns (7)-(9)). The inclusion of firm-month fixed effects in the regression does not lead to substantial changes in regression estimates, suggesting that unobserved, and potentially time varying up to the monthly frequency, firm characteristics do not drive our results.

The combined results in tables 4 and 5 indicate that insiders seem to trade in tandem with activist accumulation of shares. The likelihood of insider selling is lower during the 60-day window prior to Schedule 13D filings (relative to days outside that window). During that window, the likelihood of insider selling remains low and is similar on days when activists trade and on days when they don't trade. Insider buying is more likely not only during the 60-day window prior to Schedule 13D filings (relative to days outside that window), but also on days when activist investors trade (relative to days when they don't trade). The difference in insider selling and buying results is due to the fact that insider selling is bounded from zero (that is, the most an insider can do is not to sell at all), and "non-action" is difficult to be detected at a high, daily frequency given the low unconditional rates. On the other hand, insider buying is an action which is more detectable at a high frequency. The "net sell" results at the daily frequency in Table 5 remain consistent with those at a lower frequency (60-day) in Table 4.

We next do our best to control for the limitations imposed on trading by the common "blackout windows" during which insiders are not allowed to conduct discretionary trades. During such a window, however, pre-committed trades especially those authorized by plans compliant with Rule 10b5-1 are not restricted; moreover such pre-set trades could still be cancelled resulting in effectively discretionary "non-trading" (see Fos and Jiang, 2016; Lenkey, 2019). To our best knowledge, the blackout windows for individual firms are not publicly disclosed in filings. We thus calibrate the upper bound and lower bound based on the survey by Bettis et al. (2000). Following Bettis et al. (2000), we code [t+4,t+14] this window as the "Free trade" window and [t-14,t+2] as the "No free trade" window, where t is the earnings announcement date. We also include in the regression an indicator of the 30-day period prior to earnings announcement.

Table 6 reports the results. We find that both *Free trade* and *No free trade* have the expected coefficients in the regressions. When we include in the regression the indicator of the 30-day period prior to earnings announcement, we find that *No free trade* remains negative and significant, suggesting that insider trading restrictions are more binding closer to earnings announcement. Importantly, the finer control of insider trading freedom has little effect on the relation between insider and activist trading.

[Insert Table 6 here.]

4.3. Who leads the trade?

So far, the evidence shows that insiders and activists tend to trade on the same day during the 60 days leading to Schedule 13D filings. While certain market conditions, such as stock price changes and trading liquidity, could induce both parties to trade, the concurrence that survives the control of such conditions (and an inclusion of a stock-month fixed effect) suggests that the coincidence is likely to be due to non-random factors. Such a finding, while intriguing, does not inform us which party leads the trade. While we hypothesize that insiders respond to activist buying; the same evidence could also be construed as activists piggyback on insider buying as the latter might be motivated by positive information about the firm that is known privately to the insiders. Though the latter hypothesis is not very plausible because there is no seeming way for the activists to discern insider trading in real time, we nevertheless entertain such a possibility to maintain symmetry of hypotheses.

To separate insider defensive buying from activist trading on insider information leaked via trading, we need to step back and ask the question as how information about trading by either insiders or activists could transmit in the market place. There are two potential sources. The first is "tape watching," that is, the real-time order flow could contain information about informed trading, and activist buying for the purpose of launching activism is a special case of informed trading where the private information is their own plan (Back et al., 2018). If insiders or activists can "watch" the real-time order flows and trades, and detect trades that appear to be deliberate and purposeful, they can piggyback on almost instantly. Information flow in either direction could produce the correlation of trades by two parties on the same day.

The second is via record change. Under the T+3 settlement rule prevailing during most of our sample period (till 2017), a transaction will finish the ownership record change three days after the trade. If companies actively monitor their ownership changes—a common practice in activism defense which often involves the intermediaries such as proxy solicitors—then they might get informed three days after the activists placed their trades. If insiders buy in response to activist trades, we should observe a significant response on T+3. To evaluate this possibility, we estimate the following regression:

$$y_{it} = \alpha_{iym} + \sum_{\tau=-5}^{5} \gamma_{1,\tau} SC13D\ trade_{it+\tau} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}, \tag{12}$$

where $SC13D\ trade_{it+\tau}$ is an indicator of τ days after day when a Schedule 13D filer trades. All other variables are as in regression (11). Panel A in table 7 reports the results. Results in column (1) indicate that insiders conducted abnormally high volume of share purchases (for 68 percentage points, or at least 85% above the normal level) on exactly the same day as the activists. At the same time, abnormal selling was close to zero in magnitude and significance (column (2)). As a result, net selling (column (3)) is essentially a negative image of buying.

[Insert Table 7 here.]

An interesting additional result emerges that insider buy (but not sell) is significantly (at the 5% level) higher than usual on T+3 days relative to activist trading. Thus, the evidence is consistent with insiders trading in response to activist trading. Figure 1 further visualizes the relation presented in Table 7 Panel A. It is hard to argue that the insider trading is not a response to activist trading given the two significant bars on day 0 and day 3, and near-zero levels everywhere else.

In the reverse direction, activists could be informed of the trades placed by insiders only two days ago given that insider trading requires disclosure within 48 hours. If activist trade in response to insider trades, then we should observe abnormal activist trading two days after insider trading. To evaluate this possibility, we estimate the following regression:

$$SC13D\ trade_{it} = \alpha_{iym} + \sum_{\tau=-5}^{5} \gamma_{1,\tau} Insider\ trade_{it+\tau} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}, \tag{13}$$

where $Insider\ trade_{it+\tau}$ is an indicator of τ days after day when an insider trades. All other variables are as in regression (11). Panel B in table 7 reports the results. We find no significant correlation of activist trading with insider trading any days prior of after days when insiders trade. Therefore, the results indicate that the "source" trades are placed by the activists and then the insiders trade in response.

4.4. Testing information about firm fundamentals

A central mechanism of the theory model outlined in Section 2 is that insiders are better positioned to isolate unusual trade flows from activist interests from those motivated by leakage of or speculation on firm fundamentals, because insiders enjoy superior information on the latter. According to this hypothesis, insiders should be able to respond to activist trading more decisively precisely when there is an absence of upcoming positive news about the firm's performance.

We test the hypothesis in the context of earnings surprise, about which insiders are most likely to be informed ahead of the public. More specifically, we construct standard unexpected earnings (SUE) measure to be ($Actual\ earnings - Expected\ earnings)/Stock\ price$, where (i) *Actual earnings* is the announced earnings in quarterly disclosure; (ii) *Expected earnings* is the analyst consensus forecast, defined as the average of all *unupdated* forecasts made by analysts in the IBES database during the 90 days before the earnings announcement. When a firm is not covered by the IBES, we adopt the standard practice in the accounting literature to impute the expected earnings in quarter t using past quarterly earnings with both season- and drift- adjustment, calculated as $EPS_{t-4} \times \Sigma_{i=1}^{4} EPS_{t-i} / \Sigma_{i=5}^{8} EPS_{t-i}$; and (iii) *Stockprice* is the closing price at the quarter end. Consistently with the literature (e.g. Livnat and Mendenhall, 2006), the average (median) SUE in our sample is -0.06% (0.03%), with an interquartile range of -0.15% to 0.25%.

Table 8 repeats the exercise in Table 5 but separates the subsample with positive upcoming earnings surprise (defined as 30-day period prior to positive earnings surprise) from the subsample without such positive news which insiders likely know at least to some degree before the earnings announcement. Results show that the abnormal insider buy on the days with activist trading is solely driven by the subsample without positive SUE. In fact, within the subsample of positive SUE, there is no significant insider trade (buy or sell) on days when activists trade. It could be that insiders refrain from buying close to announcement of positive earnings news as it raises the burden to come clear of potential insider trading liability. Moreover, when there is information about strong firm fundamentals, it is difficult for insiders to discern activist trades from order flows which could be informed trading motivated by earnings.

[Insert Table 8 here.]

Another piece of fundamental information insiders potentially have is the potential for improvement if the company undergoes operational and governance reforms under activist pressure. Under this hypothesis, insiders may also be able to predict the stock return to the public disclosure of a Schedule 13D; which in turn implies that insiders purchase prior to Schedule 13D filing has predictive power on the Schedule 13D announcement returns. Table 9 puts such a prediction to test. In the table, the sample is the cross section of all Schedule 13D filings in our sample. The dependent variable is the stock return in excess of the market (defined as the value-weighted CRSP total market return) during the $[-5, +5]$ day window, where day 0 marks the filings of a Schedule 13D. The two key independent variables are *Excess insider buy*, which indicates whether insiders engage in abnormal share purchases during the 60-day window prior to 13D filing, and as a contrast, *Shortfall in insider sell*, which indicate cases when insiders engage in an abnormally small number of share sales during the 60-day window prior to 13D filing. Finally, the table reports results with and without controls of firm-level characteristic variables such as market capitalization.

[Insert Table 9 here.]

Column 1 shows that when insiders engage in excess share purchase during the [-60, -1] day window relative to the Schedule 13D filing, the Schedule 13D announcement return is on average 1.76% higher than returns to Schedule 13D filings before which insiders did not engage in excess purchase shares, and the effect is statistically significant at the 1% level. Equally informative is insider's selling behavior. Column 2 shows that when there is a shortfall in insider sales, the Schedule 13D announcement return is on average 0.97% lower than returns to Schedule 13D filings before which there was no shortfall in insider sales, and the effect is statistically significant at the 5% level.

Note that about 70% of the insider trading involves selling, as insiders like executives and directors need to dispose shares acquired via compensation in order to achieve liquidity and diversification. Hence, slowdown of selling is isomorphic to buying as they both reflect a desire to accumulate more shares. To this point, Fos and Jiang (2016) document that CEOs significantly slowdown share sales from option exercise when facing proxy contests. The duality also emerges in our setting: when anticipating a Schedule 13D filing with strong positive market reaction, insiders buy more *and* sell less during the 60 day window, which allowing them to ride market response to activism more profitably in addition to strengthening their own ownership stake, and bargaining and voting power vis-a-vis the activists at the gate.

Column (4) shows that the Schedule 13D announcement return is higher when activists accumulate a larger number of shares during the 60 day window. Specifically, the announcement returns are 0.18% percentage points higher when activists accumulate an additional 1% of shares outstanding. Finally, column (5) shows that our main findings hold when we include firm characteristics in the regression.

5. Conclusion

We show theoretically and empirically that corporate insiders are better equipped to detect activist trading than outsider investors prior to Schedule 13D filing. Whereas the existing literature shows that insiders have incentives to do so because they recognize their vulnerability from activist targeting and resort to various forms of defense (from poison pills to campaigning), this paper is the first to provide a novel channel, both theoretically and empirically, through which insiders can learn about and act on activist trading. Our key insight is that conditional on both insiders and outsiders observing the same order flows and trades, insiders have a more refined information filtration to isolate trades potentially generated by activist interests from those motivated by leakage of or speculations on firm fundamentals, such as earnings of the upcoming quarters. Whereas this paper is focused on the interaction between corporate insiders and activist investors, the implications apply to a general setting in which insiders obtain informational advantage via a better filtration of public information so that they are able to conduct informed trading that is not directly based on insider information.

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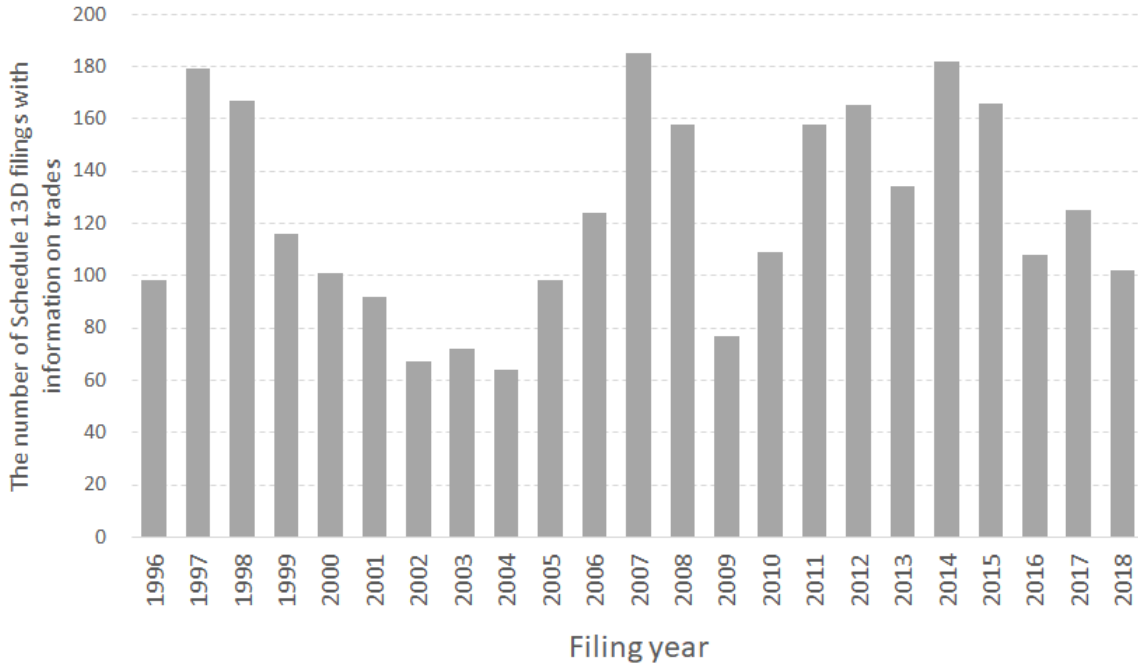

Figure 2: **Sample of Schedule 13D filings.** The figure reports the time-series distribution of 2,847 Schedule 13D filings that constitute our sample.

Table 1: **Variable Definitions.**

Variable	Definition
Insider trade	Equals one on days when an insider trades, and zero otherwise.
Insider buy	Equals one on days when an insider purchases shares, and zero otherwise.
Excess insider buy	Equals one if average of *Insider buy* during the 60-day window is higher than the average of *Insider buy* during the same calendar window one year prior to a Schedule 13D filing.
Insider sell	Equals one on days when an insider sells shares, and zero otherwise.
Shortfall in insider sell	Equals one if the average of insider sales during the 60-day window is lower than the average of insider sales during the same calendar window one year prior to a Schedule 13D filing.
Net insider sell	Equals one (minus one) on days when an insider sells (buys) shares, and zero otherwise.
SC13D 60-day window	Equals one during 60-day window prior to a Schedule 13D filing, and zero otherwise.
SC13D trade	Equals one on days when a Schedule 13D filer trades, and zero otherwise.
SC13D turnover	The ratio of number shares traded by a Schedule 13D filer to the number of shares outstanding.
SC13D turnover during SC13D 60-day window	The sum of *SC13D turnover* during 60-day window prior to a Schedule 13D filing.
Daily returns	Daily stock returns from CRSP.
Daily turnover	The ratio of daily trading volume to the number of shares outstanding.
Pre-SUE month	Equals one during 30-day window prior to earnings announcement, and zero otherwise.
Free trade	Equals one during [t+4,t+14] window around earnings announcement, and zero otherwise.
Not free trade	Equals one during [t-14,t+2] window around earnings announcement, and zero otherwise.
Market cap	Market capitalization, in $ millions.
Firm age	Number of years since the stock's first appearance on CRSP.
Q	The ratio of market value of assets to the book value of assets.
Previous year stock return	The arithmetic mean of the preceding calendar year's monthly returns.
Sales growth	Annual sales growth over the calendar year.
Amihud illiquidity	Average of all the calendar year's daily statistic: 1000*sqrt(abs(ret)/(abs(prc)*vol)).
Analyst	Number of IBES analyst covering the stock.

Table 2: **Summary statistics.** The table reports summary statistics. Panel A reports summary statistics in the full sample. Panel B reports summary statistics in the sub-sample of trading days when Schedule 13D filers trade. Panel C reports summary statistics in the sub-sample of trading days when insiders trade. All variables are defined in table 1.

Variable	N (1)	Mean (2)	STD (3)	p1 (4)	p25 (5)	p50 (6)	p75 (7)	p99 (8)
Panel A: Full sample								
Insider trade	31,899,356	2.97%	16.98%	0.00%	0.00%	0.00%	0.00%	100.00%
Insider buy	31,899,356	0.80%	8.92%	0.00%	0.00%	0.00%	0.00%	0.00%
Insider sell	31,899,356	2.16%	14.55%	0.00%	0.00%	0.00%	0.00%	100.00%
Insider net sell	31,899,356	1.36%	17.16%	0.00%	0.00%	0.00%	0.00%	100.00%
SC13D 60-day window	31,899,356	0.36%	6.02%	0.00%	0.00%	0.00%	0.00%	0.00%
SC13D trade	31,899,356	0.12%	3.43%	0.00%	0.00%	0.00%	0.00%	0.00%
SC13D turnover	31,899,356	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
Daily returns	31,363,966	0.04%	3.30%	-10.86%	-1.28%	0.00%	1.23%	12.60%
Daily turnover	31,371,402	0.63%	0.89%	0.00%	0.11%	0.32%	0.75%	5.54%
Pre-SUE month	31,899,356	19.36%	39.51%	0.00%	0.00%	0.00%	0.00%	100.00%
Free trade	31,899,356	7.13%	25.73%	0.00%	0.00%	0.00%	0.00%	100.00%
Not free trade	31,899,356	11.18%	31.51%	0.00%	0.00%	0.00%	0.00%	100.00%
Panel B: Days when Schedule 13D filers trade								
Insider trade	37,513	2.86%	16.68%	0.00%	0.00%	0.00%	0.00%	100.00%
Insider buy	37,513	1.22%	10.96%	0.00%	0.00%	0.00%	0.00%	100.00%
Insider sell	37,513	1.64%	12.69%	0.00%	0.00%	0.00%	0.00%	100.00%
Insider net sell	37,513	0.42%	16.88%	-100.00%	0.00%	0.00%	0.00%	100.00%
SC13D turnover	37,513	0.23%	0.34%	0.00%	0.03%	0.10%	0.26%	1.51%
Daily returns	37,495	0.24%	3.30%	-10.42%	-0.97%	0.00%	1.17%	12.60%
Daily turnover	37,495	1.23%	1.42%	0.02%	0.29%	0.68%	1.53%	5.54%
Pre SUE month	37,513	23.82%	42.60%	0.00%	0.00%	0.00%	0.00%	100.00%
Free trade	37,513	9.44%	29.25%	0.00%	0.00%	0.00%	0.00%	100.00%
Not free trade	37,513	14.17%	34.88%	0.00%	0.00%	0.00%	0.00%	100.00%
Panel C: Days when insiders trade								
Insider buy	947,758	26.97%	44.38%	0.00%	0.00%	0.00%	100.00%	100.00%
Insider sell	947,758	72.79%	44.50%	0.00%	0.00%	100.00%	100.00%	100.00%
SC13D 60-day window	947,758	0.28%	5.32%	0.00%	0.00%	0.00%	0.00%	0.00%
SC13D trade	947,758	0.11%	3.36%	0.00%	0.00%	0.00%	0.00%	0.00%
SC13D turnover	947,758	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
Daily returns	942,533	0.32%	3.29%	-9.87%	-1.11%	0.11%	1.57%	12.60%
Daily turnover	943,790	0.94%	1.10%	0.01%	0.26%	0.58%	1.15%	5.54%
Pre SUE month	947,758	11.28%	31.64%	0.00%	0.00%	0.00%	0.00%	100.00%
Free trade	947,758	20.36%	40.27%	0.00%	0.00%	0.00%	0.00%	100.00%
Not free trade	947,758	6.91%	25.37%	0.00%	0.00%	0.00%	0.00%	100.00%

Table 3: **Univariate analyses.** Panel A reports the average likelihood of insider buy, insider sell, and the average of insider net sell. The unit of observation is firm-trading day. In Panel B, we compare these likelihoods during the 60-day window prior to Schedule 13D filing and trading days outside this window. In panel C the analysis is restricted to the 60-day window prior to Schedule 13D filing and compares the averages during the first 50 days and the last 10 days of that window. In panel C the analysis is restricted to the 60-day window prior to Schedule 13D filing and compares the averages on days when Schedule 13D filers trade and on days when they do not trade.

Transaction type:	Insider buy (1)	Insider sell (2)	Insider net sell (3)
Panel A			
Average	0.80%	2.16%	1.36%
N	31,899,356	31,899,356	31,899,356
Panel B			
SC13D 60-day window	0.93%	1.39%	0.46%
N	115,841	115,841	115,841
Outside SC13D 60-day window	0.80%	2.17%	1.36%
N	31,783,515	31,783,515	31,783,515
difference	0.12%	-0.78%	-0.90%
t-statistic	4.17	-22.49	-20.13
Panel C: SC13D 60-day window			
Last 10 days	1.27%	1.63%	0.36%
N	19,143	19,143	19,143
First 50 days	0.86%	1.34%	0.48%
N	96,698	96,698	96,698
difference	0.41%	0.29%	-0.12%
t-statistic	4.78	2.91	0.92
Panel D: SC13D 60-day window			
SC13D trade = 1	1.22%	1.64%	0.48%
N	78,328	78,328	78,328
SC13D trade = 0	0.79%	1.27%	0.42%
N	37,513	37,513	37,513
difference	0.43%	0.37%	0.06%
t-statistic	6.62	4.76	0.60

Table 4: **Insider trading prior to Schedule 13D filings.** The table reports estimates of regression (10): $y_{it} = \alpha_i + \alpha_{ym} + \gamma_1 \textit{SC13D 60-day window}_{it} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}$, where y_{it} is a measure of insider trading activity on day t for firm i, α_i are firm fixed effects, α_{ym} are year-month fixed effects, *SC13D 60-day window* is an indicator of the 60-day window prior to Schedule 13D filings, $Return_{it}$ is stock return on day t for firm i, and $Turnover\ rate_{it}$ is share turnover rate on day t for firm i. Sample covers all firm-trading day observations during 1996-2018. All variables are defined in table 1. Standard errors are reported in brackets and are clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable:	Insider buy		Insider sell		Insider net sell	
	(1)	(2)	(3)	(4)	(5)	(6)
SC13D 60-day window	0.0006	0.0002	-0.0077***	-0.0091***	-0.0083***	-0.0093***
	[0.0005]	[0.0005]	[0.0008]	[0.0008]	[0.0010]	[0.0010]
Return		0.0070***		0.0529***		0.0459***
		[0.0009]		[0.0015]		[0.0018]
Turnover rate		0.2182***		0.6866***		0.4684***
		[0.0058]		[0.0174]		[0.0184]
R^2	0.017	0.018	0.045	0.046	0.039	0.039
N	31,899,356	31,363,930	31,899,356	31,363,930	31,899,356	31,363,930
Fixed effects:						
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year-Month	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: **Do insiders trade when Schedule 13D filers trade?** The table reports of regression (11): $y_{it} = \alpha_i + \alpha_{ym} + \alpha_{iym} + \gamma_1 SC13D\ trade_{it} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}$, where y_{it} is a measure of insider trading activity on day t for firm i, α_i are firm fixed effects, α_{ym} are year-month fixed effects, α_{iym} are firm-year-month fixed effects, $SC13D\ trade$ is an indicator of days when Schedule 13D filers trade, $Return_{it}$ is stock return on day t for firm i, and $Turnover\ rate_{it}$ is share turnover rate on day t for firm i. Sample covers all firm-trading day observations during the 60-day window prior to Schedule 13D filings. All variables are defined in table 1. Standard errors are clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable:		Insider buy			Insider sell			Insider net sell	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SC13D trade	0.0077***	0.0062***	0.0069***	0.0027**	0.0004	0.0002	-0.0050***	-0.0057***	-0.0066***
	[0.0015]	[0.0014]	[0.0016]	[0.0011]	[0.0011]	[0.0012]	[0.0018]	[0.0018]	[0.0020]
Return		0.0165	0.0130		0.0248**	0.0214*		0.0083	0.0086
		[0.0110]	[0.0106]		[0.0115]	[0.0113]		[0.0162]	[0.0157]
Turnover rate		0.2868***	0.2167***		0.4135***	0.4476***		0.1267*	0.2299***
		[0.0411]	[0.0430]		[0.0625]	[0.0661]		[0.0757]	[0.0802]
R^2	0.097	0.098	0.193	0.131	0.132	0.228	0.119	0.119	0.213
N	115,800	115,712	115,499	115,800	115,712	115,499	115,800	115,712	115,459
Fixed effects:									
Firm	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Year-Month	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Firm-Year-Month	No	No	Yes	No	No	Yes	No	No	Yes

Table 6: **Insider trading restrictions.** The table repeats analysis in table 5, while adding the following control variables to the regression: *Free trade*, which equals one during [t+4,t+14] window around earnings announcement, and zero otherwise, *No free trade*, which equals one during [t-14,t+2] window around earnings announcement, and zero otherwise, and *Pre-SUE month*, which equals one during 30-day window prior to earnings announcement, and zero otherwise. Sample covers all firm-trading day observations during the 60-day window prior to Schedule 13D filings. All variables are defined in table 1. Standard errors are clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable:	Insider buy		Insider sell		Insider net sell	
	(1)	(2)	(3)	(4)	(5)	(6)
SC13D trade	0.0066***	0.0065***	0.0000	-0.0001	-0.0066***	-0.0066***
	[0.0016]	[0.0015]	[0.0012]	[0.0012]	[0.0020]	[0.0020]
Return	0.0123	0.0128	0.0206*	0.0210*	0.0082	0.0083
	[0.0106]	[0.0106]	[0.0113]	[0.0113]	[0.0157]	[0.0157]
Turnover rate	0.2249***	0.2108***	0.4588***	0.4434***	0.2339***	0.2326***
	[0.0431]	[0.0427]	[0.0660]	[0.0662]	[0.0802]	[0.0802]
Free trade	0.0156***	0.0143***	0.0083***	0.0068**	-0.0074*	-0.0075*
	[0.0027]	[0.0027]	[0.0028]	[0.0028]	[0.0040]	[0.0040]
Not free date	-0.0058***	-0.0045***	-0.0101***	-0.0087***	-0.0043*	-0.0042*
	[0.0015]	[0.0014]	[0.0020]	[0.0020]	[0.0024]	[0.0024]
Pre-SUE month		-0.0061***		-0.0067***		-0.0006
		[0.0016]		[0.0017]		[0.0023]
R^2	0.195	0.195	0.229	0.229	0.213	0.213
N	115,459	115,459	115,459	115,459	115,459	115,459
Fixed effects:						
Firm-Year-Month	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: **Dynamic relationship between insider and Schedule 13D trading.** Panel A reports estimates of regression (12): $y_{it} = \alpha_{iym} + \sum_{\tau=-5}^{5} \gamma_{1,\tau} SC13D\ trade_{it+\tau} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}$, where $SC13D\ trade_{it+\tau}$ is an indicator of τ days after day when a Schedule 13D filer trades. All other variables are as in table 5. Panel B reports estimates of regression (13): $SC13D\ trade_{it} = \alpha_{iym} + \sum_{\tau=-5}^{5} \gamma_{1,\tau} Insider\ trade_{it+\tau} + \gamma_2 Return_{it} + \gamma_3 Turnover\ rate_{it} + \varepsilon_{it}$, where $Insider\ trade_{it+\tau}$ is an indicator of τ days after day when an insider trades. All other variables are as in Panel A. Sample covers all firm-trading day observations during the 60-day window prior to Schedule 13D filings. All variables are defined in table 1. Standard errors are clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A

Dependent variable:	Insider buy (1)	Insider sell (2)	Insider net sell (3)
SC13D trade (t-5)	0.0003	-0.0008	-0.0011
	[0.0008]	[0.0010]	[0.0012]
SC13D trade (t-4)	0.0007	-0.0013	-0.0021*
	[0.0008]	[0.0009]	[0.0012]
SC13D trade (t-3)	0.0002	-0.0001	-0.0004
	[0.0009]	[0.0009]	[0.0013]
SC13D trade (t-2)	-0.0005	-0.0004	0.0001
	[0.0007]	[0.0009]	[0.0012]
SC13D trade (t-1)	-0.0001	0.0013	0.0015
	[0.0008]	[0.0009]	[0.0012]
SC13D trade (t)	0.0068***	0.0003	-0.0064***
	[0.0015]	[0.0011]	[0.0019]
SC13D trade (t+1)	-0.0005	-0.0018*	-0.0012
	[0.0009]	[0.0009]	[0.0013]
SC13D trade (t+2)	0.0005	-0.0006	-0.0013
	[0.0008]	[0.0009]	[0.0012]
SC13D trade (t+3)	0.0018**	0.0005	-0.0012
	[0.0008]	[0.0009]	[0.0012]
SC13D trade (t+4)	-0.0002	-0.0002	0.0000
	[0.0008]	[0.0010]	[0.0013]
SC13D trade (t+5)	-0.0001	0.0003	0.0004
	[0.0008]	[0.0010]	[0.0013]
Return	0.0124	0.0211*	0.0089
	[0.0106]	[0.0114]	[0.0157]
Turnover rate	0.2204***	0.4578***	0.2365***
	[0.0435]	[0.0668]	[0.0810]
R^2	0.191	0.228	0.212
N	115,110	115,110	115,110
Fixed effects:			
Firm-Year-Month	Yes	Yes	Yes

(Table continues...)

Table 7: continued

Panel B

Dependent variable:	SC13 trade (1)
Insider trade day (t-5)	0.0030
	[0.0088]
Insider trade day (t-4)	0.0001
	[0.0085]
Insider trade day (t-3)	0.0130
	[0.0084]
Insider trade day (t-2)	0.0029
	[0.0087]
Insider trade day (t-1)	-0.0006
	[0.0093]
Insider trade day (t)	0.0475***
	[0.0128]
Insider trade day (t+1)	0.0131
	[0.0091]
Insider trade day (t+2)	0.0023
	[0.0087]
Insider trade day (t+3)	0.0083
	[0.0094]
Insider trade day (t+4)	0.0042
	[0.0087]
Insider trade day (t+5)	0.0029
	[0.0092]
Return	0.1356***
	[0.0413]
Turnover rate	11.0502***
	[0.2301]
R^2	0.427
N	115,070
Fixed effects:	
Firm-Year-Month	Yes

Table 8: **The role of upcoming earnings sunrises.** This table repeats the analyses in table 5, while considering the effect of insider trading restrictions during 30-day period prior to earnings announcements. All variables are defined in table 1. In column 1, sample covers all firm-trading day observations during the 60-day window prior to Schedule 13D filings. In column 2, sample is limited to 30-day periods prior to positive earnings surprises during the 60-day window prior to Schedule 13D filings. Earnings surprise is the difference between the actual EPS and the median EPS forecast in the one-quarter period before the earnings announcement (source: IBES). In column 3, sample excludes 30-day periods prior to positive earnings surprises during the 60-day window prior to Schedule 13D filings. Panel A reports the results for *Insider buy*, panel B reports the results for *Insider sell*, and panel C reports the results for *Insider net sell*. Standard errors are clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Sample:	Full sample (1)	Positive SUE sample (2)	Drop positive SUE sample (3)
Panel A: Insider buy			
SC13D trade	0.0068***	0.0010	0.0071***
	[0.0016]	[0.0017]	[0.0016]
Return	0.0128	-0.0253*	0.0128
	[0.0106]	[0.0135]	[0.0117]
Turnover rate	0.2177***	0.0339	0.2186***
	[0.0431]	[0.0832]	[0.0483]
R^2	0.193	0.346	0.207
N	115,459	13,614	101,673
Panel B: Insider sell			
SC13D trade	0.0002	0.0002	0.0003
	[0.0012]	[0.0028]	[0.0013]
Return	0.0214*	-0.0073	0.0240**
	[0.0113]	[0.0273]	[0.0120]
Turnover rate	0.4476***	0.4286**	0.4440***
	[0.0661]	[0.1919]	[0.0693]
R^2	0.228	0.237	0.245
N	115,459	13,614	101,673
Panel C: Insider net sell			
SC13D trade	-0.0066***	-0.0009	-0.0068***
	[0.0020]	[0.0033]	[0.0021]
Return	0.0086	0.0180	0.0112
	[0.0157]	[0.0304]	[0.0169]
Turnover rate	0.2299***	0.3947*	0.2254***
	[0.0802]	[0.2094]	[0.0858]
R^2	0.213	0.267	0.228
N	115,459	13,614	101,673
Fixed effects:			
Firm-Year-Month	Yes	Yes	Yes

Table 9: **Activism CARs and changes in insider ownership.** This table reports estimates of cross-sectional regressions, where the dependent variable is the stock return in excess of the market (defined as the value-weighted CRSP total market return) during the $[-5, +5]$ day window, where day 0 marks the filings of a Schedule 13D. All variables are defined in table 1. Firm characteristics are measures at the end of the fiscal year that precedes a Schedule 13D filing. Heteroscedasticity robust standard errors are reported in brackets. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable: Schedule 13D filing CAR	(1)	(2)	(3)	(4)	(5)
Excess insider buy	0.0176***		0.0171***	0.0180***	0.0142**
	[0.0054]		[0.0054]	[0.0054]	[0.0057]
Shortfall in insider sell		0.0097**	0.0092**	0.0083**	0.0076*
		[0.0038]	[0.0038]	[0.0038]	[0.0042]
SC13D turnover during SC13D 60-day window				0.1723**	0.1822**
				[0.0746]	[0.0826]
Market cap (lagged log)					-0.0011
					[0.0020]
Firm age (lagged)					-0.0002
					[0.0001]
Q (lagged)					-0.0014
					[0.0010]
Previous year stock return					-0.2118***
					[0.0560]
Sales growth (lagged)					0.0022
					[0.0035]
Amihud illiquidity (lagged)					-0.0013
					[0.0054]
Analyst (lagged)					0.0001
					[0.0003]
Constant	0.0254***	0.0252***	0.0232***	0.0179***	0.0328***
	[0.0018]	[0.0020]	[0.0020]	[0.0028]	[0.0114]
R^2	0.004	0.002	0.006	0.009	0.021
N	2,823	2,823	2,823	2,823	2,449

Internal Appendix for the paper

"Insider Trading Ahead of Barbarians' Arrival at the Gate: Insider Trading on Non-Insider Information"

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Appendix A: Proofs

Proof of Proposition 1. There are 4 possible combinations $\theta_A^* + \theta_{N,0} \in \{-\bar{\theta}, 0, \bar{\theta}, 2\bar{\theta}\}$. Assume that the trading strategy of the activist is given by equation (7). Note that two states $\theta_A^* + \theta_{N,0} \in \{-\bar{\theta}, 2\bar{\theta}\}$ are fully revealing because $\theta_A^* \in \{0, \bar{\theta}\}$. In particular, $\theta_A^* + \theta_{N,0} = -\bar{\theta}$ implies that $\theta_A^* = 0$, and hence, from equation (7), we observe that the latter trading strategy implies $\nu = 0$. Consequently, the market maker sets the price equal to $p(-\bar{\theta}) = D_L = 0$. Similarly, $\theta_A^* + \theta_{N,0} = 2\bar{\theta}$ implies that $\theta_A^* = \bar{\theta}$, and hence, from equation (7) $\nu = 1$ and

$$P(2\bar{\theta}) = \mathbb{E}[D_2 = D_H | \nu = 1] + \psi\bar{\theta} = \frac{D_H \eta_1}{\eta_1 + \eta_2} + \psi\bar{\theta}.$$

Suppose, $\theta_A^* + \theta_{N,0} = 0$. We note the following conditional probabilities.

$$\begin{aligned} \text{Prob}(\theta_{N,0} = -\bar{\theta} | \theta_A = \bar{\theta}) &= \text{Prob}(\theta_{N,0} = -\bar{\theta} | \theta_A = \bar{\theta}, D_H)\,\text{Prob}(D_H | \theta_A = \bar{\theta}) \\ &\quad + \text{Prob}(\theta_{N,0} = -\bar{\theta} | \theta_A = \bar{\theta}, D_L)\,\text{Prob}(D_L | \theta_A = \bar{\theta}) \\ &= \frac{\pi_{-1}^H \eta_1 + \pi_{-1}^L \eta_2}{\eta_1 + \eta_2}. \end{aligned} \tag{A1}$$

This is because $\text{Prob}(D_H | \theta_A = \bar{\theta}) = \text{Prob}(D_H | \nu = 1)$ since $\theta_A = \bar{\theta}$ is observed if and only if $\nu = 1$. Then, from equations (1) we observe that $\text{Prob}(D_H | \nu = 1) = \eta_2 / (\eta_1 + \eta_2)$. $\text{Prob}(D_H | \theta_A = \bar{\theta})$ is computed in a similar way. Next probability is computed similarly:

$$\begin{aligned} \text{Prob}(\theta_{N,0} = 0 | \theta_A = 0) &= \text{Prob}(\theta_{N,0} = 0 | \theta_A = 0, D_H)\,\underbrace{\text{Prob}(D_H | \theta_A = 0)}_{=0} \\ &\quad + \text{Prob}(\theta_{N,0} = 0 | \theta_A = 0, D_L)\,\underbrace{\text{Prob}(D_L | \theta_A = 0)}_{=1} \\ &= 0 + \pi_0^L = \pi_0^L. \end{aligned} \tag{A2}$$

Using the latter two equations (A1) and (A2), we obtain:

$$\operatorname{Prob}(\theta_A = \bar{\theta} | \theta_A + \theta_{N,0} = 0) = \frac{\operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | \theta_A = \bar{\theta}) \operatorname{Prob}(\theta_A = \bar{\theta})}{\operatorname{Prob}(\theta_A + \theta_{N,0} = 0)}$$

$$= \frac{\operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | \theta_A = \bar{\theta}) \operatorname{Prob}(\theta_A = \bar{\theta})}{\operatorname{Prob}(\theta_{N,0} = -\bar{\theta} | \theta_A = \bar{\theta}) \operatorname{Prob}(\theta_A = \bar{\theta}) + \operatorname{Prob}(\theta_{N,0} = 0 | \theta_A = 0) \operatorname{Prob}(\theta_A = 0)}$$

$$= \frac{\pi^H_{-1}\eta_1 + \pi^L_{-1}\eta_2}{\pi^H_{-1}\eta_1 + \pi^L_{-1}\eta_2 + \pi^L_0\eta_3}.$$

Here we used that $\operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | \theta_A = \bar{\theta}) = \operatorname{Prob}(\theta_{N,0} = -\bar{\theta} | \theta_A = \bar{\theta})$, and then use equation (A1).

Next, we compute the conditional probability $\operatorname{Prob}(D_H | \theta_A + \theta_{N,0})$. Before that, we compute two auxiliary probabilities below.

$$\operatorname{Prob}(\theta_{N,0} = -\bar{\theta} | D_H) = \pi^H_{-1}. \tag{A3}$$

$$\begin{aligned} \operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | D_L) &= \operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | D_L, \theta_A = \bar{\theta}) \operatorname{Prob}(\theta_A = \bar{\theta} | D_L) \\ &\quad + \operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | D_L, \theta_A = 0) \operatorname{Prob}(\theta_A = 0 | D_L) \\ &= \frac{\pi^L_{-1}\eta_2 + \pi^L_0\eta_3}{\eta_2 + \eta_3}. \end{aligned} \tag{A4}$$

Using the latter two equations (A3) and (A4), we obtain:

$$\begin{aligned} \operatorname{Prob}(D_H | \theta_A + \theta_{N,0} = 0) &= \frac{\operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | D_H)\pi_D}{\operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | D_H)\pi_D + \operatorname{Prob}(\theta_A + \theta_{N,0} = 0 | D_L)(1 - \pi_D)} \\ &= \frac{\pi^H_{-1}\pi_D}{\pi^H_{-1}\pi_D + \pi^L_{-1}\eta_2 + \pi^L_0\eta_3}. \end{aligned}$$

Using probabilities $\operatorname{Prob}(D_H | \theta_A + \theta_{N,0} = 0)$ and $\operatorname{Prob}(\theta_A = \bar{\theta} | \theta_A + \theta_{N,0} = 0)$, we obtain:

$$\begin{aligned} P(0) &= D_H \operatorname{Prob}(D_H | \theta_A + \theta_{N,0} = 0) + \psi\bar{\theta} \operatorname{Prob}(\theta_A = \bar{\theta} | \theta_A + \theta_{N,0} = 0) \\ &= \frac{D_H \pi^H_{-1}\pi_D}{\pi^H_{-1}\pi_D + \pi^L_{-1}\eta_2 + \pi^L_0\eta_3} + \psi\bar{\theta}\frac{\pi^H_{-1}\eta_1 + \pi^L_{-1}\eta_2}{\pi^H_{-1}\eta_1 + \pi^L_{-1}\eta_2 + \pi^L_0\eta_3}. \end{aligned}$$

Price $P(\bar{\theta})$ can be found analogously.

Now, we derive constant d such that the trading strategy is the equilibrium when $\bar{\theta} \geq d$. Rewrite the price function (8) as follows

$$p_1(x) = \begin{cases} 0, & x = -\bar{\theta}; \\ D_H a_0 + \psi\bar{\theta} b_0, & x = 0 \\ D_H a_1 + \psi\bar{\theta} b_1, & x = \bar{\theta} \\ D_H a_2 + \psi\bar{\theta} b_2, & x = 2\bar{\theta}, \end{cases} \tag{A5}$$

where a_k and b_k are coefficients that match the corresponding coefficients in (8). Substituting (A5) and (7) into the activist's optimization problem (3), we obtain the following conditions for (7) to be the equilibrium strategy:

$$\begin{aligned} D_H + \psi\bar{\theta} &\geq D_H \mathbb{E}^H[a] + \psi\bar{\theta}\mathbb{E}[b] \quad (\theta_A = \bar{\theta} \text{ is optimal when } \ D_2 = D_H), \\ \psi\bar{\theta} &\geq D_H \mathbb{E}^L[a] + \psi\bar{\theta}\mathbb{E}^L[b] \quad (\theta_A = \bar{\theta} \text{ is optimal when } \ D_2 = D_L, \nu = 1), \\ 0 &\leq D_H \mathbb{E}^L[a] + \psi\bar{\theta}\mathbb{E}^L[b] \quad (\theta_A = 0 \text{ is optimal when } \ D_2 = D_L, \nu = 0), \end{aligned}$$

where $\mathbb{E}^s[x] = \pi^s_{-1} x_0 + \pi^s_0 x_1 + \pi^2_1 x_2$, $s = H, L$. The first and third of the above inequalities are always satisfied because $0 < a_k \leq 1$ and $0 < b_k \leq 1$. From the second inequality we then obtain that

$$\bar{\theta} \geq d D_H, \quad d = \frac{\mathbb{E}^L[a]}{1 - \mathbb{E}^L[b]} \frac{1}{\psi}. \quad \blacksquare \tag{A6}$$

Proof of Proposition 2. Take trading strategies (7) and (9) as given. Then, we show that the price function $p_2(x,y)$ is given by:

$$
p_2(x,y) =
$$

$$
\begin{cases}
0, & y=-\bar{\theta}; \\
\psi\bar{\theta}\frac{\pi^L_{-1}\eta_2}{\pi^L_{-1}\eta_2+\pi^L_0\eta_3}, & x=-2\tilde{\theta}, y=0; \\
D_H\frac{\tilde{\pi}^H_i\pi^H_{-1}\pi_D}{\tilde{\pi}^H_i\pi^H_{-1}\pi_D+\tilde{\pi}^L_{i+1}(1-\pi_D)\frac{\pi^L_{-1}\eta_2+\pi^L_0\eta_3}{\eta_2+\eta_3}} & \\
\quad +\psi\bar{\theta}\frac{(\pi^H_{-1}\pi_D+\pi^L_{-1}(1-\pi_D))(\eta_1+\eta_2)}{(\pi^H_{-1}\pi_D+\pi^L_{-1}(1-\pi_D))(\eta_1+\eta_2)+(\pi^H_0\pi_D+\pi^L_0(1-\pi_D))\eta_3}\frac{\tilde{\pi}^H_i v_0+\tilde{\pi}^L_{i+1}(1-v_0)}{\tilde{\pi}^H_i u_0+\tilde{\pi}^L_{i+1}(1-u_0)}, & x=i\tilde{\theta}, y=0; \\
D_H+\psi\bar{\theta}, & x=\tilde{\theta}, y=0; \\
\psi\bar{\theta}\frac{\pi^L_0\eta_2}{\pi^L_0\eta_2+\pi^L_1\eta_3}, & x=-2\tilde{\theta}, y=\bar{\theta}; \\
D_H\frac{\tilde{\pi}^H_j\pi^H_0\pi_D}{\tilde{\pi}^H_j\pi^H_0\pi_D+\tilde{\pi}^L_j(1-\pi_D)\frac{\pi^L_0\eta_2+\pi^L_1\eta_3}{\eta_2+\eta_3}} & \\
\quad +\psi\bar{\theta}\frac{(\pi^H_0\pi_D+\pi^L_0(1-\pi_D))(\eta_1+\eta_2)}{(\pi^H_0\pi_D+\pi^L_0(1-\pi_D))(\eta_1+\eta_2)+(\pi^H_1\pi_D+\pi^L_1(1-\pi_D))\eta_3}\frac{\tilde{\pi}^H_j v_1+\tilde{\pi}^L_j(1-v_1)}{\tilde{\pi}^H_j u_1+\tilde{\pi}^L_j(1-u_1)}, & x=j\tilde{\theta}, y=\bar{\theta}; \\
\psi\bar{\theta}, & x=-2\tilde{\theta}, y=2\bar{\theta}; \\
D_H\frac{\tilde{\pi}^H_i\pi^H_1\pi_D}{\tilde{\pi}^H_i\pi^H_1\pi_D+\tilde{\pi}^L_{i+1}\pi^L_1\frac{\eta_2}{\eta_2+\eta_3}(1-\pi_D)}+\psi\bar{\theta}, & x=i\tilde{\theta}, y=2\bar{\theta}, \\
D_H+\psi\bar{\theta}, & x=\tilde{\theta}, y=2\bar{\theta},
\end{cases}
\tag{A7}
$$

where $i=-1,0$ and $j=-1,0,1$, and u_k and v_k are given by:

$$
u_k \quad = \quad = \text{Prob}(D_H|\theta_A+\theta_{N,0}=k\bar{\theta}) = \frac{\pi^H_{k-1}\pi_D}{\pi^H_{k-1}\pi_D+\pi^L_{k-1}\eta_2+\pi^L_k\eta_3}, \tag{A8}
$$

$$
v_k \quad = \quad = \text{Prob}(D_H|\theta_A+\theta_{N,0}=k\bar{\theta},\theta_A=\bar{\theta}) = \frac{\pi^H_{k-1}\pi_D}{\pi^H_{k-1}\pi_D+\pi^L_{k-1}\eta_2}, \tag{A9}
$$

for $k=0,1$. Equations (A8) and (A9) can be derived using Bayes' theorem, and the derivation is omitted for brevity.

We provide the derivation of the price function only for the case $x=i\tilde{\theta}$, $y=0$. All other cases can be studied analogously. First, we need to find two conditional probabilities: $\text{Prob}(D_2=D_H|\theta_I+\tilde{\theta}_{N,1}=$

$i\tilde{\theta}, \theta_A + \theta_{N,0} = 0)$ and $\text{Prob}(\theta_A = \bar{\theta} | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0)$.

$$\text{Prob}(D_2 = D_H | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0) =$$

$$\frac{\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0 | D_H)\pi_D}{\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0 | D_H)\pi_D + \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0 | D_L)(1 - \pi_D)} \tag{A10}$$

$$\frac{\text{Prob}(\tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_{N,0} = -\bar{\theta} | D_H)\pi_D}{\text{Prob}(\tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_{N,0} = -\bar{\theta} | D_H)\pi_D + \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0 | D_L)(1 - \pi_D)},$$

where the third line of derivations uses the fact that $\theta_I = 0$ and $\theta_A = \bar{\theta}$ when $D_2 = D_H$. In the latter equation,

$$\text{Prob}(\tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_{N,0} = -\bar{\theta} | D_H) = \tilde{\pi}_i^H \pi_{-1}^H, \tag{A11}$$

because $\theta_{N,0}$ and $\tilde{\theta}_{N,1}$ are uncorrelated conditional on D_H. Moreover,

$$\begin{aligned}
&\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0 | D_L) \\
&= \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, D_L)\, \text{Prob}(\theta_A + \theta_{N,0} = 0 | D_L) \\
&= \text{Prob}(\tilde{\theta}_{N,1} = (i+1)\tilde{\theta} | D_L) \Big[\text{Prob}(\theta_A + \theta_{N,0} = 0 | \nu = 1, D_L)\, \text{Prob}(\nu = 1 | D_L) + \\
&\quad \text{Prob}(\theta_A + \theta_{N,0} = 0 | \nu = 0, D_L)\, \text{Prob}(\nu = 0 | D_L) \Big] \\
&= \tilde{\pi}_{i+1}^L \Big[\tilde{\pi}_{-1}^L \frac{\eta_2}{\eta_2 + \eta_3} + \tilde{\pi}_0^L \frac{\eta_3}{\eta_2 + \eta_3} \Big].
\end{aligned} \tag{A12}$$

Here we used the fact that $\theta_I = -\tilde{\theta}$ when $D_2 = D_L$ and $\theta_A + \theta_{N,0} = 0$.

Substituting (A11) and (A12) into (A10), we obtain:

$$\text{Prob}(D_2 = D_H | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0) = \frac{\tilde{\pi}_i^H \pi_{-1}^H \pi_D}{\tilde{\pi}_i^H \pi_{-1}^H \pi_D + \tilde{\pi}_{i+1}^L (1 - \pi_D) \frac{\pi_{-1}^L \eta_2 + \pi_0^L \eta_3}{\eta_2 + \eta_3}}. \tag{A13}$$

Next, we compute the conditional probability

$$
\begin{aligned}
&\text{Prob}(\theta_A = \bar{\theta} | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0) \\
&= \frac{\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) \,\text{Prob}(\theta_A = \bar{\theta} | \theta_A + \theta_{N,0} = 0)}{\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0)}.
\end{aligned} \tag{A14}
$$

In the above equation (A14),

$$
\begin{aligned}
&\text{Prob}(\theta_A = \bar{\theta} | \theta_A + \theta_{N,0} = 0) = \frac{\text{Prob}(\theta_A + \theta_{N,0} = 0 | \theta_A = \bar{\theta}) \,\text{Prob}(\theta_A = \bar{\theta})}{\text{Prob}(\theta_{N,0} = -\bar{\theta}) \,\text{Prob}(\theta_A = \bar{\theta}) + \text{Prob}(\theta_{N,0} = 0) \,\text{Prob}(\theta_A = 0)} \\
&= \frac{(\pi_{-1}^H \pi_D + \pi_{-1}^L (1 - \pi_D))(\eta_1 + \eta_2)}{(\pi_{-1}^H \pi_D + \pi_{-1}^L (1 - \pi_D))(\eta_1 + \eta_2) + (\pi_0^H \pi_D + \pi_0^L (1 - \pi_D))\eta_3}.
\end{aligned} \tag{A15}
$$

$$
\begin{aligned}
&\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) = \\
&= \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}, D_H) \,\text{Prob}(D_H | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) \\
&+ \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}, D_L) \,\text{Prob}(D_L | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) \\
&= \text{Prob}(\tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}, D_H) \,\text{Prob}(D_H | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) \\
&+ \text{Prob}(\tilde{\theta}_{N,1} = (i+1)\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}, D_L) \,\text{Prob}(D_L | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) \\
&= \tilde{\pi}_i^H v_0 + \tilde{\pi}_{i+1}^L (1 - v_0),
\end{aligned} \tag{A16}
$$

where v_0 is given by equation (A9). The last equation again uses the fact that D_H and D_L provide most complete information needed to compute $\tilde{\theta}_{N,1}$. No other variable provides additional information.

$$
\begin{aligned}
&\text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0) = \\
&= \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, D_H)\,\text{Prob}(D_H | \theta_A + \theta_{N,0} = 0) \\
&+ \text{Prob}(\theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, D_L)\,\text{Prob}(D_L | \theta_A + \theta_{N,0} = 0) \\
&= \text{Prob}(\tilde{\theta}_{N,1} = i\tilde{\theta} | \theta_A + \theta_{N,0} = 0, D_H)\,\text{Prob}(D_H | \theta_A + \theta_{N,0} = 0) \\
&+ \text{Prob}(\tilde{\theta}_{N,1} = (i+1)\tilde{\theta} | \theta_A + \theta_{N,0} = 0, \theta, D_L)\,\text{Prob}(D_L | \theta_A + \theta_{N,0} = 0, \theta_A = \bar{\theta}) \\
&= \tilde{\pi}_i^H u_0 + \tilde{\pi}_{i+1}^L (1 - u_0),
\end{aligned}
\tag{A17}
$$

where u_0 is given by equation (A8).

Substituting probabilities (A15)–(A17) into (A14), we obtain:

$$
\begin{aligned}
&\text{Prob}(\theta_A = \bar{\theta} | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0) = \\
&\frac{(\pi_{-1}^H \pi_D + \pi_{-1}^L (1 - \pi_D))(\eta_1 + \eta_2)}{(\pi_{-1}^H \pi_D + \pi_{-1}^L (1 - \pi_D))(\eta_1 + \eta_2) + (\pi_0^H \pi_D + \pi_0^L (1 - \pi_D))\eta_3} \frac{\tilde{\pi}_i^H v_0 + \tilde{\pi}_{i+1}^L (1 - v_0)}{\tilde{\pi}_i^H u_0 + \tilde{\pi}_{i+1}^L (1 - u_0)}.
\end{aligned}
\tag{A18}
$$

The price is given by

$$
P(i\tilde{\theta}, 0) = \mathbb{E}[D_2 | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0)] + \psi\bar{\theta}\mathbb{E}[\theta_A | \theta_I + \tilde{\theta}_{N,1} = i\tilde{\theta}, \theta_A + \theta_{N,0} = 0)].
$$

Substituting (A13) and (A18) into the above equation, we obtain the third line of the price function (A7). Other cases are considered analogously.

Finding $\hat{\theta}_{\mathbf{A}} = \mathbb{E}[\theta^*_{\mathbf{A}} | \mathbf{D_2}, \theta^*_{\mathbf{A}} + \theta_{\mathbf{N.0}}]$. Solving the optimization problem of the insider also requires the knowledge of $\widehat{\theta}_A = \mathbb{E}[\theta_A | D_2, \theta_A + \theta_{N,0}]$, which is the insider's expectation of the activist's optimal strategy. From the equation (7) for θ_A, it can be easily observed that $\mathbb{E}[\theta_A | D_H] = \bar{\theta}$, $\mathbb{E}[\theta_A | D_L, 2\bar{\theta}] = \bar{\theta}$, $\mathbb{E}[\theta_A | D_L, -\bar{\theta}] = 0$. It remains to compute $\mathbb{E}[\theta_A | D_L, \theta_A + \theta_{N,0} = 0]$ and $\mathbb{E}[\theta_A | D_L, \theta_A + \theta_{N,0} = \bar{\theta}]$. We show

how to calculate the first of these expectations, and the second can be computed analogously.

$$\begin{aligned}
&\text{Prob}(\theta_A = \bar{\theta}|D_L, \theta_A + \theta_{N,0} = 0) = \\
&\frac{\text{Prob}(\theta_A + \theta_{N,0} = 0|D_L, \theta_A = \bar{\theta})\,\text{Prob}(\theta_A = \bar{\theta}|D_L)}{\text{Prob}(\theta_A + \theta_{N,0} = 0|D_L, \theta_A = \bar{\theta})\,\text{Prob}(\theta_A = \bar{\theta}|D_L) + \text{Prob}(\theta_A + \theta_{N,0} = 0|D_L, \theta_A = 0)\,\text{Prob}(\theta_A = 0|D_L)} \\
&= \frac{\text{Prob}(\theta_{N,0} = -\bar{\theta}|D_L)\,\text{Prob}(\theta_A = \bar{\theta}|D_L)}{\text{Prob}(\theta_{N,0} = -\bar{\theta}|D_L)\,\text{Prob}(\theta_A = \bar{\theta}|D_L) + \text{Prob}(\theta_{N,0} = 0|D_L)\,\text{Prob}(\theta_A = 0|D_L)} \\
&= \frac{\pi_{-1}^L \eta_2}{\pi_{-1}^L \eta_2 + \pi_0^L \eta_3}.
\end{aligned} \tag{A19}$$

Consequently,

$$\mathbb{E}[\theta_A = \bar{\theta}|D_L, \theta_A + \theta_{N,0} = 0] = \bar{\theta}\frac{\pi_{-1}^L \eta_2}{\pi_{-1}^L \eta_2 + \pi_0^L \eta_3}.$$

Summarizing all cases, when $D_2 = D_H$ then $\hat{\theta}_A = \bar{\theta}$ and when $D_2 = D_L$

$$\widehat{\theta}_A(x) = \begin{cases} 0, & D_2 = D_L,\ \theta_A + \theta_{N,0} = -\bar{\theta}; \\ \bar{\theta}\dfrac{\pi_{-1}^L \eta_2}{\pi_{-1}^L \eta_2 + \pi_0^L \eta_3}, & D_2 = D_L,\ \theta_A + \theta_{N,0} = 0; \\ \bar{\theta}\dfrac{\pi_0^L \eta_2}{\pi_0^L \eta_2 + \pi_1^L \eta_3} & D_2 = D_L,\ \theta_A + \theta_{N,0} = \bar{\theta}; \\ \bar{\theta} & D_2 = D_L,\ \theta_A + \theta_{N,0} = 2\bar{\theta}. \end{cases}, \tag{A20}$$

where $x \in \{-\bar{\theta}, 0, \bar{\theta}, 2\bar{\theta}\}$.

Conditions for equilibrium. Next, we derive condition under which (9) is an equilibrium strategy. Let $\theta_A^* + \theta_{N,0} = x$. The insider's utility is zero when $\theta_I = 0$ and $(D_2 + (\psi + \phi)\widehat{\theta}_A - p_2(-2\tilde{\theta}, x)\pi_{-1}^k - p_2(-\tilde{\theta}, x)\pi_0^k - p_2(0, x)\pi_1^k)(-\tilde{\theta})$ when $\theta_I^* = -\tilde{\theta}$, where $k = L$ or $k = H$ depending on the type of the firm. We also note that price (A7) can be represented as $p_2 = a_{ij} D_H + b_{ij}\psi\bar{\theta}$, where index $i = -1, 0, 1, 2$ corresponds to $\theta_A^* + \theta_{N,0} \in \{-\bar{\theta}, 0, \bar{\theta}, 2\bar{\theta}\}$ and $j = -2, -1, 0, 1$ corresponds to $\theta_I^* + \tilde{\theta}_{N,1} \in \{-2\tilde{\theta}, -\tilde{\theta}, 0, \tilde{\theta}\}$.

First, we check when $\theta_I = 0$ is equilibrium if $D_2 = D_H$. the insider's utility of not selling exceeds utility of selling if and only if

$$0 \geq (D_2 + (\psi + \phi)\widehat{\theta}_A - p_2(-2\tilde{\theta}, x)\tilde{\pi}^H_{-1} - p_2(-\tilde{\theta}, x)\tilde{\pi}^H_0 - p_2(0, x)\tilde{\pi}^H_1)(-\tilde{\theta}).$$

From the price (A7) it can be easily observed that in its representation $p_2 = a_{ij} D_H + b_{ij}\psi\bar{\theta}$ the parameters are such that $0 \leq a_{ij} \leq 1$ and $0 \leq b_{ij} \leq 1$. Moreover, when $D_2 = D_H$ we have $\hat{\theta}_A = \bar{\theta}$ because the activist always invests. Hence, the above inequality is satisfied when $\phi \geq 0$.

Next, suppose that $D_2 = D_L$ and $\theta^*_A + \theta_{N,0} = x$. When $x = -\bar{\theta}$ the equilibrium is fully revealing so that $\theta^*_A = 0$ and $D_2 = D_L$ are known to the market maker. Consequently, the market maker sets the price equal to zero. The insider is then indifferent between selling or not selling, and hence our strategy is consistent with equilibrium. For other values of x, the strategy (9) is equilibrium if and only if the following conditions are satisfied:

$$\begin{aligned}
&(\psi + \phi)\hat{\theta}_A(0) - p_2(-2\tilde{\theta}, 0)\tilde{\pi}^L_{-1} - p_2(-\tilde{\theta}, 0)\tilde{\pi}^L_0 - p_2(0, 0)\tilde{\pi}^L_1 \leq 0,\\
&(\psi + \phi)\hat{\theta}_A(\bar{\theta}) - p_2(-2\tilde{\theta}, \bar{\theta})\tilde{\pi}^L_{-1} - p_2(-\tilde{\theta}, \bar{\theta})\tilde{\pi}^L_0 - p_2(0, \bar{\theta})\tilde{\pi}^L_1 \geq 0,\\
&(\psi + \phi)\hat{\theta}_A(2\bar{\theta}) - p_2(-2\tilde{\theta}, 2\bar{\theta})\tilde{\pi}^L_{-1} - p_2(-\tilde{\theta}, 2\bar{\theta})\tilde{\pi}^L_0 - p_2(0, 2\bar{\theta})\tilde{\pi}^L_1 \leq 0. \quad \blacksquare
\end{aligned} \tag{A21}$$

Lemma A1. *The distribution of observed order flows $\theta^*_A + \theta_N$ conditional on bad type of the firm is as follows:*

$$\text{Prob}(\theta^*_A + \theta_N = x | D_L) = \begin{cases} \dfrac{\eta_3}{\eta_2 + \eta_3}\pi^L_{-1}, & x = -\bar{\theta}, \\[2ex] \dfrac{\eta_3}{\eta_2 + \eta_3}\pi^L_0 + \dfrac{\eta_2}{\eta_2 + \eta_3}\pi^L_{-1}, & x = 0, \\[2ex] \dfrac{\eta_3}{\eta_2 + \eta_3}\pi^L_1 + \dfrac{\eta_2}{\eta_2 + \eta_3}\pi^L_0, & x = \bar{\theta}, \\[2ex] \dfrac{\eta_2}{\eta_2 + \eta_3}\pi^L_1, & x = 2\bar{\theta}. \end{cases} \tag{A22}$$

Moreover, under the model assumptions that $\pi_{-1}^L > \pi_0^L > \pi_1^L$*, we have:*

$$\text{Prob}(\theta_A^* + \theta_{N,0} = 0|D_L) > \text{Prob}(\theta_A^* + \theta_{N,0} = \bar{\theta}|D_L) > \text{Prob}(\theta_A^* + \theta_{N,0} = 2\bar{\theta}|D_L). \tag{A23}$$

Proof of Lemma A1. We prove for $x = 0$, and the other cases are analogous.

$$\begin{aligned}\text{Prob}(\theta_A^* + \theta_N = 0|D_L) &= \text{Prob}(\theta_A^* = 0, \theta_N = 0|D_L) + \text{Prob}(\theta_A^* = \bar{\theta}, \theta_N = -\bar{\theta}|D_L) \\ &= \frac{\eta_3}{\eta_2 + \eta_3}\pi_0^L + \frac{\eta_2}{\eta_2 + \eta_3}\pi_{-1}^L.\end{aligned}$$

Inequality (A23) directly follows from (A22) and (A23). ■

A1. Calibration

As the model has many free parameters, we set probabilities to $\pi_1^H = \tilde{\pi}_1^H = 2/3$, $\pi_0^H = \tilde{\pi}_0^H = 1/6$, $\pi_{-1}^H = \tilde{\pi}_{-1}^H = 1/6$, $\pi_1^L = \tilde{\pi}_1^L = 1/6$, $\pi_0^L = \tilde{\pi}_0^L = 5/12$, $\pi_{-1}^L = \tilde{\pi}_{-1}^L = 5/12$, $\eta_1 = 0.1$, $\eta_2 = 0.3$, $\eta_3 = 0.6$, $\pi_d = \eta_1$. Next, we vary parameter ϕ and look at the ranges of $\bar{\theta}/D_H$ and ψ for which the conditions (A21) under which the equilibrium strategy of the insider is given by (9) are satisfied. For $\phi = 0.05$ the existence ranges are $\bar{\theta}/D_H \in (0.4, 4.8)$ and $\psi \geq 0.6$. For $\phi = 0.1$ the ranges are $\bar{\theta}/D_H \in (0.28, 2.4)$ and $\psi \geq 1.1$. For $\phi = 0.15$ the ranges are $\bar{\theta}/D_H \in (0.12, 1.6)$ and $\psi \geq 1.7$.