Using Managerial Attributes to Identify Market Feedback Effects: The Case of Mutual Fund Fire Sales *

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Abstract

We develop a model of feedback and learning in the aftermath of a "fire sale," and test its implications. Mutual funds gather information about a firm's potential investment opportunities. This information finds its way into stock prices and helps firms to decide on new investments. The incentive to produce information comes from two sources of profits: "trading" profits and capital gains on prior "holdings." We show that fire sales can disrupt the incentive to produce information by reducing capital gains. Further, we show that managers, who rely to a greater extent on market-feedback, are more likely to cutback on future investments and suffer a drop in firm value relative to overconfident (OC) managers, who are inherently less dependent on market information and consequently, less affected by a fire sale. Our empirical findings strongly support these testable implications. We find a monotonic relationship between level of CEO overconfidence and investment-Q sensitivity. A striking finding is that firms headed by OC CEOs suffer little drop in firm value following a fire sale vis-á-vis firms headed by non-OC CEOs.

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1 Introduction

Concentrated and intensive selling of a security can precipitate a 'fire sale' in which transaction prices drop significantly below the fundamental value of the security (see e.g., Shleifer and Vishny, 2012). The literature documents the substantial price pressure on individual stocks being sold for liquidity reasons by mutual funds. This occurs when investor withdrawals from mutual funds provoke the concerted selling of individual stocks that are held in relatively large quantities by the affected funds (see e.g., Coval and Stafford, 2007; Ellul et al., 2011; Pulvino, 1998). The price declines associated with mutual fund driven fire sales are economically significant. What makes the price declines particularly intriguing is the surprisingly (at least to us) long time, 12-24 months or more, it takes for price recovery.[1]

In the paper, we offer a possible explanation for the observed effects of fire sales. A simple model with market learning is proposed to argue that mutual fund fire sales can have real and persistent value effects by disrupting the market learning process. A sharp test of our hypothesis, based on heterogeneity in the way managers learn from the market, provides compelling empirical support for our hypothesis.

In our model, we focus on a relatively unexplored channel: the longer term effects of fire sales due to their disruption of the information gathering and market learning dimensions of the stock market. Information production is assumed to be done by a representative institutional investor, that we take to be an active mutual fund with relatively concentrated positions in a limited number of stocks. The costly private information the mutual fund produces about investment prospects of firms is eventually reflected in the stock price as a result of its trading activities (see e.g., Glosten and Milgrom, 1985; Grossman and Stiglitz, 1980; Kyle, 1985). Market learning occurs with firm managers conditioning their investment decisions on market prices. There are two sources of profits that incentivize the mutual fund to produce costly information: trading profits and capital gains on portfolio holdings. In some cases trading profits may be relatively small and the size of mutual fund's holding may be critical to encourage the production of costly private information.[2]

In this market learning set-up, fire sales can have a material effect by disrupting information production and, hence, learning by the firm manager. Specifically, we show that if the information-producing mutual fund gets an exogenous fund withdrawal shock and is forced to liquidate large part of its holdings – what we call "fire sale," it may no longer have the incentive to remain an information producer.[3] If a firm is heavily dependent on such market-produced information to shape its investment strategies, information void may result in loss of profitable future investment

[1]We identify three different reasons for short term persistence: first, falling asset prices can exacerbate cash problems, causing more distress selling. Second, as the financial condition of levered investor is propagated into future periods, some dynamic effects can arise (Holmstrom and Tirole, 1998). Finally, opportunistic arbitrage by similar institutions without withdrawal shock (see e.g., Attari et al., 2005; Edmans et al., Forthcoming; Gromb and Vayanos, 2002).

[2]See, for example, Edmans (2009) where investors with sizable holdings (blockholders) by trading on their private information make prices to reflect fundamental value.

[3]Mutual fund distress selling refers to the sale of assets, which were originally intended to be held, in order to deal with financial distress or inability to meet cash commitments or fulfill financial obligations.

opportunities and as a consequence, lead to significant drop in the fundamental value of its stock (see e.g., Berk and Green, 2004; Hubbard, 1998). Factors such as the mutual fund's holdings post withdrawal shock, the mutual fund's efficiency in producing information (costs), and the firms' dependence on such market-produced information (market feedback) will together determine the size of the drop in the firm's fundamental value. Everything else remaining the same, the greater a firm's dependence on market feedback, the more will be the drop in its fundamental value, if information production by the mutual fund stops. Similarly, if cost of producing information is low and/or post fire sale holding size is not too small, there will be little or no disruption in information production and consequently, firm's value will either not drop significantly or recover quickly.

An implication of the model is that if there is large, observable heterogeneity among firm managers in terms of sensitivity to market produced information, this could provide a way to test the model's predictions. In particular, we contend that managerial overconfidence can serve as a plausible indicator of the attention the manager is likely to pay to market information. The reason is that, by definition, overconfident CEOs (henceforth, OC CEOs) are those that believe they know "more" relative to the market and, hence, will put less weight on market-produced information. We know from the prior literature that overconfident managers tend to overestimate returns and underestimate underlying risk of new investment opportunities; as a result they invest in novel projects in situations where a non-overconfident manager will hesitate to do so.[4] In terms of the model's predictions, if overconfident managers do pay less attention to market signals – which is testable in itself – they should be less vulnerable to mutual fund driven fire sales. They would be less likely to cut investments in response to a drop in firm stock price, relative to other managers. Firms with overconfident CEOs should experience a substantially lower impact on firm market value, in the event of a mutual fund fire sale.

Our simple model, which we rely on to develop the underlying intuition, has empirical implications that we proceed to test. The objective of our empirical analysis is to first establish that there is a significant difference between overconfident and other managers in their response to market signals, e.g., in their investment-to-Q sensitivity (Chen et al., 2007). The next step is to examine whether the typical manager responds to a fire sale by cutting back on investments, while there is relatively little impact on the investment by an overconfident manager. Finally, we examine whether firms with OC CEOs are less affected by fire sales in terms of impact on market value. We follow Edmans et al. (2012) in measuring mutual fund flow-driven price pressure. The measure reflects a predicted pressure due to large outflows from mutual funds that hold the same stock, assuming that these funds would proportionally sell their existing holdings.

[4]Overconfidence can be a desirable trait in managers when, for instance, there are valuable, but risky investments are to be made in less certain situations. The downside is that overconfidence can lead to faulty assessments of investment value and risk, often resulting in suboptimal investment decisions.The double-edged nature of confidence is evident from the extant literature. Confidence is essential for success in myriad domains, including business (see e.g., Galasso and Simcoe, 2011; Hirshleifer et al., 2012; Johnson and Fowler, 2011; Puri and Robinson, 2007; Simsek et al., 2010). Not surprisingly, CEOs tend to be more confident than the lay population (Graham et al., 2013). But Malmendier and Tate (2008) find that overconfident CEOs tend to undertake acquisitions that create significantly less shareholder wealth. Also, Malmendier and Tate (2005a) show, overconfident CEOs spend more of their cash flows on capital expenditures, reflecting their greater propensity to invest.

We have several important findings. First, the empirical evidence strongly supports the idea that overconfident CEOs are less responsive to stock price fluctuations. Using the option-based measure (Malmendier and Tate, 2005a) and press-based measure (Hirshleifer et al., 2012) of CEO overconfidence, we find that firms run by overconfident CEOs are less sensitive to market produced information. We also test the market-learning hypothesis in the context of merger and acquisitions. For example, Luo (2005) and Kau et al. (2008) find that managers learn from the market when making acquisition decisions: they are more likely to cancel an merger and acquisitions deal when the market reacts negatively to the announcement. Based on our hypothesis, we conjecture and find evidence that overconfident CEOs are less likely to cancel their announced acquisitions in response to negative market reactions to the announcements.

We test for whether typical (non-OC) managers adjust their investment policies in response to non-fundamental (mutual fund driven fire sale) shocks to stock prices. We find that non-OC managers do cutback on their investments in response to the stock price drop driven by a mutual fund fire sale. Overconfident managers are, however, less sensitive in their investment response to such stock price movements. Overall, the empirical evidence strongly support the idea that overconfident CEOs are less responsive to stock price fluctuations, whether they are driven by fire sales or information.

Our model shows that the feedback loop created by firms' learning from the stock price may create a negative externality to the firm during mutual fund fire sales. In effect, the break down of the feedback loop reduces the information available to the manager on which to make investment decisions. This is expected to affect a manager that relies on market learning – while having less impact on overconfident managers that pay less heed to market signals. Our tests confirm our prediction that the price impact of mutual fund fire sales is smaller for firms managed by CEOs who are less sensitive to market signals. Also, these firms lead by overconfident CEOs recover quickly post fire sale relative to firms run by non-overconfident CEOs. The difference is also economically significant as the price impact of mutual fund fire sales on stocks with overconfident CEOs is 30.9% less than that on the other stocks. In our regression tests we control for various firm characteristics that may be relevant to firms' price stability during fire sales, such as stock illiquidity proxied by the Amihud's measure and analyst coverage.

We conduct a number of robustness tests to increase our confidence in the results and their interpretation. First, we control for various firm, CEO, and governance characteristics, and include firm/industry and year/quarter fixed effects. The results hold in multivariate regression as well as propensity score matching setting. Second, we use alternative measures of CEO overconfidence, and show that results hold when using a press-based measure of overconfidence and an option-based measure of overconfidence. We confirm that overconfidence tends to be 'sticky' over time (as Malmendier and Tate, 2005a, have previously shown), suggesting that it is a stable behavioral characteristic rather than a function of contemporaneous firm performance. Third, we find cross-sectional evidence that is consistent with our model prediction: the differential price impact of fire sales between OC and non-OC firms is stronger when the depth and/or breadth of institutional ownership is low and when information cost is high. Finally, we find similar results when we use firms' investment-Q sensitivity as an alternative measure of managers' propensity to learn from the stock market.

Our paper contributes to multiple tranches of finance literature. First, we contribute to the asset fire sale literature. There is a relatively large and growing literature on fire sales: Papers like Almazan et al. (2004), Borio (2004), Shleifer and Vishny (2011), Duarte and Eisenbach (2015) and Massa and Zhang (2015). A common pattern of financial instability is that financially distressed institutions sell assets, asset prices fall, losses spread, cash flows and balance sheets deteriorate, and more assets are sold into a falling market. This process of distress selling and asset market feedback can be costly. We document that it may cause information voids, lost investment opportunities and as a consequence, a somewhat permanent drop in the value of firms whose shares are subject to mutual fund fire sales.

Second, our finding contributes to the growing literature on market feedback effects (see, e.g., Bond, Edmans, and Goldstein (2012) for a survey). On the one hand, there has been considerable development on the theoretical front in understanding the implications of feedback effects.[5] On the other hand, documenting empirical evidence on market learning is challenging because the act of learning creates a feedback loop between market prices and firms' decisions that is hard to disentangle empirically. Previous studies tackle the endogeneity issues by testing the cross-sectional predictions that are consistent with market learning (see e.g., Chen et al., 2007; Foucault and Fresard, 2014), or by exploiting exogenous variations in stock prices due to mutual fund fire sales (see e.g., Edmans et al., 2012; William and Xiao, 2015; Xiao, 2015). Our paper identifies the market feedback mechanism by exploiting managers' propensity to learn market-produced information due to behavioral biases, such as overconfidence.

We also contribute to the managerial overconfidence literature. We confirm that CEO overconfidence can lead to excessive investment (see e.g., Banerjee et al., 2015; Malmendier and Tate, 2005a, 2008). More importantly, our results suggest that overconfident managers may be better at steering the firm in difficult market situations in which there is a break from the normal functioning of the market, such as on account of large scale selling by institutional investors and resulting price pressure. Prior literature suggests that the sharp drop in firm value post fire sale can be due to intense short term price pressure, in concert with non-distressed institutions being unable to fully arbitrage the mispricing. We argue that these reasons cannot fully explain the differential impact on valuation between otherwise similar firms run by OC CEOs and non-OC CEOs. Further, we argue that this differential impact allows us to identify that the long-term price drop can be traced to the disruption in market learning and information production, which is relatively more important for firms run by non-OC CEOs viś-a-viś OC CEOs.

This paper is organized as follows. In Section 2 we describe the model preliminaries and trading mechanisms. In Section 3 we derive equilibrium trading strategies of the information producing

[5]See, for example, Bond, Goldstein, and Prescott (2010); Dow, Goldstein, and Guembel (2015); Dow and Gorton (1997); Dow and Rahi (2003); Edmans, Goldstein, and Jiang (2012); Foucault and Gehrig (2008); Goldstein and Guembel (2008); Goldstein, Ozdenoren, and Yuan (2013); Subrahmanyam and Titman (1999, 2001).

mutual fund trading strategies assuming that the firm is run by an unbiased manager. In Section 4 we derive mutual fund's trading strategies assuming an overconfident firm manager. Section 5 describes the data. It also presents evidence on the existence and magnitudes, persistence of price pressure and asset fire sales in equity markets. Section 6 presents our main empirical result on differential impacts of fire sale on firms run by overconfident (less sensitive to market feedback) and non-overconfident CEOs (relatively more sensitive to market feedback). Section 7 discusses various robustness test and Section 8 concludes. All detailed derivations and data definitions are delegated to Appendices A1, A2 and A4 respectively.

2 Model

We propose a simple model of market-learning in the aftermath of a mutual fund "fire sale." The mutual-fund fire sale, if there is one, occurs in period 0. Our discussion concerns the subsequent periods, specifically periods 1 and 2 with or without fire sale. The question is why fire sales induced by mutual fund outflows may have persistent effects in terms of investment and value of a firm – and why these effects could depend on the behavioral attributes of the firm's manager.

We assume that the fire sale involves a single mutual fund (henceforth, MF) with a substantial ownership in the firm's stock. The initial fractional ownership is $h_0 = {}^{N_0}/_{N}$ and after the outflow it is reduced to h_1, where $h_1 = {}^{N_1}/_{N} > 0$ and $N_1 < N_0$ implying that $h_1 < h_0$. The difference between h_0 and h_1 is taken to be large and the sell decision is largely unrelated to the fundamentals of the firm; hence, we call it "fire sale."

We also assume that the mutual fund is the sole entity that is sophisticated/ knowledgeable enough about the firm to be able to assess its economic opportunities (i.e., acts as sole information producer for the firm). We take the mutual fund manager's effort to collect information about the firm to be equivalent to a pecuniary cost of c. The fund's information is assumed to be unavailable to the firm because, for instance, it represents that the information fund manager can obtain from their own analysis and familiarity with market conditions. As is typical in the market feedback literature, we rule out direct communication between the firm and MF i.e., the only credible way to communicate between these entities is through market prices.

2.1 Opportunities, uncertainties and firm value

The nature of information that the mutual fund can collect concerns the value to the firm from choosing a novel project over a more conventional (status quo) project. If the firm stays with the status quo project its value is V. On the other hand, if the firm chooses to fund the novel investment project, then the value of the firm is state contingent. We assume two states of the world: S^g and S_b. If the state of the world is good (S^g), which occurs with a probability $q < {}^1/_2$, the firm's value will be $V_g = V + \Delta$. We will denote value per share by v, where $v_g = \frac{V+\Delta}{N} = v + \delta$. On the other hand, if the state of the world is bad (S_b), which occurs with a probability of $1 - q$, then the value of the firm is $V_b = V - \Delta$ or $v_b = v - \delta$ per share. Hence, without any other information regarding the state of the world, the project is a negative NPV project.

We assume that there are two types of firm managers: *unbiased* managers and *biased* managers. An unbiased manager has beliefs similar to the rest of the market; hence, given our assumption that $q < 1/2$, an unbiased manager needs a sufficiently large positive signal from the market in order to switch to the novel project. In the absence of any market-learning, an unbiased manager disregards the novel investment.

For biased manager, we consider two levels of bias: The firm manager is "extremely overconfident" (e) believes that the possible state of the world is S^g and hence, he is not at all influenced by any market activity – neither buying, nor selling by the informed mutual fund. Thus, an extremely overconfident firm-manager always accepts the novel project. The second type of biased manager is what we called "overconfident" (o), who believes that $q^o > 1/2 > q$; i.e., an overconfident firm manager perceives the likelihood of good state, which we denote by q^o to be greater than the "true" likelihood of good state, q – what everybody else believes. Hence, an overconfident firm-manager accepts the novel project for all signals other than a sufficiently large negative signal from the market. We denote the level of bias by B, where $B^o = q^o - q$. For example, if $q = 0.33$ and $B^o = .34$, then the perceived likelihood of good state, $\text{Prob}^o(S^g) = 0.67$. Note that the perceived likelihood of good state in the case of an extremely overconfident manager, $\text{Prob}^e(S^g) = 1$; i.e., $B^e = 1 - q$.

2.2 Information Structure

The information producing MF can receive two types of private signal: One type we call "informative." This type of signal is perfectly correlated with the "true" state of the world. There are two informative private signals: good, g, and bad, b. If the mutual fund receives signal g, then the updated likelihood of state S^g is 1; whereas, if the mutual fund receives signal b, then the updated likelihood of state S^g is 0. The mutual fund can also receive an "uninformative" signal uncorrelated with the "true" state of the world. If the mutual fund obtains an uninformative private signal, n, then the likelihood of state S^g remains at the unconditional value of q. The probability of the mutual fund receiving signal n is $1 - \theta$. Thus, θ is a measure of the mutual fund's quality of information. We assume that $0 < \theta \leq 1$;[6] i.e., the mutual fund always has positive chance of being informed. The ex-ante likelihood of a good private signal, bad private signal, and an uninformative private signal, denoted by μ_g, μ_b and μ_n respectively, are

$$\mu_g = \theta\, q;\ \mu_b = \theta\,(1 - q);\ \text{and},\ \mu_n = (1 - \theta). \tag{1}$$

Signals g, b and n are mutually exclusive and exhaustive; hence, $\mu_g + \mu_b + \mu_n = 1$. As indicated, the mutual fund has no direct means of credibly communicating his private signal-type to others agents in the model; hence, the only way other agents can learn about the private signal-type is by inverting the secondary market price.

[6] We do not consider $\theta = 0$, because it implies no information is produced and thus, trading in period 1 has no information content.

2.3 Trading mechanism

There are two types of traders in our model: A potential informed trader (the MF) and the noise (or liquidity) trader. The mutual fund trades in quest for profits, whereas the noise trader trades for liquidity reasons. For simplicity we assume the order submission by the noise trader takes the following form: the noise trader either buys one share denoted by $nt = +1$, sells one share denoted by $nt = -1$ or does not trade ($nt = 0$). We assume that ex ante he is equally likely to buy, sell or not trade. Formally, we denote the trading strategy of the noise trader (nt) as follow:

$$nt = \begin{cases} +1 & \text{w.p. } 1/3; \\ 0 & \text{w.p. } 1/3; \\ -1 & \text{w.p. } 1/3. \end{cases} \tag{2}$$

The assumption that the trade levels are equally likely conserves on symbols but is without loss of generality. The prices set by the market maker will depend on his conjecture about the MF trading strategy and firm manager's investment strategy. In equilibrium the conjectured strategy will be consistent with the one actually chosen by the mutual fund manager. We begin by describing prices that would be set under a specific conjecture:

- Mutual fund buys only when it gets the signal g; i.e., if the probability that the MF bought is equal to one conditional on observed order flow, then the market maker infers that $\text{Prob}(S^g) = 1$. Hence, the market maker knows that the value per share if the firm manager invests is v_g and the value per share if the firm manager does not invest is v.

- Mutual fund sells only when it gets the signal b: i.e., if the probability that the mutual fund sold is equal to one conditional on observed order flow, then the market maker infers that $\text{Prob}(S^g) = 0$. Hence, the value per share if the firm manager invests is v_b and the value per share if the firm manager does not invest is v.

- Mutual fund does not trade if it gets signal n; i.e., if the probability that the mutual fund did not trade is equal to one conditional on observed order flow, then the market maker infers that $\text{Prob}(S^g) = q$. Hence, the value per share if the firm manager invests is $\bar{v} = q\,v_g + (1-q)\,v_b$ and the value per share if the firm manager does not invest is v.

Since the market maker observes order flow, any order by the MF that does not mimic the ±1-share trading pattern of the noise trader would completely reveal the MF's trade and hence its private information to the market maker. Thus , such trading cannot by definition lead to trading profits for the MF. But if the MF has a significant holding and is more concerned about propagating the right signal to the firm manager, it may be optimal for the mutual fund to engage in "fully revealing" trades outside ±1-share trading pattern of the noise trader. Thus, we will consider both these two types of equilibria. We formally denote the trading strategy of the mutual fund manager

(mt) as follow:

$$mt = \begin{cases} +1 \text{ or higher} & \text{if she observes signal } g \text{ w.p. } p_g; \\ 0 & \text{if she observes signal } n \text{ w.p. } p_n; \\ -1 \text{ or lower} & \text{if she observes signal } b \text{ w.p. } p_b. \end{cases} \quad (3)$$

Note that if the mutual fund manager buys more than $+1$ or sells more than -1, then we assume that he can either buy $\{+2, +3, \cdots\}$ or sell $\{-2, -3, \cdots\}$, i.e., we allow only "integer" trading.

Each trader submits a market order to a risk-neutral market maker in a competitive market. Orders arrive randomly as in Kyle (1985); that is, each trader's order arrives simultaneously at the market maker's desk. Thus, the market maker cannot distinguish between orders from the MF and the noise trader . The resulting aggregate order flow is observable by the market maker, $O = mt + nt$. Based on this order flow, the market maker fixes the secondary market price to break even. Market price is observed by all agents.[7] We denote the observed order flow as follow: $O = (mt + nt) = \{+2 \text{ or higher}, +1, 0, -1, -2 \text{ or lower}\}$. Conditioned on this information produced by the market the firm manager takes an investment decision.

The market maker's price setting decision depends both on the conjectured trading strategies, inference about the quality of the project as well as its likelihood of being undertaken by the firm. Since the firm manager's objective is to maximize NPV, the market maker knows that the firm will invest whenever management believes that NPV conditional on the observed market price (or order flow) is positive and not invest when conditional NPV is nonpositive. Since the MF's information relates only to the novel project, if the project is rejected, both the intrinsic and market value of of a share equals $p_0 = v$. In contrast, if the firm manager expects, based on the realized secondary market price, that the project has a positive NPV, then the project will be accepted and thus the market price of the firm's share will depend on the expected NPV of the project conditioned on the market produced information. This may not be the same as the expected NPV conditioned on the MF's private information.

Before further exploration, we state why it matters that there has been a fire sale. There are two reasons in our model and we will assume that at least one of the two applies, and affects the incentives to collect/transmit information through trading. As we will see, the effects can be greater when the firm's manager is unbiased:

- The fund is cash constrained after the fire sale as a result of the fund outflow. Hence, it is not surprising that the fund may find it difficult to buy new position in the stock. This may affect the fund's incentive to collect information.

- Also, due to the reduction in the share ownership to (drop from h_0 to h_1), there may be reduction in the incentive of the mutual fund to collect information. This will be the case when collecting information is significantly costly and when most or all of the benefits from

[7] For simplicity, we assume that after the trading closes, aggregate order flow is observed by the entire market, that is, to all agents including the firm. Since prices are unique in our set up, this assumption is not critical.

collecting information comes from capital gains on MF's holdings post fire sale rather than the trading profit.

Note that our model environment is different from standard trading models.[8] In Kyle's model order flow that reveals the minimum private information to the market also maximizes MF's trading profits. In our current framework, this is not necessarily true. If the MF reveals "too little" information through its trade such that an unbiased manager decides not to invest, the MF does not gain anything from such trade. On the other hand, if the MF reveals "too much" information through its trade, then an unbiased firm manager definitely invests, but most of the MF's private information is incorporated into the market price and as a result the MF does not gain anything from such trade either. Hence, trading profits are difficult to generate and MF's prior holdings of the firm's stock plays a critical role in our model. Thus, any exogenous shock that reduces MF's holding impacts its incentive to gather firm-specific information. Temporal evolution of events in our model is depicted in Figure 1 below.

2.4 Objectives and decision in our setup

The MF manager decides on date 0 on whether or not to acquire information. The decision to acquire information depends on MF's profits net of costs and can be expressed as:

Net profit from acquiring information = {Expected trading profits + Expected capital gains from prior holding − Costs of acquiring information} > 0.

We assume that the cost of acquiring information is exogenous. In choosing its trading strategy, the MF faces a trade-off between expected trading profits and the expected capital gains on prior holdings. As already discussed, the MF will not earn any trading profits (even after acquiring useful information), if the firm does not receive sufficiently strong guidance about the occurrence of state S^g. Yet, the release of information through trading will be detrimental to the MF's trading profits as the market-maker incorporates this information into market prices. Hence, in our setup, the expected capital gain (CG) plays a central role. But the expected CG depends on size of the MF's prior holding and hence, shocks to the size of its prior holding – like a "fire sale" – can affect its decision to acquire firm specific information.

The information acquisition and trading decisions will also be affected by the firm manager's type. If the manager's type requires a strong trading-based market-guidance in order to undertake the novel project, then the MF manager is forced to reveal a large part of his private information to induce the firm manager to invest. Hence, trading profits are compromised and the importance of capital gains in the decision to acquire information/trade increases. On the other hand, if the firm manager is confident about the quality of his own information and does not rely as much on market guidance to undertake the novel project, then the MF has less need to reveal his private

[8] See, for example, Kyle (1985) and Glosten and Milgrom (1985) for more detail.

information through aggressive trading, in order to induce to the firm manager to invest. As a result, trading profits will play a bigger role in MF manager's decision to acquire information.

At the beginning of date 1, the MF manager decides on whether to trade aggressively or trade within the bounds of noise trades (hide his trades). If the MF manager trades aggressively, then he forgoes trading profits. This is because "aggressive" trading will completely reveal MF manager's trades and information to the market-maker and be incorporated in market prices. The benefit is that aggressive trading, by better communicating the MF's information to the firm manager, reduces errors in firm's investment decisions. This implies that the MF manager will trade aggressively if expected capital gains are relatively more important i.e., the MF has significant holdings in firm's stock. If the MF's stock holding is small, then trading profits will play a more important role in the decision to acquire information.

Thus, an exogenous shock to the MF's holdings (forced liquidation) and the firm manager's type can be important in terms of the MF's decision to acquire information. If the firm manager is reliant on market-feedback and the MF's incentive to produce information is diminished due to exogenous shocks like a fire-sale, the firm value may go down significantly. Whereas, if the firm manager is of a type that does not rely on market-feedback, then an exogenous shock to MF's holdings and its decision to stop producing information will not materially affect the firm's investment decisions and, consequently, have little effect on firm value.

3 Unbiased firm manager, fire sale and information production

Next, we explicitly derive the investment strategy of an unbiased firm manager, conditional secondary market price, p_1 and/or net observed order flow, f_j. In Appendix A1 we show that given the trading strategies of the mutual fund and the noise trader described above, net order flow can take any one of five possible values: $f_1 = +2$, $f_2 = +1$, $f_3 = 0$, $f_4 = -1$ and $f_5 = -2$. In Section *3.1* and Appendix A1 we derive complete investment strategies of an unbiased firm manager based of market trading outcomes.

3.1 Investment strategy of an unbiased firm manager

Based on our assumptions that $q < (1 - q)$, per share $NPV_g = \delta$ and per share $NPV_b = -\delta$, we know that the expected NPV per share,

$$\bar{v}(q) = q \times (v + \delta) + (1 - q) \times (v - \delta) = v + (2\,q - 1)\,\delta < 0, \tag{4}$$

given $q < 1/2$. Hence, the mutual fund manager knows that the *unbiased* firm manager will not invest unless he receives a feedback from the market that the likelihood of S^g is significantly higher than initial assessment, q, say $\bar{q}$ – such that the expected NPV per share using $\bar{q}$ is positive. That is,

$$\bar{v}(\bar{q}) = \bar{q} \times (v + \delta) + (1 - \bar{q}) \times (v - \delta) > 0. \tag{5}$$

For example, if the market-maker observes +2, then he knows that probability of MF manager buying is one, which further implies that probability of good state conditional on order flow, $\bar{q} = 1$; hence, using expression (5) we obtain $\bar{v} = v + \delta$. Thus, the market maker sets market price, $p_1 = v + \delta$ reflecting full value of the gain from the project. In Table A1 in Appendix A1 we derive the updated likelihood for each of the five possible levels of net order flow and analyze the firm's investment decision. These results are formally stated in Proposition 1 below.

Proposition 1. *(i) For all $\theta \geqslant \underline{\theta} = \frac{1-2q}{1-q}$, an unbiased firm manager invests in the novel project only if the observed order flow in the secondary market is +1 or higher.*
(ii) For all $\theta < \underline{\theta}$, an unbiased firm manager invests in the novel project only if the observed order flow in the secondary market is +2 or higher.

Proof. See Section A1.2 in Appendix A1. □

For illustration, if $q = 1/3$, then $\underline{\theta} = 1/2$; i.e., the likelihood of the mutual fund getting an informative signal has to be greater or equal to 50% so that an unbiased firm manager when he observes a moderate buy interest in the market (+1) puts a significant weight on the possibility that the buy order came from the MF manager.[9] Aggregate order flow of +1 can occur in two ways: (i) MF buys and the noise trader does not trade, and (ii) MF does not trade and the noise trader buys. As θ increases, possibility (i) becomes relatively more likely than possibility (ii), which further implies that signal g becomes relatively more likely than signal n; hence, an unbiased firm manager invests. In Section *3.2* we discuss the trading strategies of the mutual fund given the investment strategies of an unbiased firm manager.

3.2 Trading strategies of the mutual fund manager

There are two broad trading strategies that the MF can adopt: it can trade within the trading range of the noise trader ; i.e., the mutual buys only 1 share if the signal is g and sells 1 share if the signal is b. Or the MF manager can trade aggressively (i.e., outside the noise trader's trading range). As we will show that choice between these two broad strategies depends on the pre/post fire sale shareholding of the MF. In Section *3.3* we discuss the pros and cons of trading within the trading range of the noise trader and in Section *3.4* we discuss the pros and cons of trading aggressively.

3.3 MF trades within the trading range of the noise trader

Given the investment strategy of an unbiased firm manager as stated in Proposition 1, we define $v(s, \mathcal{I})$ as the per share value of the firm based on the private signal of the MF, s, and conjectured invest decision of an unbiased firm manager, $\mathcal{I}$. For example, if the MF manager gets signal g and

[9] It is straight forward to argue that if an unbiased firm manager chooses to invest when +1 occurs, then he also invests when +2 occurs. This is because probability of the MF manager buying– i.e., probability of good state is increasing in size of the aggregate order flow, given that the noise trader always trade a fixed quantity, {+1, 0, -1}.

firm invests, i.e., $\mathcal{I} = 1$, then $v(g, 1) = v + \delta$. Note that $v(g, 0) = v$, where $\mathcal{I} = 0$ implies that the unbiased firm manager is not investing. Similarly, we derive $v(\cdot)$ for all other {s, $\mathcal{I}$} combinations in Appendix A1. Hence, the trading profit (denoted by $\pi_{tp,\, f_j}$) of the mutual fund conditional on a particular order flow (f_j, $j = 1, 2, 3, 4, 5$) can be defined as follows:

$$\pi_{tp,\, f_j} = v(s,\, \mathcal{I}) - p_1(f_j,\, \mathcal{I}), \tag{6}$$

where $p_1(f_j, \mathcal{I})$ is the per share price set by the marketmaker in period 1 based on the observed order flow (f_j) and his conjectured investment strategy of the firm ($\mathcal{I}$). In Appendix A1 we derive the trading profit for different trading outcomes conditional on different private signal of the mutual fund manager and investment strategy of an unbiased manager. We show that $\pi_{tp,\, f_j} = 0$, $\forall j$ if $\theta \leqslant \underline{\theta}$ and only $\pi_{tp,\, f_2} > 0$ for all $\theta > \underline{\theta}$. Note that $\pi_{tp,\, f_1} = 0$ even though the firm invests, because f_1 fully reveals the mutual fund's buy order to the market maker. Specifically,

$$\pi_{tp,\, f_2} = 2\,\delta\, \frac{(1-q) - \theta\,(1-q)}{1 - \theta(1-q)}, \tag{7}$$

where δ is the per share value generated from the novel project. Hence, the expected trading profit of the mutual fund manager if he decides to get informed and if $\theta > \underline{\theta}$,

$$\bar{\pi}_{tp,\, u} = \sum_{j=1}^{5} \text{Prob}(f_j) \times \pi_{tp,\, f_j} = \text{Prob}(f_2) \times \pi_{tp,\, f_2}, \tag{8}$$

where $\bar{\pi}_{tp,\, u}$ denotes the expected trading profit of the mutual fund when the firm is headed by an unbiased manager and probability of informative signal is relatively large ($\theta > \underline{\theta}$). Also, the unconditional probability of order flow f_2 occurring when the mutual fund is buying is equal to $\frac{1}{3}\,\theta\, q$.

If $\theta \leqslant \underline{\theta}$, then the expected trading profit of the mutual fund manager if he decides to get informed is zero. Hence, trading profit cannot be induce the manager to acquire costly information. Thus, in Section *3.3.1* we derive conditions under which the mutual fund's pre/post fire sale share holding, h_0 plays a critical role in the mutual fund's decision to produce costly information.

3.3.1 Mutual fund's pre fire sale portfolio value

Since the mutual fund owns h_0 fraction of the firm in the pre fire sale period, investment by the firm in the good state results in increase in portfolio value. Similarly, investment in bad state reduces portfolio value. Given that the firm manager is unbiased, the mutual fund manager knows that if $\theta > \underline{\theta}$, then there are three situation (S) where the firm will invest in the novel project:

- S1: mutual fund gets informed → gets signal g → places a buy order → noise trader also buys and the firm manager invests;
- S2: mutual fund gets informed → gets signal g → places a buy order → noise trader does not trade and the firm manager invests; and

- S3: mutual fund gets informed → gets signal n → does not trade → noise trader buys and the firm manager invests.

In S1 and S2 the MF manager's portfolio value increases; but in S3 his portfolio value decreases. The total change in portfolio value (π_{pv}) can be stated as follows:

$$\pi_{pv} = \text{Prob(S1)} \times h_0\,\Delta + \text{Prob(S2)} \times h_0\,\Delta + \text{Prob(S3)} \times h_0\,(2\,q - 1)\,\Delta, \tag{9}$$

where $\bar{V}(q) = (2\,q - 1)\,\Delta$ is negative. From Table A1 in Appendix A1 we get that Prob(S1) = Prob(S2) $= \frac{1}{3}\theta\,q$ and Prob(S3) $= \frac{1}{3}(1-\theta)$. Substituting these values in Equation (9) we obtain,

$$\pi_{pv} = \frac{1}{3}(2\,q + \theta - 1)\,h_0\,\Delta = \frac{1}{3}(2\,q + \theta - 1)\,N_0\,\delta. \tag{10}$$

Can the expression $(2\,q + \theta - 1)$ be negative? We show in Lemma 1 in Appendix A1 that $\theta \geqslant \underline{\theta}$ is also the sufficient condition for $(2\,q + \theta - 1) > 0$; i.e., the gains from S1 and S2 outweigh loss from S3. The mutual fund manager knows that if $\theta < \underline{\theta}$, then there is only one situation where an unbiased firm manager invests:

- S1: he gets informed → gets good signal → places a buy order → noise trader also buys and the firm manager invests;

The total change in portfolio value ($\pi_{\text{pv},\,\underline{\theta}}$) can be stated as follows:

$$\pi_{pv,\underline{\theta}} = \text{Prob(S1)} \times h_0 \times \Delta = \frac{1}{3}\theta\,q\,h_0\,\Delta = \frac{1}{3}\theta\,q\,N_0\,\delta. \tag{11}$$

If the mutual fund manager decides to get informed, the net profit (π or $\pi_{\underline{\theta}}$) of the mutual fund has to be nonnegative. Hence, the following condition has to be satisfied:

$$\pi\;(\text{or } \pi_{\underline{\theta}}) = \pi_{tp} + \pi_{pv}\;(\text{or } \pi_{pv,\,\underline{\theta}}) - c \geq 0. \tag{12}$$

The following proposition derives the necessary and sufficient condition for the mutual fund manager to produce costly information in the pre fire sale period while trading within the trading range of the noise trader and when the firm is headed by an unbiased manager.

Proposition 2. *(i) For all $\theta \in (\underline{\theta},\,1]$, $q \in (0, 1/2)$ and $c > \theta\,q\,\pi_{tp,f_2}$, then the mutual fund manager produces costly firm value-enhancing information only if pre fire mutual fund's shareholding (h_0) is greater than*

$$h_0^* = \frac{3\,c - \theta\,q\,\pi_{tp,f_2}}{\Delta(2\,q + \theta - 1)}.$$

(ii) For all $\theta \in (0,\,\underline{\theta}]$, $q \in (0, 1/2)$ and $c > \theta\,q\,\pi_{tp,f_2}$, the mutual fund manager produces costly firm value-enhancing information only if pre fire mutual fund's shareholding (h_0) is greater than

$$h_0^{**} = \frac{3\,c}{\theta\,q\,\Delta}.$$

Proof. See Section A1.3 in Appendix A1. □

Note that $c > \theta\, q\, \pi_{\text{tp},f_2}$ implies that the costs of information production greater than three times the trading profit. If $q = 0.33$, $\theta = 0.7$, $N = 20$, NPV of the novel project, $\Delta = 600$, cost of information production, $c = 5$, and pre fire sale holding $h_0 = 15\%$, then $\theta > \underline{\theta} = 0.5$ is satisfied, $c = 5 > 3 \times 1.66 = 4.98$ is satisfied, $h_0 > h_0^* = 4.52\%$ is satisfied, $h_0 > h_0^a = 3.61\%$ is satisfied. What is Proposition 2 ruling out? It is ruling out cases where the information production is relative cheap (i.e., c is small) and benefits from produced information is relatively large (i.e., δ is big). We want to clarify that

$$\theta\, q\, N_0\, \delta > c, \tag{13}$$

implying that the expected benefit of accepting the project net of the costs of information production in the good state of the world is large and positive. The reason trading profit is small in our model because trading profit is restricted to only one ($\{+1\}$) of the possible five trading outcomes ($\{+2,\ +1, 0, \text{-}1, \text{-}2\}$) of the model. Hence, the mutual fund's size of firm's shareholding h_0 in pre fire sale period and h_1 in the post fire sale period play a critical role in costly information production process.

Further, we show that in the absence of any trading profits, i.e., $\theta \in (0,\ \underline{\theta}]$, it is not optimal for the mutual fund manager to trade within the trading range of the noise trader . This is because by trading within $\{+1, 0, \text{-}1\}$ the mutual fund manager can induce an unbiased firm manager to invest if only f_1 occurs, which has the likelihood of only $\frac{1}{3}\theta\, q$. Instead, if the mutual fund manager trades aggressively – i.e., outside the noise trader 's trading range – he can ensure that an unbiased firm manager invest whenever the mutual fund manager gets signal g, which has the likelihood of $\theta\, q$. In fact, aggressive trading may be the optimal strategy for the mutual fund manager if additional portfolio gains resulting from such trading outweighs the trading profit that he makes by trading within the noise trader 's trading range. As noted, next we formally discuss the pros and cons of aggressive trading by the mutual fund manager.

3.4 Aggressive trading strategy

Trading within the noise trader's trading range (i.e., following the pattern $\{+1,\ 0,\ \text{-}1\}$) allows the mutual fund manager to capture trading profits. But such clandestine trading strategy imposes some costs as well. We identify two situations where it results in losses (or results in forgone profit):

- S4: firm invests when mutual fund is not trading and noise trader buys, which cause the value of pre fire sale shareholding to drop;
- S5: firm does not invest when mutual fund is buying and noise trader is selling – a forgone investment opportunity.

By trading aggressively, the mutual fund manager can eliminate S4 and induce the firm to invest in S5. In fact, the mutual fund manager can make sure that whenever he gets signal g, an unbiased firm manager invests, and whenever he gets signal n or b same firm manager does not invest.

But the mutual fund knows that such fully revealing trades eliminate all potential trading profits. Hence, it is a trade-off. If the mutual fund trades aggressively, its total profit, which we denote as π^a (same as π^a_{pv}) can be stated as follows:

$$\pi^a = \theta\, q\, h_0\, \Delta - c. \tag{14}$$

The entire profit comes from appreciated portfolio value due to the perfect coordination between an unbiased firm manager and the mutual fund manager whenever the mutual fund manager gets signal g. We can solve for the minimum size of the pre fire sale shareholding such that it is feasible for the mutual fund manager to trade aggressively and produce costly information. We formally state the result in Proposition 3 below.

Proposition 3. *For all $\theta \in (0, \underline{\theta})$ and $q \in (0, 1/2)$, the minimum pre fire sale shareholding required such that the mutual fund manager produces costly information and trades aggressively to make an unbiased firm manager invests whenever the he gets signal g is given by*

$$h_0 \geqslant h_0^a = \frac{c}{\theta\, q\, \Delta}.$$

Proof. Directly follows from Equation (14). □

It is obvious that h_0^a has to be relatively large, because it is the only source of profit to mitigate the cost of information production. Also, it is straightforward to check that h_0^{**} is bigger than h_0^a; i.e., by trading in sync with the noise trader , the mutual fund manager is throwing away some additional portfolio gain for no reason whatsoever ($\pi_{\text{tp},\underline{\theta}} = 0$). But the difference between h_0^* and h_0^a is not obvious. This is because for any given level of pre fire sale holding h_0, switching from trading in sync with the noise trader to aggressive trading imposes some cost and generates some additional benefits, thereby creating a tradeoff. Using our assumptions that $\theta \geqslant \underline{\theta}$ and $c > \theta\, q\, \pi_{\text{tp}}$ by assumption, we show in Lemma 2 in Appendix A1 that

$$h_0^* \geqslant h_0^a. \tag{15}$$

Inequality (15) is important for the mutual fund's choice of trading strategy. This is because Inequality (15) implies that whenever trading within the noise trader 's trading range is profitable, aggressive trading is also profitable. Next, we derive the level of the mutual fund's shareholding such that the mutual fund manager is indifferent between the two strategies in terms of their profitability. Proposition 4 formally describes this result.

Proposition 4. *For all $\theta \in (0,\, 1]$, $q \in (0,\, 1/2)$ and provided both the trading strategies are profitable, i.e., the pre fire sale shareholding is such that $h_0 \geqslant h_0^*$, then the mutual fund manager chooses to trade aggressively if only*

$$h_0 \geqslant \hat{h} = \frac{\theta\, q\, \pi_{tp,f_2}}{\Delta(1 + 3\,\theta\, q - \theta - 2\, q)}.$$

Proof. See Section A1.4 in Appendix A1. □

Proposition 4 gives two important conditions: feasibility of the trading strategies (both are profitable or not) and acceptability of trading strategies (which is more profitable). If both the trading strategies are profitable and $h_0 \geqslant \hat{h}_0$, then the mutual fund manager chooses aggressive trading strategy. Whereas if both the trading strategies are profitable and $h_0 < \hat{h}_0$, then the mutual fund manager chooses trading in sync with the noise trader . In Appendix A1 we show that $\forall\, \theta \in (0,\, 1]$, $\forall\, q \in (0, 1/2)$ and $c > \theta\, q\, \pi_{\text{tp}}$, the pre fire sale holding size that makes aggressive trading more profitable, i.e., $\hat{h}_0$, is less than the pre fire holding size that makes aggressive trading feasible. This result is formally stated in Proposition 5 below.

Proposition 5. *For all $\theta \in (0,\, 1]$, $q \in (0,\, 1/2)$ and $c > \theta\, q\, \pi_{tp,f_2}$, whenever aggressive trading is profitable, i.e., pre fire sale mutual fund's shareholding, $h_0 > h_0^a$, the mutual fund manager will choose aggressive trading strategy over the strategy of trading within the noise trader 's trading range; i.e., $\hat{h}_0 \leq h_0^a$.*

Proof. See Section A1.5 in Appendix A1. □

As stated earlier this makes the pre fire shareholding of the mutual fund critical for costly information production. Fortified with this result and Inequality (15) we are ready to define the pre fire sale equilibrium in our setup. Proposition 6 depicts the parametric conditions, investment strategy of an unbiased firm manager, and the mutual fund manager's decision to acquire costly information and his trading strategy, and the pricing strategy of the market-maker.

Proposition 6. *For all $\theta \in (0,\, 1)$ and $q \in (0,\, 1/2)$, $c > \theta\, q\, \pi_{tp,f_2}$ and $h_0 > h_0^a$*
(i) the mutual fund manager always acquire signal spending c dollars in period 0;
(ii) he always trade aggressively in period 1 such that whenever the mutual fund manager places buy order, all other agents in the market is aware of his exact trade without any uncertainty;
(iii) an unbiased firm manager always invests in period 2 whenever the mutual fund manager buys in period 1;
(iv) Market price per share in period 0 equals per share value of the assets-in-place plus the expected NPV per share of the novel investment; i.e., $p_0 = v + \theta\, q\, \delta$.

Proof. See Section A1.6 in Appendix A1. □

3.5 Fire sale, information production and firm value

What effects does a fire sale have in our set-up? Fire sale can cause the mutual fund manager to liquidate large chunks of his portfolio holding, and a result cause the post fire sale holding to drop to level lower than the minimum holding required to adopt either the aggressive trading strategy or to trade within the range of the noise trader . We have the following result stated in Proposition 7 below.

Proposition 7. *For all $\theta \in (0, 1]$ and $q \in (0, 1/2)$, $c > \theta\, q\, \pi_{tp,f_2}$, if the mutual fund's post fire sale shareholding, h_1 is less than h_0^a, then the mutual fund will stop producing costly information.*

Proof. See Section A1.7 in Appendix A1. □

Next, we look at the valuation effect of fire sale. If the mutual fund stops producing information, then the market-maker knows that an unbiased manager is not going to invest in the novel project irrespective of the trading outcome in period 1. Hence, the market price, which is $v + \theta\, q\, \delta$ in anticipation of a complete information production prior to the fire sale will drop to the v post fire sale in anticipation of the void in information production. We document this result formally in Proposition 8 below.

Proposition 8. *If the post fire sale mutual fund's share holding, h_1 is such that the mutual fund manager stops producing costly information, then an unbiased manager will stop investing in the novel project, and as a result value per share will drop from $p_1 = v + \theta\, q\, \delta$ to $p_1 = v$.*

Proof. See Section A1.8 in Appendix A1. □

Next, we consider the case of a biased firm manager. As we have already stated, a biased manager thinks that the ex ante likelihood of S^g is q^o, where $q^o > 1 - q^o$; hence, q^o is strictly greater than q. We define the level of bias of a biased manager by $B = q^o - q$. In Section 4 we derive the investment strategy of a biased manager, the decision to get informed and the trading strategy of the mutual fund knowing that the firm manager is biased.

4 Biased firm manager, fire sale and information production

As already stated, we consider two types of biased manager: first type of biased manager is so overconfident about his own assessment of investment projects that he does not care at all about market feedbacks about his investment decisions. We call this type of biased firm manager "extremely overconfident." There is a second types of biased manager who has a positive bias, $B > 0$ but does care about market feedback. We call this type of biased firm manager "overconfident."

4.1 Investment strategy of an extremely overconfident firm manager

Extremely overconfident manager thinks $q^o = 1$ or his assessment bias, $B = 1-q$. Hence, the market maker as well as the mutual fund manager knows that an extremely overconfident firm manager always invest irrespective of any market outcome. Thus, the market price prior to trading,

$$p_1^e = v + (2q - 1)\delta \tag{16}$$

where p_0^e is the price per share when the firm manager is extremely overconfident. We formally state the investment strategy of an extremely overconfident firm manager.

Proposition 9. *For all $\theta \in (0, 1)$, $q \in (0, 1/2)$ and $B = 1 - q$, an extremely overconfident firm manager invests in the novel project irrespective of the trading outcome in period 1.*

Proof. See Section A1.9 in Appendix A1. □

4.2 Investment strategy of an overconfident firm manager

We assume that the overconfident manager believes that $q^o > (1 - q^o)$, per share $NPV_g = \delta$ and per share $NPV_b = -\delta$. Hence, the expected NPV per share,

$$\bar{v}(q^o) = q^o \times (v + \delta) + (1 - q^o) \times (v - \delta) = v + (2\, q^o - 1)\, \delta \tag{17}$$

is positive. Hence the market maker as well as the mutual fund manager knows that the *biased* firm manager invest unless he receives a signal from the market that the likelihood of S_g is significantly lower than his initial assessment, q^0, say $\hat{q}$ – such that the expected NPV per share using $\hat{q}$ is negative. That is,

$$\bar{v}(\hat{q}) = \hat{q} \times (v + \delta) + (1 - \hat{q}) \times (v - \delta) \tag{18}$$

is strictly negative. For example, if the marketmaker observes f_5, then he knows that Prob$(mt = -1) = 1$, which further implies that Prob$(S_g) = \hat{q} = 0$; hence, using expression (18) we obtain value per share $\bar{v} = v - \delta$. Thus, the market maker sets market price, $p_1 = v$, reflecting the fact that even an overconfident manager is not going to invest in the novel project. Table A1 in Appendix A1 we derive the updated likelihood for each of the five possible aggregate order flow and analyze the investment decision of the firm. These results are formally stated in Proposition 10 below.

Proposition 10. *(i) For all $\theta \leqslant \bar{\theta} = 2 - \frac{1}{q}$ and $B > \frac{1}{2} - q$, an overconfident firm manager invests in the novel project if the observed order flow in period 1 is anything other than -2.*
(ii) For all $\theta > \bar{\theta} = 2 - \frac{1}{q}$, an overconfident firm manager invests in the novel project only if the observed order flow in period 1 is -1 or less.

Proof. See Section A1.10 in Appendix A1. □

If $q^o = 4/5$, then $\bar{\theta} = 3/4$; i.e., the likelihood of the mutual fund getting an informative signal has to be less than or equal to 75% so that an biased firm manager when he observes moderate sell interest in the market (f_4) concludes that it might have come from the noise trader with significant probability.

In Appendix A1 we derive the mutual fund's trading strategies, pre fire sale equilibrium and post fire equilibrium assuming that the firm manager is extremely overconfident. We derive the case when the firm manager is extremely overconfident or the firm manager is overconfident.

Proposition 11. *If the mutual fund gets informed and $\theta \leqslant \bar{\theta} = 2 - \frac{1}{q}$, then trading profit of the mutual fund when the firm manager is extremely overconfident is same as the trading profit of the mutual fund if the firm manager is overconfident; i.e., $\pi_{tp,e} = \pi_{tp,o}$.*

Proof. See Section A1.11 in Appendix A1. □

Since an extremely overconfident firm manager invests in the novel project irrespective of the market trading outcome in period 1, the mutual fund's decision to get informed is irrelevant as far as signal to the firm about the true state of the world is concerned. The following proposition formally states these results.

Proposition 12. *(i)The mutual fund will get informed if the trading profits earned is greater than cost of getting informed; i.e., $\pi_{tp,e} > c$ and the mutual fund's prior share holding plays no role in his decision to get informed.*
(ii) The firm value will stay fixed at $v + (2\,q - 1)\,\delta$ irrespective of market conditions.
(iii) Extremely overconfident manager will consider his firm as perennially undervalued, because his perceived valuation of the firm is $v + \delta$.

Proof. See Section A1.12 in Appendix A1. □

In Appendix A1 we discuss the case of an "overconfident" manager. Remember, an OC manager will not invest if market conditions are significantly negative: either f_5 or both f_4 and f_5 depending on the parameters of the model. Hence, a mutual fund with significant share holding prior to the fire sale has an incentive to sell aggressively whenever he does not receive signal g in an effort to try to prevent an OC manager investing in state S_b. In the process the mutual fund will lower its trading profits but will have less capital loss on his prior holdings. In fact, we show that the equilibrium that we established in the case of a rational manager – a separating equilibrium that conjectures that the mutual fund buys if it gets signal g, does not trade when it gets signal n and sells when it gets signal b – is not an equilibrium when the firm manager is overconfident and the mutual fund has significant share holding. What we show in Appendix A1 that the mutual fund still buys only when it gets signal g, but sells either when it gets signal n or signal b.

5 Data

Our study utilizes several standard finance databases. Our data on CEO compensation is from the Execucomp Database. We begin with all U.S. public firms with quarterly accounting information and executive compensation data in Compustat from 1992 to 2007.[10] We extract stock price information and mutual fund performance data from CRSP and mutual fund holding data from Thomson Reuters. We collect corporate news information from Factiva. After merging data from the above sources, we have an unbalanced panel data with 48,672 firm-quarter observations for 2,202 companies that have CEO overconfidence measures available from 1992 to 2007.

[10] We exclude data after 2007 from our sample to prevent the estimates from being driven by systemic liquidity shocks due to the financial crisis.

5.1 Overconfidence measures

The first measure of CEO overconfidence is based on the CEO's vested option holdings. The logic is that CEO's human capital is extremely undiversified. Also, shareholders deliberately tie a large part of CEOs' wealth to firm performance in order to incentivize CEOs to exert effort and make optimal decisions. Thus, a rational CEO should serve the labor-financial income link and diversify by exercising options when they vest and investing the money in assets not directly connected with the firm's performance. Therefore, holding vested in-the-money options represents a degree of overconfidence – investment based on "perceived" private information (see e.g., Malmendier and Tate, 2005a).[11]

We use Execucomp database to construct the CEO overconfidence measure. We first calculate the total value-per-option of the in-the-money options by dividing the value of all unexercised vested options (Execucomp item named: *opt_unex_exer_est_val*) by the number of options (Execucomp item named: *opt_unex_exer_num*). Next we scale this value-per-option by the stock price at the end of the fiscal year (Compustat item named: *prcc_f*). This gives an indication of the extent to which a CEO retains in-the-money options that are already vested. This is quite similar to the constructed measure in Malmendier and Tate (2008). Our measure differs slightly from those in Malmendier and Tate (2008) because the Execucomp database does not provide the same set of information on option holding as Malmendier and Tate's proprietary database. We examine a continuous variable, in addition to the indicator variable, due to prior evidence (in Ben-David et al., 2013) that many executives mis-calibrate the risk/return distribution, suggesting that there is a continuum of mis-calibration and overconfidence. The indicator variable equals one from the first year if the ratio exceeds 0.67 on at least two occasions.

We also use a press-based measure of overconfidence. As per Hirshleifer et al. (2012), we hand-collect data on how the press portrays each of the CEOs from 2000 to 2006. We search for articles referring to the CEOs in The New York Times (NYT), Business Week (BW), Financial Times (FT), The Economist, Forbes Magazine, Fortune Magazine and The Wall Street Journal. For each CEO and sample year, we record the number of articles containing the words "over confident" or "over confidence;" the number of articles containing the words "optimistic" or "optimism". We also record the number of articles containing the words "reliable", "cautious", "conservative", "practical", "frugal", or "steady." We carefully hand-check that these terms are generally used to describe the CEO in question and separate out newspaper articles describing the CEO of interest as "not confident" or "not optimistic." We then construct the variable "Net News", which is equal to the number of "confident" references less the number of non-confident references. This alternative proxy of CEO over confidence is significantly positively correlated with our option-based financial

[11] Malmendier and Tate (2005a, 2008) highlight that holding such in-the-money options is indeed a behavioral bias, and they find no evidence that such option-holdings support any real private information. This is because these companies tend to underperform the market rather than outperform, which would have been the case in real private information are involved. Further, while it is arguable that CEOs that choose to hold such options are simply well-incentivized, so should perform better, such an interpretation is inconsistent with the finding both in this paper, and in prior work (see e.g., Malmendier and Tate, 2005a, 2008), that option-based measures of overconfidence are weak negatively associated with corporate performance.

measures.

5.2 Mutual fund fire sales

We follow Edmans, Goldstein, and Jiang (2012) in measuring mutual fund flow-driven price pressure. The measure is calculated based on mutual fund holding data from Thomson Reuters and mutual fund return data from CRSP, excluding funds that specialize in a particular industry to address the concern that this measure might reflect industry fundamentals. First, we calculate mutual fund flows as:

$$Outflow_{j,t} = -F_{j,t}/TA_{j,t-1}, \tag{19}$$

where $F_{j,t}$ is the dollar inflow of fund j in quarter t, and $TA_{j,t-1}$ is the total assets of fund j at the end of previous quarter. We keep funds with $Outflow$ more severe than 5% (e.g. $Outflow_{j,t} \geq 5\%$) to ensure that we identify mutual fund that suffer from liquidity shocks. For each fund that experiences large outflow, we compute the percentage of fund's assets invested in each stock as:

$$s_{i,j,t} = \frac{SHARES_{i,j,t} \times PRC_{i,t}}{TA_{j,t}}. \tag{20}$$

$SHARES_{i,j,t}$ is the number of shares of stock i held by fund j in quarter t, and $PRC_{i,t}$ is the price of stock i in quarter t. Finally, we have the quarterly mutual fund flow-driven price pressure as:

$$MFFlow_{i,t} = \sum_{j=1}^{m} \frac{F_{j,t} s_{i,j,t-1}}{VOL_{i,t}}, \tag{21}$$

where $VOL_{i,t}$ is total dollar trading volume of stock i in quarter t and the measure is summed over funds that are identified as having extreme outflows. We define stocks as being under significant mutual fund flow-driven price pressure if $MFFlow_{i,t}$ is in the bottom decile of the sample.

This measure reflects a predicted pressure due to large outflows from mutual funds that hold the same stock, assuming that these funds would proportionally sell their existing holdings. For example, if a mutual fund holds one million shares of a stock at the beginning of the quarter and the fund is experiencing a 10% outflow, then *MFFlow* assumes that this fund will sell 100,000 shares of this stock. This construction differs from that in Coval and Stafford (2007), which captures the actual trading by mutual funds. Even when a mutual fund undergoes a liquidity shock, it can choose to sell a certain subset of its holdings and the selection may reflect the underlying firms' fundamentals. Thus looking at a *hypothetical* pressure inferred from the holding prior to the liquidity shock mitigates the endogeneity concern of the mutual fund pressure. In Section 6 we show that mutual funds do not systematically sell stocks managed by overconfident CEOs more than the other stocks when they experience large outflows.

5.3 Control variables

In the regression analysis, we include a number of firm and CEO characteristics that are related to firms' investment policies and/or stock liquidity, which is a primary factor for price stability during mutual fund fire sales. Firm characteristics include firm size, leverage, profitability, Tobin's Q, cash, tangibility, firm age, stock return volatility, stock illiquidity, and analyst coverage. CEO characteristics include CEO's age, tenure, cash compensation, and ownership. Detailed description of the variables is in Appendix A3.

5.4 Summary statistics

Table 1 presents summary statistics of the variables. In our sample, 61% of the observations are regarded as having an overconfident CEO by the option-based measure. This is in line with the observation by Malmendier and Tate (2005b), who find that 58 out of 113 firms in their sample are categorized as having an overconfident CEO based on the same measure. The press-based measure of CEO overconfidence shows that on average the number of articles that refer to a manager as confident is 3.14 more than those that refer to the manager as not confident. In Table A2 in Appendix A4, we show the fraction of observations each year that are subject to significant mutual fund flow-driven price pressure (*MFFlow* in the bottom decile). The result shows that every year some firms suffer from mutual fund fire sales. Further, mutual fund fire sales seem to take place more often around early 2000s.

6 Empirical Results

6.1 Biased CEOs and market learning

We start the empirical analysis by testing the hypothesis that overconfident CEOs are less likely to learn from the stock market when making investment decisions. Chen et al. (2007) show that firms' investment-Q sensitivity increases with price informativeness, suggesting that managers learn from stock prices for making investment decisions and that the response depends on the information quality of the stock prices. We thus follow their approach and test the market-learning hypothesis by examining whether overconfident managers have lower investment-Q sensitivity. We estimate the following model in the panel data

$$\begin{aligned} Investment_{t+1} =& \alpha_1 + \beta_1 Q_t + \beta_2 Q_t \times Confidence_t + \beta_3 Confidence_t \\ &+ \gamma_1' CONTROL + \phi_{i(j)} + \psi_t + \epsilon_{i,t}, \end{aligned} \tag{22}$$

where $Investment_{t+1}$ is the total investment in quarter $t+1$, defined as the sum of capital expenditure and R&D expenditure, divided by the average of current and lagged total assets. *CONTROL* refers to firm and CEO characteristics that are related to CEO overconfidence or investment policies, including *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, and *CEO Ownership*. ψ_t denotes time fixed effects, including year fixed effects and fiscal and calendar quarter fixed effects. We also control for firm or industry fixed effects in the regressions ($\phi_{i(j)}$). We predict that β_2 should be significantly negative while β_1 is significantly positive if overconfident managers are less responsive to stock prices than average managers.

The estimates are in Table 2. The result shows that overconfident CEOs do exhibit significantly lower investment-Q sensitivity. In column 1, β_1 is 0.0184 while β_2 is -0.0061, suggesting that overconfident CEOs who do not exercise their deep in-the-money options are 33.2% less sensitive stock prices compared with other CEOs when making their investment decisions. We find similarly significant difference when using the press-based measure of overconfidence. In columns 5 to 8, instead of directly using overconfidence measures, we divide the sample into terciles based on the two measures of overconfidence. Specifically, we sort the sample by the ratio of the value-per-vested-unexercised option to the average strike price of those options, or the difference in the number of articles that refer a manager as overconfident or non-overconfident. We then interact Tobin's Q with binary variables indicating firms with high, medium, or low level of CEO overconfidence. The estimates show that investment-Q sensitivity monotonically decreases with the level of CEO overconfidence in all different specifications. This pattern shows the robustness of our finding that overconfident managers tend to be less sensitive to stock prices when making their investment decisions.

Next, we test the market-learning hypothesis in the context of merger and acquisitions (M&A). Luo (2005) and Kau et al. (2008) find that managers learn from the market when making acquisition decisions: they are more likely to cancel an merger and acquisitions (M&A) deal when the market reacts negatively to the announcement. Based on our hypothesis, we conjecture that overconfident CEOs are less likely to cancel their announced acquisitions in response to negative market reactions to the announcements. To test this hypothesis, we collect all the takeover attempts for majority ownership over the sample period from the Securities Data Company (SDC). We follow (Edmans et al., 2012) and exclude acquisitions of partial stakes, minority squeeze-outs, buybacks, recapitalizations, and exchange offers. Additionally, we only keep bids for which the acquirers had a stake under 50% before the acquisition, and end with a final ownership over 50%. After merging with acquiring firms' accounting information and CEO compensation data from Compustat and stock price data from CRSP, the final sample consists of 15,196 M&A announcements from 1992 to 2007. We then test the Probit model below following Kau et al. (2008).

$$\begin{aligned} Pr(Cancel) = \quad & \Phi(\alpha_1 + \beta_1 CAR[-1,1] + \beta_2 CAR[-1,1] \times Confidence \\ & + \beta_3 Confidence + \gamma_1' CONTROL + \phi_j + \psi_t + \epsilon_{i,t}), \end{aligned} \tag{23}$$

where CAR[-1,1] is the market-adjusted cumulative abnormal return from one day before to one day after the M&A announcements. *CONTROL* refers to deal control variables including *Tender Offer Dummy*, *Compete Dummy*, *Litigation Dummy*, *Lockup of Target Shares Dummy*, *Target Termina-*

tion Fee Dummy, *Defense Dummy*, *Friendly Dummy*, *Public Target Dummy*, *Toehold Dummy*, and *Toehold Shares*, firm control variables including *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Return Volatility*, *Ln(Amihud)*, and *Ln(Analysts)*, and CEO characteristics including *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, and *Ln(CEO Ownership)*.[12] We also include industry fixed effects (ϕ_j) and announcement year fixed effects (ψ_t) in the regression. Our prediction suggests that β_1 (β_2) should be significantly negative (positive), if average managers are more likely to cancel an M&A deal in response to negative market reactions than overconfident managers.

Estimates presented in Table 3 confirm our prediction. The coefficient for CAR is significantly negative while the coefficient for the interaction is significantly positive, suggesting that overconfident CEOs are less sensitive to the market reaction to their acquisition announcements. To the extent that short term market movements around acquisition announcements reveal information about the value of the transactions, this finding further shows that overconfident managers are less likely to respond to investment-relevant information from the stock prices.

Finally, we examine how overconfident managers differ from other managers in responding to exogenous movement is the stock prices due to mutual fund fire sales. We focus on stock price movements in the quarters when mutual fund flow-driven price pressure is present (when *MFFlow* is in the bottom decile), and test the relation between the change in investment and the change in firm market value around fire sales using the following model:

$$\begin{aligned}\Delta Investment_{t-1,t+3} =& \alpha_1 + \beta_1 \Delta Q_{t-1,t+1} + \beta_2 \Delta Q_{t-1,t+1} \times Confidence_{t-1} + \beta_3 Confidence_{t-1} \\ &+ \gamma_1' CONTROL_{t-1} + \gamma_2' \Delta CONTROL_{t-1,t+1} + \phi_j + \psi_t + \epsilon_{i,t}, \qquad (24)\end{aligned}$$

Table 4 reports the estimates of Model (24). The coefficient for $\Delta Q_{t-1,t+1}$ is significantly positive, suggesting that exogenous drops in market value during mutual fund fire sales are associated with significant decrease in investment by managers. This is an indication that average managers adjust their investment policies in response to non-fundamental shocks to the stock prices. However, the coefficient for the interaction term $\Delta Q_{t-1,t+1} \times Confidence_{t-1}$ is significantly negative, implying that overconfident managers are less sensitive to stock price movements driven by mutual fund fire sales. Overall, the empirical evidence strongly support the idea that overconfident CEOs are less responsive to stock price fluctuations, whether it is driven by information or liquidity.

6.2 Biased CEOs and the price impact of mutual fund fire sales

The previous section confirms our conjecture that overconfident CEOs put less weight on market-generated information in making their investment decisions. As our model predicts, the feedback loop created by firms' learning from stock prices may create negative externality to the firm during mutual fund fire sales. Hence in this section we test whether firms with overconfident CEOs are less impacted by mutual fund fire sales due to their lower propensity to learn from the market.

[12] Detailed description of the deal control variables is in Appendix A4.

We start with a univariate comparison between stocks with and without overconfident CEOs. In Figure 2 we compare the cumulative abnormal returns (CARs) around mutual fund fire sales identified by the *MFFlow* measure between stocks with overconfident CEOs and the others. In subfigure 2a we divide the sample based on the option-based measure of CEO overconfidence. It shows that stocks with overconfident CEOs experience significantly less negative CARs during mutual fund fire sales. While stocks without overconfident CEOs have a more than 15% drop in value around mutual fund fire sales, stocks with overconfident CEOs only experience a 5% drop in firm value. Stocks with overconfident CEOs also have a faster price recovery: the average CAR for firms with overconfident CEOs reverses to zero within 18 months after mutual fund fire sales, while that of the other stocks do not reverse to zero even after two years. In subfigure 2b, when we divide the sample using the media-based measure of CEO overconfidence, the difference is more striking: the price impact of mutual fund fire sales on stocks with overconfident CEOs is only around 2% and is quickly reversed, while that on the other stocks is close to 20%. This sharp difference strongly supports our prediction, that stocks managed by overconfident CEOs are less vulnerable to mutual fund fire sales.

Next, we test the prediction formally in the following multivariate regression:

$$\begin{aligned} CAR_t = &\alpha_1 + \beta_1 Pressure_t + \beta_2 Pressure_t \times Confidence_{t-1} \\ &+ \beta_3 Confidence_{t-1} + \gamma_1' CONTROL_{t-1} + \phi_j + \epsilon_{i,t}, \end{aligned} \tag{25}$$

where CAR_t is one-quarter cumulative abnormal return, *Pressure* is a binary variable that equals one when *MFFlow* is in the bottom decile.[13] *CONTROL* denotes a set of control variables including *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, and *Ln(CEO Ownership)*. ϕ_j refers to the fixed effect for industry j. Our model predicts that β_2 should be significantly positive if firms with overconfident CEOs are less affected by mutual fund flow-driven pressure.

Table 5 reports the estimates of Model (25). The coefficient for *Pressure* is significantly negative, indicating that average firms have a significant drop in firm value when they are under mutual fund flow-driven pressure. Importantly, we find that the coefficient for interaction $Pressure_t \times Confidence_{t-1}$ is significantly positive across all the specifications. This estimate is consistent with what we observe in Figure 2, and confirms our prediction that the price impact of mutual fund fire sales is smaller for firms with CEOs who are less sensitive to market signals. The difference is also economically significant. For example, based on the coefficient estimate in column (1), the price impact of mutual fund fire sales on stocks with overconfident CEOs is 28.2% less than that on the other stocks.

The price impact of mutual fund fire sales depends on various stock characteristics, such as stock liquidity and the information environment. In Model (25) we control for various firm characteristics

[13] Our result is robust to using Carhart's (1997) four-factor alpha. We report the results in Table A4 in Appendix A4.

that may be relevant to firms' price stability during fire sales, such as stock illiquidity proxied by the Amihud's measure and analyst coverage. To further test the robustness of our result, we repeat the test using propensity score matching. Among all the firm-quarter observations under mutual fund fire sales (*MFFlow* in the bottom decile), we estimate the propensity score for being a treated firm (with overconfident CEOs) based on firm and manager characteristics in Model (25). We then match each treated firm with a neatest neighbor from the control group (without overconfident CEOs) based on propensity score (within 0.001 caliper). Panels A and B of Table 6 show the difference in firm characteristics between treated group and control group after matching. The difference is insignificant in all the characteristics, especially stock illiquidity and analyst coverage. The kernel density distribution of the propensity score presented in Figures A1a and A1b in Appendix A4 confirm the common support condition. At the bottom of the two panels we report the average treatment effect on the one-quarter CAR. The result shows that, after matching, firms with overconfident CEOs still have significantly less negative CARs during mutual fund fire sales compared with the other firms. Overall, we find robust evidence that firms with overconfident CEOs, who are less sensitive to market signals, are also significantly less affected by mutual fund fire sales in terms of decline in firm value.

6.3 Depth and breadth of ownership

Our model further predicts that the difference in the price impact of mutual fund fire sales between those with overconfident CEOs and the others should be weaker if there is greater depth or breadth of institutional ownership. This is because larger ownership will generally increase investors' incentives to acquire information even when facing large withdrawal. Firms with multiple large shareholders may also be less vulnerable to fire sales because when one investor fire sells a stock, other unaffected shareholders can still take the role of information acquisition. We therefore test this prediction by re-estimating Model (25) in subsamples divided based on the depth and breadth of institutional ownership.

In Panel A of Table 7, we divide the sample based on the average ownership per blockholder (depth of ownership). The result shows that, overall the price impact of mutual fund fire sales is weaker when the average block ownership is higher. Further, stocks with overconfident CEOs have significantly lower price impact by mutual fund fire sales only when the average block ownership is low. When the average block ownership is in the top quarter, stocks with different types of managers are similarly affected by mutual fund fire sales. This is consistent with our prediction that when the depth of ownership is significantly large, investors' incentives to produce information is less affected by managers' learning from the prices.[14]

In Panel B of Table 7, we divide the sample based on the number of blockholders (breadth of ownership). We again find consistent evidence, in that when there are three or more blockholders owning a stock, mutual fund fire sales have similar impact on the stock price, whether or not the firm is managed by overconfident CEOs. This supports our prediction that having more investors

[14]We find similar results using total institutional ownership. The results are in Table A3 in Appendix A4

with significant ownership can mitigate the joint impact of fire sales and managerial market-learning on firm value.

6.4 Cost of information acquisition

We next explore the role of information cost in driving our model predictions. As our model suggests, stocks with lower cost of information acquisition should be less affected by mutual fund fire sales because investors are more likely to acquire information despite a significant decrease in holding. Moreover, the role of CEO overconfidence in maintaining investors' incentive to collect information will be weaker if information is not costly to produce. We looking into two proxies for the cost of information acquisition. First, we look at multi-segment firms. Firms with multiple segments are generally harder to value given the complex structure. Learning and interpreting from the stock prices of multi-segment firms also become more difficult because the stock prices contain information of different sectors. The second proxy is analyst coverage. Security analysts can act as an alternative source of information, especially when stock mispricing occurs (Sulaeman and Wei, 2012). Hence lower analyst coverage indicates higher information cost.

We re-estimate Model (25) in subsamples divided based on the above two proxies. As Panels A and B of Table 8 show, stocks with overconfident CEOs experience less price drops compared with those without overconficant CEOs and this difference is significant only when firms have high cost of information acquisition, as reflected by having multiple segments and/or having two or fewer analysts following the stocks. This is consistent with our model that information cost exacerbates the impact of fire sales on firm value when the feedback effect is present.

6.5 Alternative explanations

Our model suggests that CEO bias improves price stability during mutual fund fire sales because their low sensitivity to market signals preserves investors' incentive to acquire information. However, there may be alternative explanations for the observed difference in the price impact of mutual fund fire sales. In this section, we examine several possible explanations.

First, it is possible that overconfident CEOs are more concerned about the price impact of mutual fund fire sales and hence take more aggressive actions against the price pressure. We test this possibility by estimating the following model:

$$\begin{aligned} Action_{t+1} = &\alpha_1 + \beta_1 Pressure_t + \beta_2 Pressure_t \times Confidence_t \\ &+ \beta_3 Confidence_t + \gamma_1' CONTROL + \phi_{i,(j)} + \psi_t + \epsilon_{i,t}, \end{aligned} \tag{26}$$

Biased CEOs may act against mutual fund fire sales by repurchasing stocks. We test this explanation by using the log of firms' stock repurchase over the next four quarters as the dependent variable for Model (26). If overconfident CEOs are more likely to repurchase stocks in response to mutual fund fire sales, then β_2 should be significantly positive. However, the estimates reported in Table 9 shows that the coefficient on the interaction in not statistically significant. Thus our empirical evidence does not support this mechanism in explaining the difference in the price drop during mutual fund fire sales.

Another possible action by overconfident CEOs is voluntary disclosure. If better transparency can facilitate price recovery, overconfident CEOs may improve the information environment in the market by increasing voluntary disclosure. We examine whether overconfident CEOs are more likely to issue managerial earnings forecasts in response to mutual fund fire sales in Model (26). Specifically, we a binary variable that indicates an issuance of earnings guidance in quarter $t+1$ as the dependent variable. The estimates in Table 10 again show that the coefficient for the interaction $Pressure_t \times Confidence_t$ is not statistically significant, thus overconfident CEOs are not more likely to issue earnings guidance in response to mutual fund fire sales.

The second possible explanation is that while mutual funds are under large outflow pressure, they choose not to sell stocks with overconfident CEOs for unobserved reasons. We explore this possibility by examining what mutual funds actually sell when they are under large outflow pressure:

$$MFSale_{i,t} = \sum_{j=1}^{m} \frac{min(Trade_{i,j,t}, 0)}{VOL_{i,t}}, \tag{27}$$

where $Trade_{i,j,t}$ is number of shares of stock i traded by fund j in quarter t, conditional on the fund having more than 5% outflow. $VOL_{i,t}$ is the total share trading volume of stock i in quarter t. We only focus on sales by these funds as only sales can be driven by mutual fund outflow shocks. Using this measure, we test whether mutual funds selectively sell other stocks more than stocks with overconfident CEOs using the following model:

$$\begin{aligned} MFSale_t =& \alpha_1 + \beta_1 MFFlow_t + \beta_2 MFFlow_t \times Confidence_{t-1} \\ &+ \beta_3 Confidence_{t-1} + \gamma_1' CONTROL_{t-1} + \phi_i + \epsilon_{i,t}. \end{aligned} \tag{28}$$

We use this model to check whether mutual fund outflow proportionally translate into actual selling to all the underlying stocks. First, we expect β_1 to be significantly positive if stocks with more mutual funds under outflow pressure indeed experience more selling by these funds. Further, if mutual funds under outflow pressure refrain from selling stocks with overconfident CEOs, then β_2 should be significantly negative.

Table 11 shows the estimates for Model (28). The coefficient on $MFFlow$ is significantly positive, suggesting that mutual funds under large outflows indeed sell a significant amount of their existing holdings. Importantly, the estimated coefficient for $MFFlow_t \times Confidence_{t-1}$, is not statistically significant, suggesting that stocks with overconfident CEOs are under the same actual selling pressure by their mutual funds when these funds undergo large outflow. Hence mutual funds' discretion of selling cannot explain the observed difference in price impact between firms with and without overconfident CEOs.[15]

[15]We also find insignificant results for the above alternative explanations using propensity score matching. We

7 Robustness tests

We also conduct a number of robustness tests which we report in Appendix A4. First, it is possible that CEO overconfidence is related to weak governance (Banerjee et al., 2015), which in turn affects price stability around mutual fund fire sales. To address this concern, we include *G Index* by Gompers, Ishii, and Metrick (2003) as a proxy for corporate governance in Model (25). This index reflects the level of takeover defenses, thus a higher index value reflects weaker corporate governance. Due to limited data availability of *G Index*, this test results in a smaller sample. Nevertheless, the results in Table A6 show that the difference in the price impact of mutual fund fire sales between firms with and without overconfident CEOs is greater after controlling for *G Index*. Thus corporate governance, at least as reflected by takeover defenses, cannot explain the weaker price impact of mutual fund fire sales on firms with overconfident CEOs.

Second, we examine whether price becomes less informative during mutual fund fire sales. As our model suggests, fire sales reduce investors' incentives to produce information, but this effect is attenuated if firm managers do not learn from the stock prices. Hence, we expect mutual fund fire sales to have a weaker negative effect on price informativeness among firms with overconfident CEOs. We measure price informativeness by estimating the predictability of quarter abnormal return for future earnings using the following model:

$$ROE_{t+1} = \alpha_1 + \beta_1 CAR_t + \beta_2 CAR_t \times Pressure_t + \beta_3 Pressure_t + \gamma_1' CONTROL + \phi_i + \psi_t + \epsilon_{i,t}. \tag{29}$$

The dependent variable ROE is measured by earnings before extraordinary items in quarter $t+1$ divided by market capitalization in quarter $t-1$. We use market value of equity in quarter $t-1$ so it is not affected by fire sales. CAR_t is the market-adjusted cumulative abnormal return in the current quarter. If stock returns are generally informative about future earnings, β_1 should positive. Further, we predict β_2 to be significantly negative if mutual fund fire sales reduce price informativeness. We estimate the regression in the subsamples of firms with and without overconfident CEOs. The results in Table A7 show that the coefficient for $CAR_t \times Pressure_t$ is significantly negative only when CEOs are not overconfident. Hence CEO overconfidence seems to attenuate the impact of mutual fund fire sales on price informativeness, which is consistent with out prediction.

Finally, we look beyond overconfident CEOs and use a more general measure of market learning – investment-Q sensitivity. All else equal, managers that tend to learn from stock prices in making investment decisions should exhibit greater investment-Q sensitivity (Chen et al., 2007). We therefore attempt to measure investment-Q sensitivity at the firm level and use it as a proxy for market learning. For each firm, we run the following time series regression over the sample period:

$$Investment_{t+1} = \alpha_1 + \beta_1 Q_t + \beta_2 Ln(Assets)_t + \beta_3 Profitability_t + \psi_t + \epsilon_{i,t}. \tag{30}$$

report the estimates in Table A5 in Appendix A4.

ψ_t refers to fiscal and calendar quarter fixed effects, which are included to control for seasonality in investment. Our focus is on β_1, the coefficient measuring investment-Q sensitivity. We define a firm as having significant investment-Q sensitivity if the estimated β_1 is in the top quartile of our sample and significant at 5% level. As our model predicts, firms that have significant investment-Q sensitivity should experience greater price drops during mutual fund fire sales.

The estimates of Model 30 are in Table A8. The result shows that stocks with significant investment-Q sensitivity have greater price drops during mutual fund fire sales. This is consistent with our main result where we use CEO overconfidence to capture managers' propensity to learn from stock prices. We note that investment-Q sensitivity can be driven by many factors other than market learning. For example, firms that are financially constrained and equity-dependent may also exhibit greater investment-Q sensitivity (Baker, Stein, and Wurgler, 2003). Also, investment-Q sensitivity at the firm level is subject to measurement error driven by liquidity in the data and the limited sample. Therefore, we believe that CEO overconfidence is a more intuitive way to capture a group of managers that tend to be less dependent on market information due to exogenous behavioral bias.

8 Conclusion

Our paper studies informed mutual fund trading, mutual fund fire sales, and institutional price pressure more generally, in equity markets by developing a simple model of informed trading and examining a large sample of stock transactions of mutual funds to test the empirical implications of our model. We consider two types of firm managers: an unbiased firm manager who relies heavy on market produced information to shape his firm's investment decisions and a biased manager, who take investment decision based on own assessment of the profitability of projects. We find that post mutual fund fire sale an unbiased firm manager reduces investment, and as a consequent there is a significant drop in his firm's market value; whereas, post mutual fund fire sale a biased firm manager keeps investments unchanged and and there is no change in his firm's market value. Empirically we find considerable support for the notion that investment-Q sensitivity is monotonically decreasing in CEO overconfidence and widespread selling by financially distressed mutual funds leads to significant drop in valuation of firms led by non-overconfidence CEOs but not much change in valuation of firms led by overconfident CEOs. These findings suggest that even in the most liquid markets fire sale can have long term valuation effects. We also throw light on one possible advantages of having a overconfident CEO when market activities do not reflect firm fundamentals.

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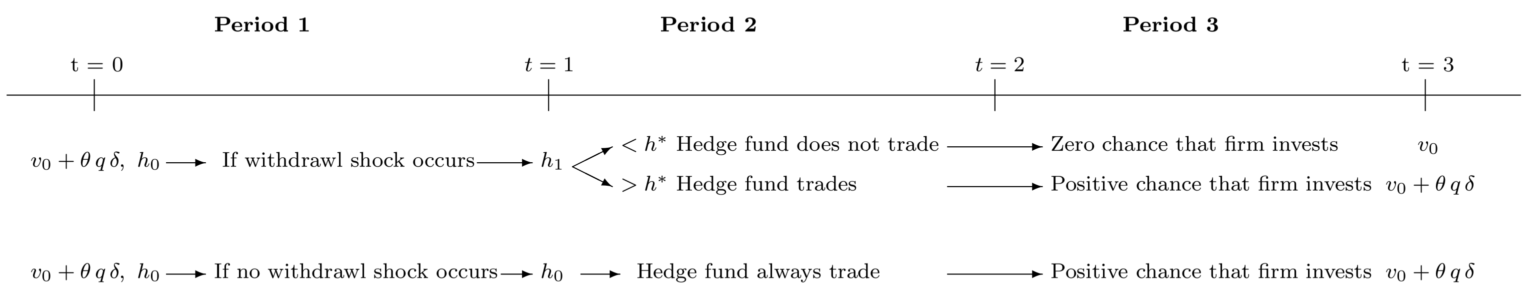
Figure 1: Model Timeline



A1 Appendix: Detailed derivation of the model

Suppose that the marketmaker conjectures that the mutual fund buys when her private signal is g, does not trade when his private signal is n, and she sells when her private signal is b. Also, the firm invests in the novel project if the NPV of the novel project conditioned on the secondary market price and volume at the end of period 1 is positive. The firm does not invest otherwise.

A1.1 Observed order flow and marketmaker's inference

Based on Table A1 we know that there are five distinct observed order flow (O) in this simple Kyle (1985) based model. Each communicate different information to the marketmaker as well as the firm manager. We denote the observed order flow in descending size of total order: $\{f_1 = +2,\ f_2 = +1,\ f_3 = 0,\ f_4 = -1,\ f_5 = -2\}$.

A1.1.1 The marketmaker observes order flow, f_1

The marketmaker knows that f_1 can occur only in one way: the mutual fund is buying and the noise trader is also buying. Hence,

$$\text{Prob}(g) = \frac{\mu_g}{\mu_g} = 1, \tag{A-1}$$

which implies that for sure signal is g which further implies that state of the world is S_g for sure. The marketmaker knows that in S_g, an unbiased manager is going to invest in the novel project. Hence, the marketmaker sets price, $p_1 = v + \delta$.

We also know that value per share of the firm conditional on private signal g and the firm manager invests ($\mathcal{I} = 1$) is $v + \delta$. This implies that trading profit conditional on signal g, f_1 and $I = 1$,

$$\pi_{\text{tp},f_1} = v + \delta - v - \delta = 0. \tag{A-2}$$

A1.1.2 The marketmaker observes order flow, f_2

The marketmaker knows that f_2 can occur two ways: either (i) the mutual fund is buying and the noise trader is not trading; or, (ii) the mutual fund is not trading and the noise trader is buying. The marketmaker cannot distinguish between these two possibilities; hence, the marketmaker uses bayes rule to updates the likelihood of private signals g (or the mutual fund buying) conditioned on order flow f_2. Thus,

$$\text{Prob}(g) = \frac{\mu_g}{\mu_g + \mu_n} = \frac{\theta\, q}{1 - \theta\,(1-q)}, \tag{A-3}$$

where Prob(g) is the updated likelihood of state S_g under the equilibrium conjecture of the trading strategies of the mutual fund.

Firm observes the market price and the order flow at the end of period 1. Using these the firm management decides whether to invest or not to invest in the novel project. An unbiased firm manager faces a dilemma: If the the mutual fund has private signal g, then the novel project is a positive NPV project and undertaking the novel project is a good decision; whereas if the the mutual fund received private signal n and does not trade in period 1, then the novel project on an average is a negative NPV project and investing in the novel project is a bad decision. On an average, the firm value is

$$\frac{\theta\, q}{1-\theta\,(1-q)}\,(v+\delta) + \frac{(1-\theta)}{1-\theta\,(1-q)}\,(v + (2\,q-1)\delta = v + \delta \left(\frac{2q}{1-\theta\,(1-q)} - 1\right) \tag{A-4}$$

Firm's decision rule: If increase in the firm value from capturing the positive NPV associated with state g outweighs the loss to the firm value from taking on a expected negative NPV project, then the firm will undertake the novel project. Otherwise, the firm will let go the novel project. This implies that for some sub ranges of θ within the relevant ranges $0 < \theta \leq 1$ and $0 < q < 1/2$, the expected NPV has be nonnegative.

$$\delta \left(\frac{2q}{1 - \theta\,(1-q)} - 1 \right) > 0. \tag{A-5}$$

Solving θ, for a given value of q gives us: $\underline{\theta} = \frac{1-2\,q}{1-q}$. For all $\theta \geq \underline{\theta}$, expected NPV is positive. It is straightforward to verify that for q strictly contained in $(0,\ 1/2)$, $\underline{\theta}$ is strictly contained in $(0,\ 1)$. For all $\theta < \underline{\theta}$, an unbiased firm manager will not invest in the novel project, because expected NPV is negative.

Trading profit of the mutual fund is the difference between valuation based on private valuation and market price. If the mutual fund gets signal g and $\theta \geq \underline{\theta}$, then private valuation,

$$v(g,\ I = 1) = v + \delta, \tag{A-6}$$

and the market price,

$$p_1(f_2) = v + \delta \left(\frac{2q}{1 - \theta\,(1-q)} - 1 \right) \tag{A-7}$$

Hence, the mutual fund's trading profit

$$\pi_{\mathrm{tp},\, f_2,\, \theta \geqslant \underline{\theta}} = v + \delta - v - \delta \left(\frac{2q}{1 - \theta\,(1-q)} - 1 \right) = 2\,\delta \left(1 - \frac{q}{1 - \theta\,(1-q)} \right). \tag{A-8}$$

If $\theta < \underline{\theta} = \frac{1-2\,q}{1-q}$, then the marketmaker knows that an unbiased manager is not going to invest even if f_2; hence, the marketmaker set period 1's price, $p_1(f_2, I = 0) = v$. Also, $v(g,\ I = 0) = v$ implying that

$$\pi_{\mathrm{tp},\, +1,\, \theta < \underline{\theta}} = v - v = 0. \tag{A-9}$$

A1.1.3 The marketmaker observes order flow, f_3

The marketmaker knows that f_3 can occur three ways: either (i) the mutual fund is buying and the noise trader is selling; or (ii) the mutual fund is not trading and the noise trader is also not trading; or (iii) the mutual fund is selling, whereas the noise trader is buying. The marketmaker cannot distinguish between these two possibilities; hence, the marketmaker uses bayes rule to updates the likelihood of private signals g (or the mutual fund buying) conditioned on order flow f_3. Thus,

$$\mathrm{Prob}(g) = \frac{\mu_g}{\mu_g + \mu_n + \mu_b} = \theta\, q;\ \mathrm{Prob}(n) = 1 - \theta;\ \mathrm{Prob}(b) = \theta\,(1-q). \tag{A-10}$$

On an average, the firm value is

$$\theta\, q\,(v + \delta) + (1-\theta)\,(v + (2q-1)\delta) + \theta\,(1-q)\,(v - \delta) = v + (2\,q - 1)\delta \tag{A-11}$$

Given $q < 1/2$, the expected value of NPV, $(2\,q - 1)\,\delta$ is strictly negative. Hence, an unbiased manager is not going to invest in the novel project. This further implies that $p_1(f_3) = v$, the private valuation $v(g\,\mathcal{I} = 0) = v$ and hence, the trading profit,

$$\pi_{\mathrm{tp},\ 0} = v - v = 0. \tag{A-12}$$

A1.1.4 The marketmaker observes order flow, f_4

The marketmaker knows that f_4 can occur two ways: either (i) the mutual fund is not trading and the noise trader is selling; or (ii) the mutual fund is selling and the noise trader is not trading. The marketmaker cannot distinguish between these two possibilities but knows for sure that the mutual fund manager did not buy; hence, the marketmaker knows that the likelihood of private signals g (or the mutual fund buying) conditioned on order flow f_4 is zero. Thus,

$$\text{Prob}(g) = 0;\ \text{Prob}(n) = \frac{\mu_n}{\mu_n + \mu_b} = \frac{1-\theta}{1-\theta\, q};\ \text{Prob}(b) = \frac{\theta\,(1-q)}{1-\theta\, q}. \tag{A-13}$$

On an average, the firm value is

$$\frac{(1-\theta)}{1-\theta\, q}(v + (2q-1)\delta) + \frac{\theta\,(1-q)}{1-\theta\, q}(v-\delta) = v + \delta\left(1 - \frac{2\,(1-q)}{1-\theta\, q}\right) \tag{A-14}$$

Given $(2q-1)\delta$ and $-\delta$ are both negative, the expected value of NPV is strictly negative. Hence, an unbiased manager is not going to invest in the novel project. This further implies that $p_1(f_3) = v$, the private valuation $v(g\,\mathcal{I} = 0) = v$ and hence, the trading profit,

$$\pi_{\text{tp},\,-1} = v - v = 0. \tag{A-15}$$

A1.1.5 The marketmaker observes order flow, f_5

The marketmaker knows that f_5 can occur only in one way: the mutual fund is selling and the noise trader is also selling. Hence,

$$\text{Prob}(g) = 0;\ \text{Prob}(n) = 0;\ \text{Prob}(b) = 1. \tag{A-16}$$

which implies that for sure signal is not g or n, which further implies that state of the world is S_b for sure. The marketmaker knows that in S_b, an unbiased manager is not going to invest in the novel project. Hence, the marketmaker sets price, $p_1 = v$.

We also know that value per share of the firm conditional on private signal b and the firm manager invests ($\mathcal{I} = 0$) is v. This implies that trading profit conditional on signal b, f_5 and $I = 0$,

$$\pi_{\text{tp},\,-2} = v - v = 0. \tag{A-17}$$

A1.1.6 Invest decision (I) of an unbiased firm manager

If $\theta \geqslant \underline{\theta}$ and $q \in (0,\ {}^1\!/_2)$, then an unbiased manager invests, i.e.,

$$\mathcal{I} = \begin{cases} 1 & \text{if expected NPV } \geq 0; \text{i.e., if order flow, } f_1 \text{ or } f_2; \\ 0 & \text{otherwise.} \end{cases} \tag{A-18}$$

Whereas if $\theta < \underline{\theta}$ and $q \in (0,\ {}^1\!/_2)$, then an unbiased manager invests, i.e.,

$$\mathcal{I} = \begin{cases} 1 & \text{if expected NPV } \geq 0; \text{i.e, only if order flow, } f_1; \\ 0 & \text{otherwise.} \end{cases} \tag{A-19}$$

For all O, an unbiased firm manager is expected not to invest, the marketmaker sets the price in period 1, $p_1 = v$. Also, irrespective of what private signal s is, if an unbiased firm manager is expected not to invest, the mutual fund manager's private valuation, $v(s, \mathcal{I} = 0)$ is always v.

A1.1.7 Expected trading profits of the mutual fund when there is an unbiased firm manager

If $\theta \geqslant \underline{\theta}$ and $q \in (0, 1/2)$, then

$$\pi_{\text{tp,u}} = \theta\, q \frac{1}{3} \pi_{\text{tp}} = 2\, \theta\, q \frac{1}{3} \left(1 - \frac{q}{1 - \theta\,(1-q)}\right) \delta$$

Wheras if $\theta < \underline{\theta}$ and $q \in (0, 1/2)$, then

$$\pi_{\text{tp,u}} = 0.$$

A1.2 Proof of Proposition 1

First, we show that if $O = +2$, an unbiased firm manager invests. We know from Section *A1.1.1* that Prob(g) =1. Under the market's conjecture of mutual fund's equilibrium trading strategies, we know that Prob(g) =1 implies Prob(S_g) =1. Hence, the expected NPV is equal to $\delta > 0$ if an unbiased firm manager invests. Hence, an unbiased firm manager invests.

Next, we show that if f_2, the expected NPV is nonnegative only if $\theta \geqslant \underline{\theta}$. We also show that the expected NPV is strictly negative for all $\theta < \underline{\theta}$. Differentiating the expected NPV conditional on f_2 (e.g., Equation (A-4)) w.r.t. θ we obtain

$$\frac{\partial}{\partial\,\theta}\left(\frac{2q}{1-\theta\,(1-q)} - 1\right)\delta = \frac{2(1-q)\,q}{(1-\theta\,(1-q))^2}\,\delta,$$

which is positive for all relevant ranges of θ and q. Hence, substituting the minimum value of θ and simplifying we get that the $\left(\frac{2q}{1-\theta\,(1-q)} - 1\right)\delta$ is nonnegative. Hence, for all $\theta \in [\underline{\theta}, 1]$ the expected NPV conditional on f_2 is nonnegative. Hence, an unbiased firm manager invests if f_2 and $\theta \geqslant \underline{\theta}$.

Substituting $\theta = 0$ we obtain expected NPV is equal to $(-1 + 2\,q)\delta]$, which is negative for $q \in (0, 1/2)$. Given at expected NPV is zero when $\theta = \underline{\theta}$ and expected NPV is strictly increasing function of θ, we know that for all $\theta \in (0, \underline{\theta})$, expected NPV conditional on f_2 is negative. Thus, an unbiased firm manager invests if f_2 and $\theta < \underline{\theta}$.

A1.3 Proof of Proposition 2

Decision to get informed depends on benefits of producing costly information and costs of producing information, c. If the mutual fund has no prior holding then the decision to get informed depends on the expected trading profit. For all $\theta \geqslant \underline{\theta}$ and using Equation (A-20), we know that expected trading profit,

$$\pi_{\text{tp,u}} = \theta\, q \frac{1}{3} \pi_{\text{tp}}$$

Hence, the mutual fund manager will not get informed if

$$c > \theta\, q \frac{1}{3} \pi_{\text{tp}} \text{ or } 3\,c > \theta\, q\, \pi_{\text{tp}}$$

Then, $c > \theta\, q\, \pi_{\text{tp}}$ implies that $3\,c > \theta\, q\, \pi_{\text{tp}}$ and this further implies that the mutual fund manager will not get informed only based on expected trading profit. For all $\theta \geqslant \underline{\theta}$ and pre fire sale holding, h_0, change in portfolio value of the mutual fund if it produces costly information and trades within the noise traders' trading range.

$$\pi_{\text{pv}} = \frac{1}{3}\theta\, q\, h_0\, \delta + \frac{1}{3}\,\theta\, q\, h_0\, \delta + \frac{1}{3}(1-\theta)\, h_0\,(2q-1)\,\delta = \frac{1}{3}h_0\,\delta\,(2\,q+\theta-1)$$

First two component is positive change in portfolio value due to investment when the mutual fund manager has signal g, and the third term is drop in portfolio value due to investment when the mutual fund manager has signal n and the noise trader buys. Hence, the mutual fund manager will get informed if $\theta \geqslant \underline{\theta}$ and his pre fire sale holding, h_0 is such that

$$\pi_{\text{pv}} + \pi_{\text{tp}} - c = \frac{1}{3}(2\,q+\theta-1)\,h_0\,\delta + \frac{1}{3}\theta\,q\,\pi_{\text{tp}} - c > 0$$

Solving for the critical value of pre fire sale holding, h_0^* for all $\theta \geqslant \underline{\theta}$ and $q \in (0,\, 1/2)$, we obtain

$$h_0^* = \frac{3\,c - \theta\,q\,\pi_{\text{tp}}}{(2q+\theta-1)\,\delta}$$

If $\theta < \underline{\theta}$ and $q \in (0,\, 1/2)$, then from Equation (A-20) we know that $\pi_{\text{tp},\,\theta<\underline{\theta}} = 0$. We also know that an unbiased firm manager does not invest if f_2. Hence, change in portfolio value for low θ,

$$\pi_{\text{pv},\,\theta<\underline{\theta}} = \frac{1}{3}\theta\,q\,h_0\,\delta.$$

Thus, the mutual fund manager will get informed if $\theta \geqslant \underline{\theta}$ and his pre fire sale holding, h_0 is such that

$$\frac{1}{3}\theta\,q\,h_0\,\delta - c$$

The mutual fund manager will get informed if $\theta < \underline{\theta}$ and his pre fire sale holding, h_0 is such that

$$h_0^{**} = \frac{3c}{q\delta\theta}.$$

A1.4 Proof of Proposition 4

Proof. If the mutual fund manager trades aggressively, then his total gain (same as his portfolio gain),

$$\theta\,q\,h_0\,\Delta \tag{A-20}$$

If the mutual fund manager trades in sync with the noise trader, then total gain (portfolio gain plus trading gain),

$$\frac{1}{3}\theta\,q\,h_0\Delta + \frac{1}{3}\theta\,q\,h_0\Delta - \frac{1}{3}(1-\theta)h_0(1-2\,q)\Delta + \frac{1}{3}\theta\,q\,\pi_{\text{tp},f_2} \tag{A-21}$$

Solving for the critical value of the pre fire sale holding, h_0 such that expressions (A-20) and (A-21) are equal, we obtain

$$\hat{h}_0 = \frac{\theta\,q\,\pi_{\text{tp},f_2}}{\Delta(1+3\theta\,q-2\,q-\theta)}$$

Next, we show that for all $q \in (0,\, 1/2)$ and $\theta \in (0,\,1]$, the term $1-\theta+q\,(3\,\theta-2)$ is positive. Substituting the minimum value of $\theta = \frac{1-2\,q}{1-q}$ and the maximum value of $\theta = 1$ in the expression $1-\theta+q\,(3\,\theta-2)$ and simplifying we get the value of the expression as $2\left(2-\frac{1}{1-q}\right)$ and q respectively. We find that $2\left(2-\frac{1}{1-q}\right)$ is monotonically decreasing in q implies that the minimum value $2\left(2-\frac{1}{1-q}\right)$, which is 0 is obtained by substituting maximum value of $q = 1/2$. Hence, for the expression $1-\theta+q\,(3\,\theta-2)$ the minimum value is nonnegative and the maximum value is positive. It is also monotonic in θ; and also, q is bounded away from either 0 or $1/2$. Hence, the result. □

A1.5 Proof of Proposition 5

Proof. To show that $\hat{h}_0 < h_0^a$, we need to show $1+3\theta\,q-2\,q-\theta > \theta\,q$. This is because the numerator of $\hat{h}_0$ is smaller than the numerator of h_0^a by assumption. If the denominator of $\hat{h}_0$ is bigger than the denominator of h_0^a, then $\hat{h}_0$ will be smaller than h_0^a. Note that $1+3\theta\,q-2\,q-\theta-\theta\,q$ is a linear function of θ. Taking the derivative of $1+3\theta\,q-2\,q-\theta-\theta\,q$ w.r.t. θ, we obtain

$$\frac{\partial}{\partial\theta}1+3\theta\,q-2\,q-\theta-\theta\,q=-1+2\,q,$$

which negative for all relevant values of q. Hence, substituting the maximum value of θ in the expression we get

$$1+3\,q-2\,q-1-q=0,$$

which is nonnegative. Hence, $1+3\theta\,q-2\,q-\theta$ weakly greater than $\theta\,q$ at $\theta=1$ and strictly greater than $\theta\,q$ everywhere else. Hence, the proof. □

A1.6 Proof of Proposition 6

Deviation with signal g

There are two possible deviations: either do not trade or sell.
<u>If the mutual fund does not trade</u>
Only f_2 can occur and an unbiased manager will invest if $\theta > \underline{\theta}$. Then the mutual fund's change in portfolio value from not trading with signal g is equal to

$$h_0\,\frac{1}{3}(2\,q-1)\delta-c,$$

which is strictly negative given $q<\frac{1}{2}$ and strictly less than $h_0\,\delta-c$, which is what the mutual fund earns if it plays the equilibrium strategy of buying with signal g.
<u>If the mutual fund sells</u>
hen both f_1 and f_2 cannot occur on the equilibrium path, which further implies that investment cannot occur on the equilibrium path given an unbiased manager. Hence, the mutual fund's change in portfolio value is equal to $-c$ instead of $h_0\,\delta-c$ which is strictly positive.

Hence, the mutual fund with signal g will buy and trade aggressively given our assumption that $h_0 > h_0^a > \hat{h}_0$.

Deviation with signal n

There are two possible deviations: either buy or sell.
<u>If the mutual fund buys</u>
Both f_1 and f_2 can occur and an unbiased manager will invest if $\theta > \underline{\theta}$. Then the mutual fund's change in portfolio value from buying with signal n is equal to

$$h_0\,\frac{2}{3}(2\,q-1)\,\delta-c,$$

which is strictly negative given $q < \frac{1}{2}$ and strictly less than $-c$, which is what the mutual fund earns if it does not trade.

<u>If the mutual fund sells</u>

Then both f_1 and f_2 cannot occur on the equilibrium path, which further implies that investment cannot occur on the equilibrium path given an unbiased manager. Hence, the mutual fund's change in portfolio value is equal to $-c$ instead of $h_0\,\delta - c$ which is strictly positive.

Hence, the mutual fund with signal n will does not trade.

Deviation with signal b

There are two possible deviations: either buy or do not trade.

<u>If the mutual fund buys</u>

Both f_1 and f_2 can occur and an unbiased manager will invest if $\theta > \underline{\theta}$. Then the mutual fund's change in portfolio value from buying with signal n is equal to

$$-h_0\,\frac{2}{3}\,\delta - c,$$

which is strictly negative and strictly less than $-c$, which is change in mutual fund's profit if it sells.

<u>If the mutual fund do not trade</u>

Then only f_2 can occur on the equilibrium path, which further implies that investment can occur on the equilibrium path given an unbiased manager. Hence, the mutual fund's change in portfolio value is equal to $(2\,q - 1)\,\delta - c$ instead of $-c$.

Hence, the mutual fund with signal b will sell.

A1.7 Proof of Proposition 7

Proof. If post fire sale holding $h_1 < h_0^a$, which also implies that $h_1 < h_0^*$, because we have shown in Lemma then total profit of the mutual fund

$$h_1\,\theta\,q\Delta < c.$$

This implies that the mutual fund will not collect costly information. Note that $h_1 < h_0^*$ rules out the strategy to trade within the trading range of the noise trader. Hence, the proof. □

A1.8 Proof of Proposition 8

Given that the pre fire sale holding $h_0 > h_0^a$, the mutual fund was always producing information because it is profitable for them to do so. Hence, the pre fire sale expected price,

$$p_0 = v + \theta\,q\,\delta.$$

At date 1 if there is a withdrawal shock and the mutual fund's holding drop to h_1, then as shown in Proposition 7 the mutual fund is not not going to produce costly information. The market maker knows that without the mutual fund's information, an unbiased manager is not expected to invest. Hence, the post fire sale expected price,

$$p_1 = v,$$

i.e., a drop of $\theta\,q\,\delta$ is per share value.

A1.9 Proof of Proposition 9

If $B = 1 - q$, then $q^e = q + B = q + 1 - q = 1$, irrespective of the value of q. Even if updated q = 0, i.e., observed order flow is less than or equal to -2, updated $q^e = 1$. Hence, expected perceived value of the firm conditional on investment $= v + \delta$ based on perceived q^e.. Thus, the biased CEO invests in the novel project irrespective of what the market trading outcome is.

A1.10 Proof of Proposition 10

On an average, the firm value is

$$\theta\,(1-q)\frac{1}{3}\,(v-\delta) + (1-\theta)\,\frac{1}{3}\,(v+(2q-1)\delta) + \theta\,(1-q)\,(v-\delta) \tag{A-22}$$

If solving the expected value equation with the mutual fund not trading or selling we get

$$\theta < \bar{\theta} = 2 - \frac{1}{q}.$$

A1.11 Proof of Proposition 11

If the firm manager is extremely overconfident, then the firm manager invests in all observed order flows. If the firm manager is overconfident and $\theta \leqslant \bar{\theta} = 2 - \frac{1}{q}$, then the firm manager invests in all observed order flows except -2. Hence, the MF manager earns trading profits. But order flow -2 reveals with probability 1 to the marketmaker that the MF manager has sold. Also, the marketmaker knows that an overconfident firm manager will not invest if the observed order flow is -2; hence, the marketmaker set price equal to v. Thus, the MF manager does not earn any trading profit if the observed order flow is -2.

A1.12 Proof of Proposition 12

Lemma 1. *For all $q \in (0,\, 1/2)$ and $\theta \in [\underline{\theta},\, 1]$, the term $2\,q + \theta - 1$ is positive.*

Proof. Substituting the minimum value of $\theta = \frac{1-2\,q}{1-q}$ in the expression $2\,q + \theta - 1$ and simplifying we get

$$1 + 2\,q - \frac{1}{1-q} \tag{A-23}$$

The last component of the above expression, $\frac{1}{1-q}$ is a increasing function of q. Hence, the maximum value of $\frac{1}{1-q}$ is 2, which we obtain if we substitute the maximum value of $q = 1/2$. But value of the two other component of the above expression, $1+2q$ also sum to 2 when $q = 1/2$. Hence, expression A-23 is always nonnegative. Any higher values of θ will increase the positive component of the expression A-23. Also, q is bounded away from either 0 or $1/2$. Hence, the result. □

Lemma 2. *For all $q \in (0,\, 1/2)$ and $\theta \in (\underline{\theta},\, 1]$, the expression $h_0^* - h_0^a$ is positive.*

Proof. Given our assumption $c > \theta\, q \pi_{\mathrm{tp},f_2}$ to show that $\frac{3\,c - \theta\, q \pi_{\mathrm{tp},f_2}}{(2\,q+\theta-1)\,\Delta} - \frac{c}{\theta\, q\, \Delta} > 0$, it is sufficient to show that $\frac{2}{(2\,q+\theta-1)} - \frac{1}{\theta\, q} > 0$. Simplifying the expression and rewriting it we get

$$2\,\theta\, q - (2\,q + \theta - 1) = (1 - 2\,q)(1 - \theta),$$

which is positive for all relevant values of q and θ. Hence, the proof. □

A2 Overconfident firm manager and equilibrium in the secondary market

Next, we consider the trading strategy of the mutual fund. We know that due to the bias, there will be trading profits if f_2, f_3 and if a biased manager invests also f_4. For example, if the mutual fund manager gets good signal, i.e., $s = g$ and the firm invest, i.e., $I = 1$, then $v(g, 1) = v + \delta$. Note that $v(g, 0) = v$, where $I = 0$ implies that a biased firm manager is not investing. Similarly, we derive $v(\cdot)$ for all other {s, I} combinations in Appendix A1. Hence, the trading profit (denoted by π_{tp}) of the mutual fund conditional on a particular order flow (f) can be defined as follows:

$$\pi_{\text{tp, o}} = v(s,\, I) - p_1(O,\, I), \tag{A-24}$$

where $p_1(O,\, I)$ is the per share price set by the marketmaker in period 1 based on the observed order flow (O) and his conjectured investment strategy of the firm (I). In Appendix A1 we derive the trading profit for different trading outcomes, different private signal of the mutual fund and investment strategy of a biased manager. We show that $\pi_{tp} > 0$ only if $O = +1$ and $\theta \geqslant \underline{\theta}$. Specifically,

$$\pi_{\text{tp, o}} = \left\{0,\, 2\,\delta\,\left(1 - \frac{q}{1-\theta\,(1-q)}\right),\, 2\,(1-q)\,\delta,\, 2\,q\,\delta,\, \frac{2\,(1-\theta)\,q\,\delta}{1-\theta\,q},\, 0\right\}, \tag{A-25}$$

where δ is the per share value generated from the novel project and $\pi_{\text{tp, u}}$ is the trading profit of the mutual fund when an unbiased firm manager is taking the investment decision. Note that $\left\{2\,(1-q)\,\delta,\, 2\,q\,\delta,\, \frac{2\,(1-\theta)\,q\,\delta}{1-\theta\,q}\right\}$ are the additional trading profits, when $\theta < \bar{\theta}$ and a biased manager is taking the investment decision. Multiplying by the likelihood of each order flow, we derive the expected trading profit in Appendix A1.

Since the trading profit is bigger when there is a biased manager, it may be be sufficient to incentivize the mutual fund manager to produce costly information even if the pre sale portfolio holding is $h_0 \approx 0$. If we assume that $c = 4$, $\delta = 15$, $q = 0.4$ and $\theta = 0.65$, then trading profit, then additional trading profit is 3.86, which gives $\pi_{\text{tp, o}} = 3.86 + 0.895 = 4.755 > 4.00 = c$. Remember, we assumed in the unbiased manager case that the cost of information production is three times thet trading profit when the observed order flow, f_2; i.e., $c = 4 > 3 \times \pi_{\text{tp, u}} = 3 \times 0.895 = 2.685$. Hence, the sufficient condition for the mutual fund manager to produce costly information when there is a biased manager taking the investment decision is stated in Proposition 13 below.

Proposition 13. *For all $\theta \in (0,\, \bar{\theta})$, $q \in (0,\, 1/2)$, $c > \theta\, q\, \pi_{tp}$, if*

$$c < c^* = \frac{2\,\theta\,q\,(1-q)\delta\,(1-\theta\,(2-\theta-q\,(3-\theta-2\,\theta\,q)))}{3\,\left(1-\theta(1-\theta\,q\,(1-q)\right)} + \theta\,q\,\pi_{tp}$$

and the firm manager is biased, then the mutual fund will costly produce information irrespective of its level of pre fire sale shareholding, h_0.

Proof. See Section XXX in Appendix A1. □

A2.1 Fire sale, information production and firm value

When the firm manager is biased, expected trading profit of the mutual fund is sufficiently large to induce the mutual fund manager to produce costly information. Pre fire sale shareholding will have no implication for the investment decision of the firm, when the firm manager is a biased. Hence, fire sale cannot have any implication on the decision to produce costly information.

But biased manager's investment strategy has adverse effect on the mutual fund's portfolio value. Since a biased manager invest when the mutual fund manager gets an uninformative signal or sometimes even when the mutual fund manager has signal b. This cause value of the mutual fund to have lower value. Next, we show that if the mutual fund's pre fire sale holding, h_0 is large, then it is optimal for the mutual fund to trade aggressive whenever he gets signal b and make sure that there is no uncertainty about his selling and hence, signal b. Again, the mutual fund manager knows that by trading aggressively when he gets signal b, then he has to forgo all his trading profits associated with selling within the range of noise trader. The following Proposition 14 formally state this result.

Proposition 14. *(i) For all $\theta \in (0, \bar{\theta})$, $q \in (0, 1/2)$ and $B > 1/2 - q$, the mutual fund manager will trade aggressively and all trading profits associated with selling within the noise trader's trading range whenever he gets signal b and his pre fire sale holding, $h_0 \geqslant H_0^*$, where*

$$H_0^* = \frac{\delta\,(1-q)\,(2-\theta-\theta\,q)}{\Delta\,(1-\theta\,q)}.$$

(ii) For all $\theta \in [\bar{\theta}, 1]$, $q \in (0, 1/2)$ and $B > 1/2 - q$, the mutual fund manager will trade aggressively and all trading profits associated with selling within the noise trader's trading range whenever he gets signal b and his pre fire sale holding, $h_0 \geqslant H_0^{**}$, where

$$H_0^{**} = \frac{2\,\delta\,(1-q)}{\Delta}.$$

(ii) For all $\theta \in (0, 1]$, $q \in (0, 1/2)$ and $B > 1/2 - q$, the mutual fund manager will trade within the trading range of the noise trader if he gets signal b if his pre fire sale holding, $h_0 < H_0^*$.

Proof. See Section A1.3 in Appendix A1. □

Intuition is quite straightforward: if the mutual fund has large pre fire sale holding (i.e., $h_0 \geqslant H_0^*$), stopping a biased manager from investing in state S_b prevents a large loss in portfolio value of the mutual fund. Since a biased manager does not invest only if the observed order flow, $O = -2$ when $\theta < \bar{\theta}$, one way to prevent value destroying investment to make sure that whenever the mutual fund manager gets signal b he trades in such a way that the observed order flow, $O \geqslant -2$. Naturally, full revealing trade by the mutual fund manager does not allows him to capture trading profit associated with $O = 0$ and f_4, which occurs when the mutual fund manager sells and the noise trade buys or the noise trader does not trade. Part (ii) of Proposition 14 shows that $h_0 \geqslant H_0^{**}$ is a sufficient condition for aggressive trading, because $\theta \geqslant \bar{\theta}$ implies that a biased manager does not invest even when $O = -1$. This lowers that trading profits as well as the drop in portfolio value due to suboptimal investment when observed order flow, $O = -1$. Part (iii) of Proposition 14 shows that if the mutual fund's pre fire sale holding is small keeping the trading profits associated with selling within the noise trader's trading range and forgoing efforts to prevent suboptimal investment is the optimal thing to do for the mutual fund manager.

Table A1: Depicting different market trading outcomes

Mutual Fund's market order (mt)	Noise Trader's market order (nt)	Marketmaker observed order flow, ($mt+nt$)	Likelihood of various ways this order flow, (($mt+nt$) can occur	Probability of the mutual fund buying ($\bar{q}$)
The mutual fund getting informative signal g				
+1	+1	+2	$\theta\, q\, \frac{1}{3}$	1
+1	0	+1	$\theta\, q\, \frac{1}{3} + (1-\theta)\frac{1}{3}$	$\frac{\theta\, q}{1-\theta\,(1-q)}$
+1	-1	0	$\theta\, q\, \frac{1}{3} + (1-\theta)\frac{1}{3} + \theta\,(1-q)\, \frac{1}{3}$	$\theta\, q$
The mutual fund getting uninformative signal n				
0	+1	+1	$\theta\, q\, \frac{1}{3} + (1-\theta)\frac{1}{3}$	$\frac{\theta\, q}{1-\theta\,(1-q)}$
0	0	0	$\theta\, q\, \frac{1}{3} + (1-\theta)\frac{1}{3} + \theta\,(1-q)\, \frac{1}{3}$	$\theta\, q$
0	-1	-1	$(1-\theta)\, \frac{1}{3} + \theta\,(1-q)\frac{1}{3}$	0
Mutual fund getting informative bad signal b				
-1	+1	0	$\theta\, q\, \frac{1}{3} + (1-\theta)\frac{1}{3} + \theta\,(1-q)\, \frac{1}{3}$	$\theta\, q$
-1	0	-1	$(1-\theta)\, \frac{1}{3} + \theta\,(1-q)\frac{1}{3}$	0
-1	-1	-2	$\theta\,(1-q)\, \frac{1}{3}$	0

A4 Appendix: Additional Empirical Results

Table A2: Mutual Fund Fire Sales by Year

This table shows the percentage of observations with mutual fund fire sales, defined as *MFFlow* in the bottom decile.

Year	Percentage of Observations with Fire Sales
1992	4.84%
1993	5.08%
1994	7.75%
1995	6.13%
1996	6.41%
1997	4.77%
1998	14.16%
1999	28.29%
2000	17.30%
2001	4.71%
2002	15.42%
2003	8.48%
2004	9.86%
2005	16.79%
2006	12.26%
2007	3.37%

Table A3: Institutional Ownership, CEO Overconfidence and CAR under Mutual Fund Pressure

This table presents the differential price impacts of mutual fund price pressure in subsamples based on institutional ownership. The dependent variable is the quarterly cumulative abnormal return. The independent variables of interest are the interactions between *Pressure* and measures of CEO overconfidence. The following lagged control variables are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, *Ln(CEO Ownership)*, *Ln(Amihud)*, and *Ln(Analysts)*. Industry fixed effects are also included. *t*-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	*One-quarter CAR adjusted by*			
	R_m^{EW}		R_m^{VW}	
Institutional Ownership:	Low	High	Low	High
	(1)	(2)	(3)	(4)
Pressure	-0.0199***	-0.0101***	-0.0284***	-0.0093***
	(-8.42)	(-3.94)	(-7.79)	(-2.88)
Pressure × Confidence Options	0.0061*	0.0010		
	(1.87)	(0.33)		
Pressure × Confidence Press			0.0028***	0.0005
			(2.99)	(0.59)
Confidence Options	0.0014	0.0042***		
	(1.02)	(3.32)		
Confidence Press			0.0020***	0.0014***
			(4.29)	(3.76)
Observations	17,069	17,438	9,116	9,356
Adjusted R^2	0.014	0.012	0.029	0.016
Lagged Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes

Table A4: Four-factor Alpha under Mutual Fund Pressure

This table shows that the weaker price impact of mutual fund fire sales on firms with overconfident CEOs is robust to using Carhart (1997) four-factor alpha.

Dependent Variable:	*Four-factor Alpha*	
	(1)	(2)
Pressure	-0.0003***	-0.0006***
	(-4.67)	(-5.37)
Pressure × Confidence Options	0.0002*	
	(1.76)	
Pressure × Confidence Press		0.0001**
		(2.28)
Confidence Options	0.0001***	
	(2.85)	
Confidence Press		0.0001***
		(7.83)
Observations	45,157	22,952
Adjusted R^2	0.016	0.025
Lagged Firm Controls	Yes	Yes

Table A5: Difference in Share Repurchase, Earning Guidance and Mutual Fund Sales in the Matched Sample

This table present the difference in stock repurchase, earnings guidance, and actual mutual fund trade during mutual fund price pressure between firms with and without overconfident CEOs in the matched sample.

Propensity Score Matched Sample						
Variable	Treated	Confidence Measure	Controls	Difference	S.E.	T-stat
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Repurchase)	Option	1.934	1.814	0.119	0.083	1.43
Ln(Repurchase)	Press	2.048	2.004	0.044	0.127	0.35
Earnings Guidance	Option	0.310	0.310	-0.001	0.018	-0.04
Earnings Guidance	Press	0.493	0.479	0.014	0.026	0.53
Mutual Fund Sales	Option	-1.280	-1.235	-0.045	0.057	-0.79
Mutual Fund Sales	Press	-1.140	-1.113	-.0272	0.069	-0.40

Table A6: CEO Overconfidence and CAR under Mutual Fund Pressure: Controlling for Governance

This table shows that the weaker price impact of mutual fund fire sales on firms with overconfident CEOs is robust after controlling for the level of corporate governance as proxied by *G Index* (Gompers, Ishii, and Metrick, 2003).

Dependent Variable:	*One-quarter CAR adjusted by*			
	R_m^{EW}		R_m^{VW}	
Institutional Ownership:	Low	High	Low	High
	(1)	(2)	(3)	(4)
Pressure	-0.0166***	-0.0175***	-0.0157***	-0.0146***
	(-8.45)	(-6.41)	(-8.27)	(-5.50)
Pressure × Confidence Options	0.0068***		0.0071***	
	(2.85)		(3.05)	
Pressure × Confidence Press		0.0021***		0.0014**
		(3.00)		(2.04)
Confidence Options	0.0016*		0.0028***	
	(1.67)		(2.99)	
Confidence Press		0.0014***		0.0022***
		(4.83)		(7.63)
G Index	-0.0000	0.0000	0.0002	0.0001
	(-0.08)	(0.07)	(0.95)	(0.66)
Observations	29,175	16,987	29,175	16,987
Adjusted R^2	0.013	0.021	0.019	0.038
Lagged Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes

Table A7: CEO Overconfidence and Price Informativeness under Mutual Fund Pressure

In this table, we show that the impact of mutual fund fire sales on price informativeness is insignificant for firms with overconfident CEOs. We measure price informativeness in terms of the predictability of quarterly cumulative abnormal return for future earnings, and estimate the regressions in subsamples with and without overconfident CEOs. The dependent variable is *ROE*, measured as earnings before extraordinary items in quarter $t+1$ divided by market capitalization in quarter $t-1$. The independent variable of interest is the interactions between *CAR* and *Pressure* in quarter t. The following lagged control variables are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, *Ln(CEO Ownership)*, *Ln(Amihud)*, and *Ln(Analysts)*. Firm fixed effects are also included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	ROE_{t+1}			
OC based on:	Option		Press	
Sample:	Non-OC	OC	Non-OC	OC
	(1)	(2)	(3)	(4)
CAR^{EW}	0.0561***	0.0495***	0.0565***	0.0318***
	(6.87)	(11.79)	(6.11)	(4.71)
CAR^{EW} × Pressure	-0.0387**	-0.0158	-0.0445**	-0.0094
	(-2.00)	(-1.55)	(-2.07)	(-0.45)
Pressure	0.0013	0.0012**	0.0011	-0.0005
	(1.25)	(2.01)	(0.93)	(-0.76)
Observations	19,016	29,402	12,545	12,699
Adjusted R^2	0.298	0.294	0.385	0.333
Lagged Firm Controls	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes

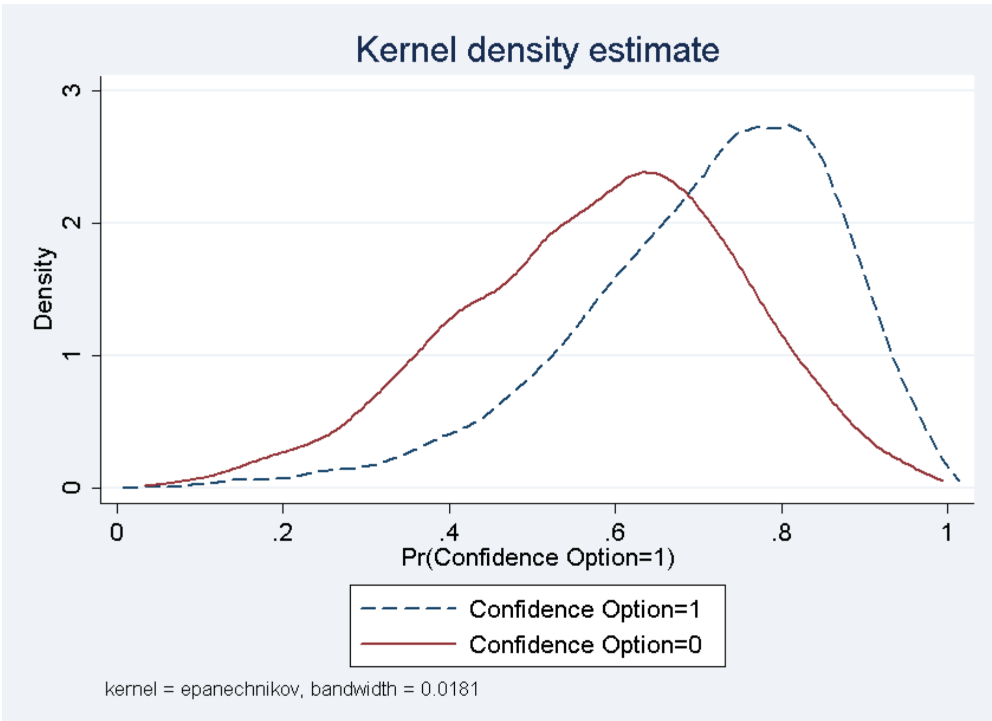
Table A8: Investment-Q Sensitivity and CAR under Mutual Fund Pressure

This table presents estimates from regressions where the dependent variable is the quarterly cumulative abnormal return. The independent variables of interest are the interactions between *Pressure* and *Significant Investment-Q Sensitivity*, an binary variable indicating firms with significant investment-Q sensitivity. The following lagged control variables are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, *CEO Ownership*, *Ln(Amihud)*, and *Ln(Analysts)*. Industry fixed effects are also included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

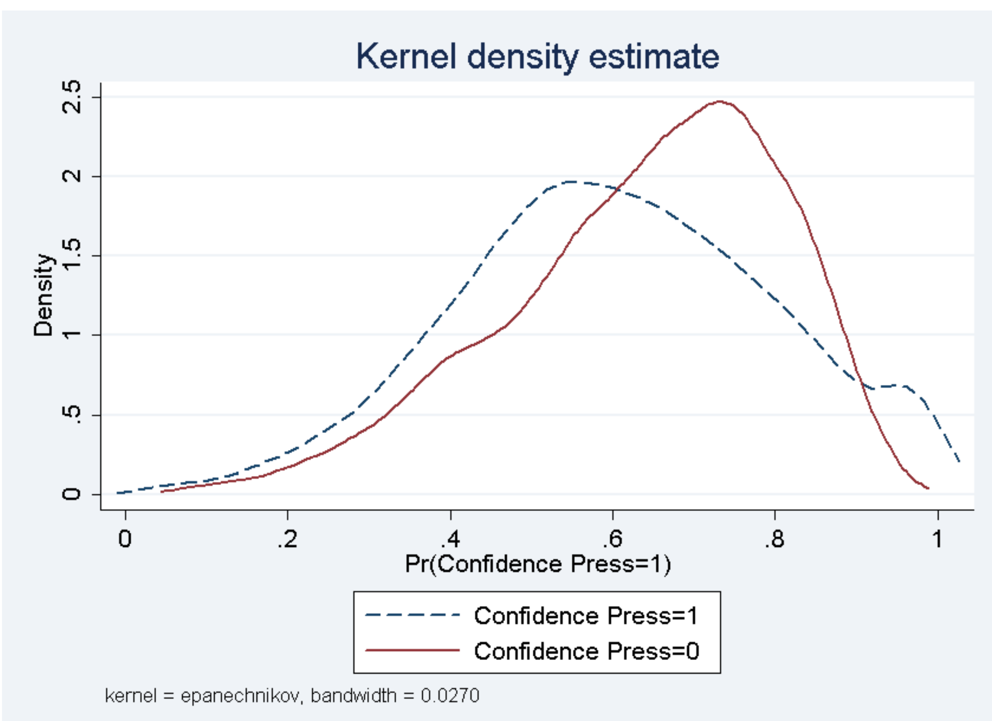
Dependent Variable:	*One-quarter CAR adjusted by*			
	R_m^{EW}		R_m^{VW}	
	(1)	(2)	(3)	(4)
Pressure	-0.0107***	-0.0112***	-0.0091***	-0.0098***
	(-9.62)	(-10.01)	(-8.45)	(-8.96)
Pressure × Significant Inv-Q Sensitivity	-0.0085**	-0.0086***	-0.0077**	-0.0079**
	(-2.58)	(-2.59)	(-2.27)	(-2.29)
Significant Inv-Q Sensitivity	0.0017*	0.0016	0.0011	0.0010
	(1.66)	(1.55)	(1.04)	(0.90)
Observations	43418	43418	43418	43418
Adjusted R^2	0.012	0.013	0.015	0.017
Firm Controls	Yes	Yes	Yes	Yes
Liquidity Controls	Yes	No	Yes	No
Industry Fixed Effects	Yes	Yes	Yes	Yes

Figure A1: This figure presents the kernal density estimate for the predicted likelihood of CEO overconfidence.

(a) Option-based Overconfidence



(b) Press-based Overconfidence



A3 Appendix: Data Definition

1. *Confidence Options* is the 'Holder67' measure (Malmendier and Tate, 2005), an indicator for CEOs that has an option with five years remaining duration that is at least 67% in the money. The option-based measure of overconfidence is measured as the value-per-vested-unexercised option scaled by the average strike price of those options. Holder67 is then an indicator that equals one from the first year in which the above ratio exceeds 0.67 if the ratio exceeds 0.67 on at least two occasions.

2. *Confidence Press* is the number of articles refering to the CEO as overconfident minus the number of articles refering to the CEO as nonconfident.

3. *Ln(Assets)* is the natural logarithm of total assets.

4. *Leverage* is the sum of long term debt and debt in current liabilities divided by total assets.

5. *Profitability* is the operating income before depreciation divided by average of current and lagged total assets.

6. *Q* is the market value of equity plus total liability minus deferred taxes and investment tax credit, divided by total assets.

7. *Cash* is cash and equivalent divided by total assets.

8. *Tangibility* is the net total value of property, plant and equipment, divided by total assets.

9. *Ln(Firm Age)* is the natural logarithm of firm's age.

10. *Return Volatility* is the standard deviation of daily stock returns.

11. *Ln(CEO Age)* is the natural logarithm of CEO's age.

12. *Ln(CEO Tenure)* is the natural logarithm of CEO's tenure in terms of month.

13. *Cash Compensation* is the sum of CEO salary and bonus, divided by total compensation.

14. *Ln(CEO Ownership)* is the natural logarithm of one plus CEO's percentage of ownership excluding options.

15. *Ln(Amihud)* is defined as $ln(1 + AvgILLIQ \times 10^9)$, where $AvgILLIQ$ is an yearly average of illiquidity measured as the absolute return divided by dollar trading volume:$AvgILLIQ_{i,t} = \frac{1}{Days_{i,t}} \sum_{d=1}^{Days_{i,t}} \frac{|R_{i,t,d}|}{DolVol_{i,t,d}}$. $Days_{i,t}$ is the number of valid observation days for stock i in fiscal year t, and $R_{i,t,d}$ and $DolVol_{i,t,d}$ are the return and dollar trading volume of stock i on day d in the fiscal year t.

16. *Ln(Number of Analysts)* is the natural logarithm of one plus maximum number of analysts following the stock for the year. It is coded as 0 if there is not coverage from I/B/E/S.

17. *Ln(Repurchase)* is the natural logarithm of the amount firm spends repurchasing stock over the next four quarters.

18. *Earnings Guidance* is a binary variable that equal one if there is earnings guidance provided by the management in the quarter and zero otherwise.

19. *Mutual Fund Sales* is the total number of shares sold by mutual funds with larger than -5% outflow, divided by the total trading volume of the stock.

20. *Investment* is the sum of capital expenditure and R&D expenditure, divided by average of current and lagged total assets.

21. *Significant Investment-Q Sensitivity*: the following time-series regression is estimated for each firm: $Investment_{t+1} = \alpha + \beta_1 Q + \beta_2 Ln(Assets) + \beta_3 Profitability + QuarterFE + \epsilon$. Significant Investment-Q Sensitivity equals 1 if β_1 is in the top quartile and significant at 5% level.

Table 1: Summary Statistics

This table shows the summary statistics of all the variables. We depict sample averages, median, 25^{th}, 75^{th} percentiles and standard deviations of all of our variables of interest as well as our control variables. These are averages over all years between 1992 and 2011.

	N	Mean	P25	Median	P75	Std. Dev.
Confidence Options	48,444	0.614	0.000	1.000	1.000	0.487
Confidence Press	23,509	3.141	1.100	2.900	5.000	2.381
Ln(Assets)	48,672	6.989	5.888	6.833	7.937	1.545
Leverage	48,672	0.218	0.051	0.205	0.331	0.181
Profitability	48,672	0.152	0.093	0.150	0.216	0.130
Q	48,672	2.148	1.232	1.649	2.446	1.535
Cash	48,672	0.146	0.019	0.065	0.211	0.179
Tangibility	48,672	0.303	0.127	0.242	0.434	0.224
Ln(Firm Age)	48,672	2.757	2.165	2.760	3.432	0.878
Ret. Volatility	48,672	0.027	0.017	0.024	0.033	0.015
Ln(CEO Age)	48,672	3.999	3.912	4.007	4.094	0.135
Ln(CEO Tenure)	48,672	3.998	3.332	4.127	4.804	1.117
Cash Compensation	48,672	0.480	0.249	0.435	0.674	0.281
Ln(CEO Ownership)	48,672	0.683	0.102	0.315	0.931	0.841
Ln(Amihud)	47,413	1.150	-0.379	1.018	2.564	2.183
Ln(Number of Analysts)	47,453	1.650	1.099	1.792	2.303	0.905
Ln(Repurchase)	39,984	2.033	0.000	1.018	3.908	2.314
Earnings Guidance	46,001	0.309	0.000	0.000	1.000	0.462
Mutual Fund Sales	48,670	-0.386	-0.371	-0.053	0.000	0.824
Investment	46,897	0.107	0.038	0.077	0.140	0.101
Withdrawal of Acquisitions	16,032	0.028	0.000	0.000	0.000	0.164

Table 2: CEO Overconfidence and Investment-Q Sensitivity

This table presents estimates from regressions where the dependent variable is *Investment* in quarter $t+1$. In columns 1 to 4, interactions between *Q* and *Confidence Options* or *Confidence Press* are included in the regressions. In column 5 to 8, the sample is divided into terciles based on the ratio of average value per vested unexercised option to the average strike price of those options, or *Confidence Press*. We then include the interactions between *Q* and binary variables indicating firms with high/medium/low CEO overconfidence. Firm control variables include *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, and *Ln(CEO Ownership)*. Industry or Firm fixed effects as well as time fixed effects (year, fiscal quarter, and calendar quarter) are included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	*Investment*$_{t+1}$							
Overconfidence Measure:	*Options*		*Press*		*Options*		*Press*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Q	0.0184***	0.0128***	0.0251***	0.0134***				
	(9.24)	(7.26)	(8.89)	(5.97)				
Q × Confidence	-0.0061***	-0.0041**	-0.0023***	-0.0010***				
	(-3.07)	(-2.48)	(-5.66)	(-2.98)				
Confidence	0.0175***	0.0167***	0.0051***	0.0028***				
	(4.54)	(4.83)	(5.76)	(3.50)				
Q × High Confidence					0.0105***	0.0077***	0.0112***	0.0071***
					(8.52)	(7.41)	(6.25)	(4.59)
Q × Medium Confidence					0.0148***	0.0097***	0.0145***	0.0077***
					(8.16)	(6.98)	(5.92)	(4.84)
Q × Low Confidence					0.0240***	0.0160***	0.0253***	0.0120***
					(9.62)	(8.71)	(7.66)	(4.65)
High Confidence					0.0163***	0.0088***	0.0092*	0.0037
					(4.37)	(3.22)	(1.79)	(0.92)
Low Confidence					-0.0191***	-0.0154***	-0.0197***	-0.0110**
					(-5.12)	(-5.30)	(-3.28)	(-2.51)
Ln(Assets)	-0.0082***	-0.0221***	-0.0077***	-0.0212***	-0.0083***	-0.0226***	-0.0080***	-0.0211***
	(-7.74)	(-8.33)	(-5.97)	(-6.05)	(-8.09)	(-8.48)	(-6.11)	(-5.99)
Leverage	-0.0296***	-0.0488***	-0.0197*	-0.0493***	-0.0305***	-0.0475***	-0.0206**	-0.0494***
	(-3.71)	(-6.41)	(-1.96)	(-4.68)	(-3.87)	(-6.01)	(-2.06)	(-4.71)
Profitability	-0.0343**	0.0225**	-0.0612***	0.0154	-0.0430***	0.0204*	-0.0578***	0.0165
	(-2.13)	(2.09)	(-2.96)	(1.35)	(-2.65)	(1.88)	(-2.75)	(1.46)
Cash	0.0839***	-0.0236**	0.0717***	-0.0104	0.0842***	-0.0278***	0.0715***	-0.0104
	(7.77)	(-2.41)	(5.89)	(-1.00)	(7.65)	(-2.75)	(5.81)	(-1.00)
Tangibility	0.1835***	0.0901***	0.1726***	0.0471**	0.1803***	0.0917***	0.1724***	0.0489**
	(20.57)	(5.76)	(16.70)	(2.30)	(20.32)	(5.60)	(16.62)	(2.39)
Ln(Firm Age)	-0.0010	0.0009	0.0000	-0.0064**	-0.0007	0.0003	0.0000	-0.0064**
	(-0.74)	(0.38)	(-0.01)	(-2.00)	(-0.49)	(0.11)	(0.02)	(-1.99)
Ret. Volatility	0.5873***	-0.0775	0.5347***	-0.0549	0.6045***	-0.0611	0.5136***	-0.0637
	(7.65)	(-1.33)	(5.54)	(-0.76)	(7.87)	(-1.01)	(5.29)	(-0.88)
Ln(CEO Age)	-0.0247***	-0.0146	-0.0103	0.0102	-0.0230**	-0.0097	-0.0106	0.0111
	(-2.74)	(-1.43)	(-0.92)	(0.82)	(-2.55)	(-0.96)	(-0.94)	(0.88)
Ln(CEO Tenure)	0.0034***	0.0016*	0.0026**	0.0017	0.0032***	0.0016*	0.0026**	0.0017
	(3.33)	(1.82)	(2.02)	(1.49)	(3.14)	(1.86)	(2.03)	(1.45)
Cash Compensation	-0.0167***	-0.0034	-0.0136***	0.0004	-0.0176***	-0.0046**	-0.0140***	0.0004
	(-5.30)	(-1.57)	(-3.41)	(0.13)	(-5.60)	(-2.00)	(-3.47)	(0.14)
Ln(CEO Ownership)	-0.0051***	0.0003	-0.0048**	0.0008	-0.0046***	0.0018	-0.0050**	0.0006
	(-3.10)	(0.14)	(-2.43)	(0.33)	(-2.90)	(0.90)	(-2.49)	(0.26)
Observations	46,458	46,682	22,343	22,471	43,849	44,073	22,343	22,471
Adjusted R^2	0.397	0.630	0.405	0.683	0.406	0.639	0.403	0.683
Industry Fixed Effects	Yes	No	Yes	No	Yes	No	Yes	No
Firm Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 3: Market Reaction to the M&A Announcement and Withdrawal of Acquisitions

This table shows that while average CEOs are more likely to withdraw an acquisition if the stock market reacts negatively to the announcement, overconfidence CEOs are not. We report the marginal effects estimated from probit models where the dependent variable is *Withdrawl Dummy*, which equals 1 if the acquirer cancel the acquisition. The following deal characteristics are included in the regressions: *Tender Offer Dummy*, *Compete Dummy*, *Litigation Dummy*, *Lockup of Target Shares Dummy*, *Target Termination Fee Dummy*, *Defense Dummy*, *Friendly Dummy*, *Public Target Dummy*, *Toehold Dummy*, and *Toehold Shares*. The following firm control variables also are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, LnCash Compensation, *Ln(CEO Ownership)*, *Ln(Amihud)*, and *Ln(Analysts)*. Industry and year fixed effects are also included. *t*-statistics using robust, acquirer-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively. Marginal effects of CAR on the likelihood of cancelling an M&A deal for the subsamples of overconfident and non-overconfident CEOs are reported for each specification.

Dependent Variable:	*Withdrawl of Acquisitions*							
CAR adjusted by:	R_m^{EW}				R_m^{VW}			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CAR[-1,1]	-2.1515**	-1.9043**	-2.9232*	-2.0541	-2.0272**	-1.7907*	-2.6459*	-1.852
	(-2.19)	(-1.97)	(-1.87)	(-1.38)	(-2.06)	(-1.88)	(-1.67)	(-1.26)
CAR[-1,1] × Confidence Option	1.9946*	2.3892**			1.7797	2.1965*		
	(1.74)	(2.06)			(1.54)	(1.91)		
CAR[-1,1] × Confidence Press			1.0492***	0.8247**			0.9521***	0.7440**
			(3.31)	(2.55)			(2.95)	(2.30)
Confidence Option	0.1125*	0.0845			0.1094*	0.0814		
	(1.90)	(1.28)			(1.86)	(1.24)		
Confidence Press			0.0307	0.0510**			0.0295	0.0503**
			(1.39)	(2.11)			(1.34)	(2.08)
Tender Offer Dummy	-0.6131***	-0.7050***	-0.3546	-0.4593*	-0.6113***	-0.7035***	-0.3580	-0.4608*
	(-3.93)	(-4.25)	(-1.42)	(-1.66)	(-3.92)	(-4.25)	(-1.43)	(-1.67)
Compete Dummy	1.5028***	1.3987***	1.5333***	1.4107***	1.5016***	1.3986***	1.5318***	1.4077***
	(12.14)	(10.52)	(7.00)	(5.81)	(12.14)	(10.52)	(6.99)	(5.80)
Litigation Dummy	0.4230**	0.4134*			0.4216**	0.4128*		
	(2.20)	(1.91)			(2.19)	(1.91)		
Lockup of Target Shares Dummy	-1.0961***	-0.8991***	-0.3861	-0.7698	-1.0972***	-0.9006***	-0.4509	-0.8124
	(-4.17)	(-2.84)	(-0.60)	(-1.19)	(-4.17)	(-2.85)	(-0.70)	(-1.27)
Target Termination Fee Dummy	-0.4784***	-0.4387***	-0.3629*	-0.2360	-0.4793***	-0.4396***	-0.3593*	-0.2324
	(-4.73)	(-3.83)	(-1.71)	(-1.09)	(-4.74)	(-3.84)	(-1.68)	(-1.06)
Defense Dummy	0.8391***	0.9765***	1.3096***	1.5367***	0.8393***	0.9760***	1.3187***	1.5421***
	(3.66)	(3.62)	(3.93)	(4.27)	(3.65)	(3.62)	(3.96)	(4.28)
Friendly Dummy	-1.1331***	-1.1180***	-1.0409***	-1.0954***	-1.1342***	-1.1191***	-1.0434***	-1.0982***
	(-12.20)	(-10.55)	(-6.67)	(-6.53)	(-12.20)	(-10.56)	(-6.67)	(-6.54)
Public Target Dummy	0.9906***	1.0259***	0.9468***	0.9740***	0.9903***	1.0257***	0.9426***	0.9708***
	(11.42)	(10.91)	(5.05)	(4.84)	(11.41)	(10.89)	(4.98)	(4.79)
Toehold Dummy	0.3847	0.4806	1.0311*	1.0572*	0.3852	0.4793	1.0250*	1.0556*
	(1.15)	(1.29)	(1.76)	(1.66)	(1.15)	(1.28)	(1.75)	(1.65)
Toehold Shares	-0.0158	-0.0185	-0.0276	-0.0256	-0.0159	-0.0185	-0.0275	-0.0256
	(-1.15)	(-1.18)	(-1.07)	(-0.91)	(-1.16)	(-1.18)	(-1.07)	(-0.91)
Observations	15196	12389	6446	5551	15196	12389	6446	5551
Pseudo R^2	0.303	0.312	0.308	0.331	0.303	0.312	0.306	0.330
CEO Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	No	Yes	No	Yes	No	Yes	No	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marginal Effect:								
Non-overconfident	-0.0827	-0.0787	-0.0582	-0.0484	-0.0778	-0.0739	-0.0551	-0.0533
Overconfident	-0.0059	0.0243	0.1477	0.1427	-0.0097	0.0214	0.1394	0.1334

Table 4: CEO Overconfidence and Investment-Q Sensitivity around Mutual Fund Pressure

This table presents estimates from regressions from a sample consists of firm-quarters that are under mutual fund flow-driven pressure. The dependent variable is the change in *Investment* from quarter $t-1$ to quarter $t+3$. The independent variables of interest are the interaction term between the change in Q over the quarter or the average of Q over the past year and measures of CEO overconfidence. Firm control variables include *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*. CEO control variables include *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, and *Ln(CEO Ownership)*. Liquidity control variables include *Ln(Amihud)* and *Ln(Analysts)*. The lagged level of *Investment*, the change in the above firm and liquidity controls from $t-1$ to $t+1$ are also included in the regression. Industry and time fixed effects (year, fiscal quarter, and calendar quarter) are also included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	ΔInvestment$_{t-1,t+3}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Q_{t-1,t+1}$	0.0075***	0.0065***	0.0198**	0.0187**	0.0096***	0.0088**
	(3.31)	(2.85)	(2.55)	(2.36)	(2.75)	(2.47)
$\Delta Q_{t-1,t+1}$ × Confidence Options			-0.0138*	-0.0133*		
			(-1.75)	(-1.68)		
$\Delta Q_{t-1,t+1}$ × Confidence Press					-0.0014*	-0.0014*
					(-1.74)	(-1.72)
Confidence Options			-0.0033	-0.0040*		
			(-1.36)	(-1.70)		
Confidence Press					0.0003	-0.0000
					(0.37)	(-0.06)
Observations	4,340	4,340	3,921	3,921	2,111	2,111
Adjusted R^2	0.258	0.259	0.255	0.256	0.220	0.221
Lagged Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Lagged CEO Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Change in Firm Characteristics$_{t-1,t+1}$	Yes	Yes	Yes	Yes	Yes	Yes
Lagged Liquidity Controls	No	Yes	No	Yes	No	Yes
Change in Liquidity Controls$_{t-1,t+1}$	No	Yes	No	Yes	No	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: CEO Overconfidence and CAR under Mutual Fund Pressure

This table presents estimates from regressions where the dependent variable is the quarterly cumulative abnormal return. The independent variables of interest are the interactions between *Pressure* and measures of CEO overconfidence. The following lagged control variables are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, *Ln(CEO Ownership)*, *Ln(Amihud)*, and *Ln(Analysts)*. Industry fixed effects are also included. t-statistics using robust standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	*One-quarter CAR adjusted by*							
	R_m^{EW}				R_m^{VW}			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pressure	-0.0149***	-0.0156***	-0.0180***	-0.0196***	-0.0133***	-0.0142***	-0.0138***	-0.0165***
	(-8.59)	(-8.93)	(-7.15)	(-7.69)	(-7.77)	(-8.24)	(-5.62)	(-6.60)
Pressure × Confidence Options	0.0042*	0.0042*			0.0040*	0.0040*		
	(1.93)	(1.93)			(1.88)	(1.88)		
Pressure × Confidence Press			0.0017***	0.0018***			0.0011*	0.0012*
			(2.72)	(2.85)			(1.68)	(1.91)
Confidence Options	0.0022**	0.0031***			0.0036***	0.0048***		
	(2.44)	(3.44)			(3.93)	(5.24)		
Confidence Press			0.0015***	0.0017***			0.0021***	0.0026***
			(4.95)	(5.90)			(7.04)	(8.61)
Ln(Assets)	-0.0014***	0.0016***	-0.0021***	0.0025***	-0.0004	0.0037***	-0.0016***	0.0061***
	(-3.83)	(2.61)	(-4.05)	(2.98)	(-1.15)	(5.83)	(-3.07)	(7.08)
Leverage	-0.0036	-0.0070**	0.0026	-0.0023	-0.0038	-0.0083***	0.0042	-0.0039
	(-1.18)	(-2.32)	(0.64)	(-0.56)	(-1.24)	(-2.74)	(1.02)	(-0.96)
Profitability	0.0559***	0.0588***	0.0628***	0.0665***	0.0599***	0.0638***	0.0660***	0.0722***
	(10.60)	(11.08)	(8.20)	(8.67)	(11.10)	(11.77)	(8.43)	(9.22)
Q	-0.0036***	-0.0026***	-0.0056***	-0.0038***	-0.0046***	-0.0031***	-0.0064***	-0.0034***
	(-7.14)	(-4.74)	(-7.26)	(-4.59)	(-8.78)	(-5.66)	(-8.22)	(-4.09)
Cash	0.0156***	0.0198***	0.0149***	0.0198***	0.0186***	0.0242***	0.0138***	0.0219***
	(4.17)	(5.20)	(3.09)	(4.08)	(4.86)	(6.24)	(2.79)	(4.43)
Tangibility	0.0011	0.0005	-0.0049	-0.0054	-0.0005	-0.0013	0.0011	0.0003
	(0.41)	(0.20)	(-1.25)	(-1.37)	(-0.19)	(-0.47)	(0.27)	(0.06)
Ln(Firm Age)	-0.0004	-0.0006	-0.0002	-0.0004	-0.0001	-0.0003	0.0002	-0.0002
	(-0.84)	(-1.18)	(-0.21)	(-0.53)	(-0.10)	(-0.56)	(0.32)	(-0.20)
Ret. Volatility	0.1599***	0.1097**	0.1661**	0.0491	0.4334***	0.3663***	0.4751***	0.2786***
	(3.04)	(2.08)	(2.38)	(0.69)	(8.10)	(6.83)	(6.66)	(3.81)
Ln(CEO Age)	-0.0022	-0.0039	-0.0015	-0.0042	-0.0013	-0.0035	0.0003	-0.0042
	(-0.66)	(-1.14)	(-0.32)	(-0.92)	(-0.37)	(-1.01)	(0.06)	(-0.92)
Ln(CEO Tenure)	-0.0007*	-0.0005	-0.0004	-0.0000	-0.0013***	-0.0011**	-0.0010*	-0.0004
	(-1.73)	(-1.32)	(-0.66)	(-0.04)	(-3.11)	(-2.56)	(-1.75)	(-0.74)
Cash Compensation	0.0023	0.0008	0.0041*	0.0018	0.0023	0.0004	0.0064***	0.0026
	(1.39)	(0.51)	(1.80)	(0.78)	(1.39)	(0.22)	(2.80)	(1.12)
Ln(CEO Ownership)	0.0008	0.0004	0.0005	-0.0002	0.0011*	0.0006	0.0011	-0.0000
	(1.31)	(0.68)	(0.55)	(-0.22)	(1.90)	(1.06)	(1.25)	(-0.02)
Ln(Amihud)		0.0025***		0.0040***		0.0034***		0.0067***
		(5.63)		(5.99)		(7.41)		(9.82)
Ln(Analysts)		-0.0003		-0.0003		-0.0004		-0.0004

		(-0.52)		(-0.38)		(-0.74)		(-0.46)
Observations	42,237	42,237	22,316	22,316	42,237	42,237	22,316	22,316
Adjusted R^2	0.012	0.013	0.019	0.021	0.016	0.018	0.026	0.033
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: OEO Overconfidence and CAR under Mutual Fund Pressure: Propensity Score Matching

This table presents the differences in CAR in the quarter of fire sales between firms with and without overconfident CEOs in the matched sample. Among all the firm-quarter observations under mutual fund fire sales (*MFFlow* in the bottom decile), we estimate the propensity score for being a treated firm (with overconfident CEOs) based on firm and manager characteristics used in Model (25). We then match each treated firm with a neatest neighbor from the control group (without overconfident CEOs) based on propensity score (within 0.001 caliper). Panels A and B present the result for option-based and press-based measures of CEO overconfidence, respectively.

Panel A: Propensity Score Matching (Confidence Option)

Variable	Sample (1)	Confidence Option=1 (Treated) (2)	Confidence Option=0 (Controls) (3)	T(diff) (4)	$p > \|t\|$ (5)
Ln(Assets)	Unmatched	6.790	6.680	2.96	0.003
	Matched	6.750	6.789	-0.82	0.414
Leverage	Unmatched	0.218	0.236	-3.33	0.001
	Matched	0.238	0.232	0.82	0.413
Profitability	Unmatched	0.173	0.149	8.07	0.000
	Matched	0.161	0.155	1.52	0.130
Q	Unmatched	2.130	1.630	13.71	0.000
	Matched	1.780	1.728	1.33	0.185
Cash	Unmatched	0.120	0.092	6.49	0.000
	Matched	0.098	0.100	-0.25	0.803
Tangibility	Unmatched	0.291	0.329	-5.66	0.000
	Matched	0.325	0.318	0.81	0.416
Ln(Firm Age)	Unmatched	2.700	2.781	-3.38	0.001
	Matched	2.736	2.755	-0.60	0.547
Ret. Volatility	Unmatched	0.025	0.026	-1.80	0.071
	Matched	0.025	0.025	1.00	0.319
Ln(CEO Age)	Unmatched	4.010	4.009	0.10	0.922
	Matched	4.010	4.009	0.32	0.748
Ln(CEO Tenure)	Unmatched	4.243	3.775	14.84	0.000
	Matched	4.007	4.011	-0.09	0.929
Cash Compensation	Unmatched	0.524	0.564	-5.03	0.000
	Matched	0.554	0.554	-0.04	0.966
Ln(CEO Ownership)	Unmatched	0.798	0.718	3.05	0.002
	Matched	0.785	0.765	0.59	0.558
Ln(Amihud)	Unmatched	1.487	2.375	-15.88	0.000
	Matched	2.029	1.974	0.77	0.439
Ln(Analysts)	Unmatched	1.476	1.271	8.26	0.000
	Matched	1.363	1.367	-0.14	0.892

Difference in CAR in the Matched Sample

Variable	Treated (1)	Controls (2)	Difference (3)	S.E. (4)	T-stat (5)
One-quarter CAR (R_m^{EW})	-0.008	-0.012	0.004	0.003	1.79*
One-quarter CAR (R_m^{VW})	-0.003	-0.009	0.006	0.003	2.43**

Panel B: Propensity Score Matching (Confidence Press)

Variable	Sample (1)	Confidence Press>=Median (Treated) (2)	Confidence Press<Median (Controls) (3)	T(diff) (4)	$p > \|t\|$ (5)
Ln(Assets)	Unmatched	6.844	6.794	0.99	0.323
	Matched	6.881	6.904	-0.36	0.723
Leverage	Unmatched	0.192	0.225	-4.79	0.000
	Matched	0.217	0.209	0.86	0.388
Profitability	Unmatched	0.176	0.124	14.26	0.000
	Matched	0.146	0.144	0.44	0.656
Q	Unmatched	2.255	1.532	17.10	0.000
	Matched	1.771	1.722	1.06	0.291
Cash	Unmatched	0.136	0.121	2.34	0.019
	Matched	0.120	0.126	-0.73	0.463
Tangibility	Unmatched	0.266	0.263	0.36	0.721
	Matched	0.270	0.257	1.16	0.246
Ln(Firm Age)	Unmatched	2.726	2.814	-3.00	0.003
	Matched	2.801	2.788	0.32	0.748
Ret. Volatility	Unmatched	0.023	0.026	-6.84	0.000
	Matched	0.024	0.024	0.80	0.426
Ln(CEO Age)	Unmatched	4.007	4.004	0.64	0.520
	Matched	4.006	4.004	0.36	0.718
Ln(CEO Tenure)	Unmatched	4.106	3.976	2.99	0.003
	Matched	4.040	4.029	0.18	0.857
Cash Compensation	Unmatched	0.500	0.528	-2.62	0.009
	Matched	0.515	0.506	0.59	0.553
Ln(CEO Ownership)	Unmatched	0.712	0.679	1.03	0.303
	Matched	0.665	0.678	-0.29	0.771
Ln(Amihud)	Unmatched	0.964	1.974	-13.03	0.000
	Matched	1.409	1.281	1.34	0.180
Ln(Analysts)	Unmatched	1.599	1.372	6.90	0.000
	Matched	1.498	1.513	-0.34	0.734

Difference in CAR in the Matched Sample

Variable	Treated (1)	Controls (2)	Difference (3)	S.E. (4)	T-stat (5)
One-quarter CAR (R_m^{EW})	-0.004	-0.011	0.006	0.003	2.11**
One-quarter CAR (R_m^{VW})	0.005	-0.003	0.008	0.003	2.68***

Table 7: Depth and Breadth of Block Ownership, CEO Overconfidence and CAR under Mutual Fund Pressure

This table presents the differential price impacts of mutual fund price pressure across depth and breadth of block ownership. In Panel A, we divide the sample based on the average ownership by blockholders (depth). In Panel B, we divide the sample based on the number of blockholders (breadth). The dependent variable is the quarterly cumulative abnormal return. The independent variables of interest are the interactions between *Pressure* and measures of CEO overconfidence. The following lagged control variables are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, *Ln(CEO Ownership)*, *Ln(Amihud)*, and *Ln(Analysts)*. Industry fixed effects are also included. t-statistics using robust standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Panel A: Subsample by average block ownership

Dependent Variable:	*One-quarter CAR adjusted by* R_m^{EW}			
Average Block Ownership:	< top quartile	>= top quartile	< top quartile	>= top quartile
	(1)	(2)	(3)	(4)
Pressure	-0.0174***	-0.0116***	-0.0218***	-0.0136***
	(-8.55)	(-3.47)	(-7.54)	(-2.72)
Pressure × Confidence Options	0.0053**	0.0026		
	(2.10)	(0.62)		
Pressure × Confidence Press			0.0022***	0.0012
			(3.04)	(0.95)
Confidence Options	0.0027**	0.0014		
	(2.52)	(0.73)		
Confidence Press			0.0016***	0.0019***
			(4.53)	(3.12)
Observations	25,836	8,681	13,830	4,646
Adjusted R^2	0.012	0.015	0.020	0.027
Lagged Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes

Panel B: Subsample by the number of blockholders

Dependent Variable:	*One-quarter CAR adjusted by* R_m^{EW}			
Number of blockholders:	< 3	>= 3	< 3	>= 3
	(1)	(2)	(3)	(4)
Pressure	-0.0169***	-0.0157***	-0.0225***	-0.0188***
	(-7.89)	(-5.52)	(-6.01)	(-4.47)
Pressure × Confidence Options	0.0074***	0.0013		
	(2.81)	(0.35)		
Pressure × Confidence Press			0.0028***	0.0010
			(3.11)	(0.88)
Confidence Options	0.0007	0.0054***		
	(0.68)	(3.60)		
Confidence Press			0.0012***	0.0024***
			(3.42)	(5.54)
Observations	23,145	12,639	11,126	7,977
Adjusted R^2	0.011	0.018	0.020	0.029
Lagged Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes

Table 8: Information Cost, CEO Overconfidence and CAR under Mutual Fund Pressure

This table presents estimates from regressions where the dependent variable is the quarterly cumulative abnormal return, and the independent variables of interest are the interactions between *Pressure* and measures of CEO overconfidence. We divide the sample based on the cost of information acquisition, as measured by analyst coverage (Panel A) and the number of segments (Panel B). The following lagged control variables are included in the regressions: *Ln(Assets)*, *Leverage*, *Profitability*, *Q*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, *Ln(CEO Ownership)*, *Ln(Amihud)*, and *Ln(Analysts)*. Industry fixed effects are also included. *t*-statistics using robust standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Panel A: Subsample by analyst coverage

Dependent Variable:	*One-quarter CAR adjusted by* R_m^{EW}			
Number of analysts:	<= 2 (1)	> 2 (2)	<= 2 (3)	> 2 (4)
Pressure	-0.0164***	-0.0094***	-0.0217***	-0.0097**
	(-8.39)	(-2.62)	(-7.24)	(-2.36)
Pressure × Confidence Options	0.0047*	0.0003		
	(1.88)	(0.08)		
Pressure × Confidence Press			0.0019**	0.0008
			(2.49)	(0.76)
Confidence Options	0.0026**	0.0042***		
	(2.30)	(3.40)		
Confidence Press			0.0016***	0.0018***
			(4.28)	(4.69)
Observations	25,363	16,874	12,305	10,011
Adjusted R^2	0.015	0.011	0.024	0.022
Lagged Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	

Panel B: Subsample by number of segments

Dependent Variable:	*One-quarter CAR adjusted by* R_m^{EW}			
Number of segments:	> 1 (1)	= 1 (2)	> 1 (3)	= 1 (4)
Pressure	-0.0175***	-0.0119***	-0.0198***	-0.0171***
	(-7.76)	(-4.36)	(-6.04)	(-4.17)
Pressure × Confidence Options	0.0053*	0.0025		
	(1.87)	(0.74)		
Pressure × Confidence Press			0.0023***	0.0014
			(2.68)	(1.40)
Confidence Options	0.0025**	0.0047***		
	(2.18)	(3.48)		
Confidence Press			0.0011***	0.0025***
			(2.99)	(5.65)
Observations	19976	20069	11528	9004
Adjusted R^2	0.018	0.013	0.028	0.024
Lagged Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes

Table 9: CEO Overconfidence and Stock Repurchase under Mutual Fund Pressure

This table presents estimates from regressions where the dependent variable *Ln(Repurchase)* over the next four quarters and the independent variables of interest are the interactions between *Pressure* and measures of CEO overconfidence. Firm control variables include *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation* and *Ln(CEO Ownership)*. Liquidity control variables include *Ln(Amihud)* and *Ln(Analysts)*. Industry or firm fixed effects as well as time fixed effects (year, fiscal quarter, and calendar quarter) are included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	$Ln(Repurchase)_{t+1}$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pressure	0.0034	0.0543	0.0942	0.1500*	0.0259	0.0530	0.0635	0.0787
	(0.06)	(0.88)	(1.05)	(1.69)	(0.55)	(1.13)	(0.99)	(1.23)
Pressure × Confidence Options	-0.0243	-0.0349			-0.0117	-0.0169		
	(-0.29)	(-0.42)			(-0.18)	(-0.27)		
Confidence Options	0.1242**	0.0744			0.1159	0.0765		
	(2.16)	(1.27)			(1.57)	(1.02)		
Pressure × Confidence Press			-0.0149	-0.0169			-0.0059	-0.0058
			(-0.62)	(-0.71)			(-0.36)	(-0.36)
Confidence Press			0.0274*	0.0076			0.0354**	0.0274*
			(1.83)	(0.48)			(2.19)	(1.67)
Observations	45,388	45,388	21,497	21,497	45,596	45,596	21,618	21,618
Adjusted R^2	0.373	0.377	0.393	0.398	0.605	0.606	0.671	0.671
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Liquidity Controls	No	Yes	No	Yes	No	Yes	No	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 10: CEO Overconfidence and Earnings Guidance under Mutual Fund Pressure

This table presents estimates from logit regressions where the dependent variable is *Earnings Guidance* in quarter $t+1$ and the independent variables of interest are the interaction term between *Pressure* and measures of CEO overconfidence. Firm control variables include *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation* and *Ln(CEO Ownership)*. Liquidity control variables include *Ln(Amihud)* and *Ln(Analysts)*. Industry or Firm fixed effects as well as time fixed effects (year, fiscal quarter, and calendar quarter) are included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	*Earnings Guidance*$_{t+1}$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pressure	0.2727***	0.3690***	0.2155**	0.3156***	0.0337	0.0929	-0.0718	-0.0067
	(3.18)	(4.31)	(2.08)	(3.09)	(0.38)	(1.06)	(-0.63)	(-0.06)
Pressure × Confidence Options	-0.1891*	-0.1944*			-0.1017	-0.1063		
	(-1.85)	(-1.89)			(-0.94)	(-0.98)		
Confidence Options	0.2143***	0.1029			0.1194	0.0138		
	(3.08)	(1.43)			(1.02)	(0.12)		
Pressure × Confidence Press			-0.0173	-0.0197			0.0039	0.0006
			(-0.68)	(-0.77)			(0.14)	(0.02)
Confidence Press			0.0499***	0.0147			0.0623**	0.0333
			(3.39)	(0.95)			(2.56)	(1.36)
Observations	45,550	45,550	22,402	22,402	35,313	35,313	15,989	15,989
Pseudo R^2	0.212	0.229	0.130	0.146	0.196	0.202	0.060	0.067
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Liquidity Controls	No	Yes	No	Yes	No	Yes	No	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

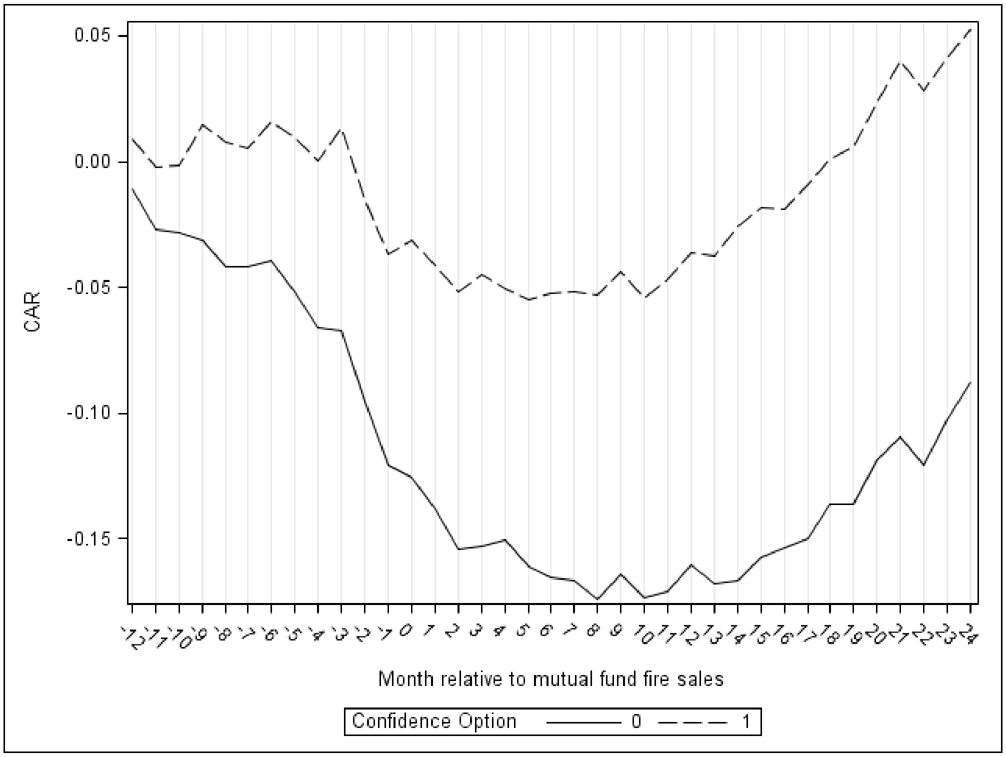
Table 11: CEO Overconfidence and Mutual Fund Sales under Pressure

This table presents estimates from regressions where the dependent variable is *Mutual Fund Sales* in quarter t and the independent variables of interest are the interaction term between *Pressure* and measures of CEO overconfidence. Lagged firm control variables include *Ln(Assets)*, *Leverage*, *Profitability*, *Cash*, *Tangibility*, *Ln(Firm Age)*, *Ret. Volatility*, *Ln(CEO Age)*, *Ln(CEO Tenure)*, *Cash Compensation*, and *CEO Ownership*. Lagged liquidity control variables include *Ln(Amihud)* and *Ln(Analysts)*. Firm fixed effects as well as time fixed effects (year, fiscal quarter, and calendar quarter) are included. t-statistics using robust, firm-clustered standard errors are in brackets. *, ** and *** indicate significance better than 10%, 5%, and 1% respectively.

Dependent Variable:	*Mutual Fund Sales*$_t$	
	(1)	(2))
MFFlow	0.4939***	0.4398***
	(17.72)	(11.18)
MFFlow × Confidence Options	0.0412	
	(1.20)	
Confidence Options	-0.0260	
	(-1.56)	
MFFlow × Confidence Press		0.0157
		(1.55)
Confidence Press		-0.0060
		(-1.43)
Ln(Assets)	-0.0229	-0.0842***
	(-1.54)	(-3.09)
Leverage	0.1256***	0.1411**
	(2.64)	(1.98)
Profitability	-0.1621***	-0.1262**
	(-3.93)	(-2.10)
Q	0.0019	0.0076
	(0.39)	(1.16)
Cash	-0.0527	-0.1012
	(-1.06)	(-1.54)
Tangibility	-0.0811	-0.1716
	(-1.07)	(-1.42)
Ln(Firm Age)	0.0183	-0.0297
	(0.95)	(-0.75)
Ret. Volatility	1.4912***	0.5776
	(3.45)	(0.95)
Ln(CEO Age)	0.0203	-0.1453
	(0.27)	(-1.04)
Ln(CEO Tenure)	0.0058	-0.0022
	(0.86)	(-0.21)
Cash Compensation	0.0265	0.0308
	(1.33)	(1.22)
Ln(CEO Ownership)	-0.0029	0.0489*
	(-0.22)	(1.94)
Ln(Amihud)	-0.0183**	-0.0346***
	(-2.43)	(-2.59)
Ln(Analysts)	0.0000	0.0258**
	(0.01)	(2.06)
Observations	43,392	22,789
Adjusted R^2	0.233	0.224
Firm Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes

Figure 2: This figure presents the cumulative abnormal return (CAR) over equal-weight market return around mutual fund flow-driven price pressure.

(a) Option-based Overconfidence



(b) Press-based Overconfidence