The Value of Silence: Voluntary Disclosure, Market Feedback, and Investment Efficiency*

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Abstract

Price feedback can inform the efficiency of firms' investment decisions, but the amount of decision-relevant information embedded in prices depends on firms' voluntary disclosure choices. When deciding whether to voluntarily disclose, firms trade-off short-term price level incentives against long-term learning and investment efficiency incentives. We study whether firms gain or lose investment-decision-relevant information from market prices when they disclose and the resulting investment efficiency implications. We develop and structurally estimate a model of voluntary disclosure with price feedback. We find that voluntary disclosure substantially diminishes the informational content of prices, whereas non-disclosure preserves richer price feedback. Firms lose about a quarter of long-term value due to the crowding out of price feedback and managers' myopic incentives to disclose.

Keywords: Disclosure; Real Efficiency; Price Feedback; Myopia; Structural Estimation

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Introduction

Market prices are an important source of information for real decision makers (Hayek (1945)), including firms (Dow and Gorton (1997); Subrahmanyam and Titman (1999); Chen et al. (2006); Bakke and Whited (2010); Bond et al. (2012)). Prices aggregate information from different market participants, and firms can use prices to learn relevant investment or product information that they do not have but various market participants privately acquire. Which information market participants acquire, however, depends on which information is already available publicly. In particular, public information can crowd in or crowd out private information acquisition by investors (Goldstein and Yang (2019)), and thus the amount of public information affects how much firms can glean from market prices.

Importantly, a large amount of public information is provided by firms themselves voluntarily. Firms face a trade-off when providing information. On the one hand, by disclosing or not disclosing information to the market, firms can regulate how much they can learn from price feedback. For example, to find out investors' assessment of demand for a new product, a firm needs to announce it. In contrast, providing detailed updates regarding a product's sales can discourage investors from doing their own research on customer demand and limit the amount of feedback a firm gets. On the other hand, when voluntarily disclosing information, firms are concerned with their price levels and have incentives to withhold (disclose) unfavorable (favorable) information, even if this information might trigger useful market feedback.

Do firms mostly lose or gain real-decision-relevant information from market prices when they voluntarily disclose information? How much real efficiency is lost or gained due to firms' short-term focus on price levels? What is the value of staying silent versus being transparent? We aim to answer these questions in our paper.

We employ a structural estimation approach because we believe it has at least two advantages in answering our research questions. First, voluntary disclosure decision is inherently endogenous. While reduced form analysis can examine whether disclosing firms listen to feedback (e.g., Jayaraman and Wu (2019); Fox et al. (2026)), it cannot tell how much these firms could learn had they not disclosed their information to investors. Structural estimation accounts for the firms' choice to disclose and thus we can evaluate how much price feedback disclosing (non-disclosing) firms would gain or lose had they withheld (disclosed). Second, because we can estimate overall uncertainty about investment and quality of firm managers' and investors' information, we can quantify real efficiency gains and losses due to the "voluntary" nature of price feedback.

We begin by constructing a model of voluntary disclosure in the presence of price feedback. A firm is traded on the market. Firm manager, who cares about both the firm's short-term stock price and long-term value, needs to make a capital investment decision. They have a private signal about the *idiosyncratic component* of productivity of the firm's investment and can disclose this signal to the market. After disclosing or not, the manager observes the realized short-term price and uses it to glean feedback from the market – a signal about the *common component* of the firm's productivity that the manager does not have. Importantly, we are agnostic as to whether managerial disclosure crowds-in or crowds-out price feedback and allow our estimates to tell which one is the case. Finally, the manager makes their investment decision based on all the information they have.

In equilibrium, the manager trades off the short-term price level incentive against the long-term investment efficiency incentive. The manager chooses to disclose (withhold) if they have sufficiently good (bad) news and sufficiently care about the short-term price, or if disclosure substantially improves (worsens) their learning from the market price. The manager's myopia can distort the long-term investment efficiency if price feedback is substantially better upon withholding (i.e., if managerial disclosure crowds out investors' private information) yet the manager chooses to disclose.

We estimate the key parameters of interest – the quality of the manager's information and the quality of information from price feedback upon disclosure and non-disclosure – in the context of capital investment by U.S. firms. We use firms' voluntary capital expenditure (CapEx) forecasts as voluntary disclosures of managers' information because they, at least to some extent, represent managers' information about the productivity of their firms' investments. To glean market feedback, we use price reactions to disclosed CapEx forecasts and to the absence of forecasts. Finally, we use CapEx values as ultimate investment decisions by firm managers.

Our first conclusion from the estimates is that firms' voluntary provision of CapEx forecasts on average **crowds out** market feedback. Specifically, when no firm disclosure is provided, investors' privately acquired information resolves about 56% of the uncertainty regarding the common component of the firm's productivity. This uncertainty resolution drops to about 17% if firm managers voluntarily disclose their information to the market. Managers' information does not enhance price feedback but rather discourages investors from conducting their own research of the firm. Prior literature studied how provision of public information affects investors' information production and found mixed results (for instance, Gao and Huang (2019) find that investors start producing more information when more firm information is available publicly, while Jayaraman and Wu (2018) and Chen et al. (2020) find the opposite). We show that information about investment plans that voluntarily comes from firm management tends to discourage investors' information production.

The next important result that emerges from our exercise is that firm managers' private information about their firms' idiosyncratic productivity factors and investors' private information about firms' common productivity factors are of comparable importance. The reduction in uncertainty about firms' idiosyncratic component of productivity due to managers' private information is about 29% (which is comparable to 56% and 17% for investors' information). This result is interesting given the common perception that corporate managers possess superior information. We find that, while managers do have useful firm-specific information, firms need the market's knowledge to the same extent as they need managers' expertise.

Using these estimates, we study the real efficiency implications of the voluntary disclosure and price feedback effect. We define real efficiency as the firm's long-term value relative to a benchmark. We consider two different benchmarks. The first benchmark is when the firm's manager does not learn from prices. We find that the firm's value with learning from prices is about 27% higher than without learning. This result is not surprising because any informative price signal reduces the manager's uncertainty about the common productivity factor, thereby improving investment choices. This benchmark highlights the importance of price feedback for real efficiency.

The second benchmark is when the manager has no short-term price incentives. In the model, strategic disclosure is driven by managerial myopia, and therefore, the "no-myopia" benchmark helps us evaluate the efficiency implications of voluntary disclosure and price feedback. Our results suggest that, because of the worse price feedback upon disclosure, firms lose, on average, 29% of value relative to the no-myopia benchmark. Due to short-term incentives, managers forgo firms' long-term value gains due to improved learning in favor of higher short-term stock prices.

Our decomposition also suggests that the primary driver of the efficiency loss is the strategic nature of managerial disclosure while the crowding-out effect plays a relatively smaller role. Since about two-thirds of firms in our sample provide CapEx forecasts, a lot of information that could be learned from prices is crowded out, leading to this large efficiency loss.[1] This result

[1]Our sample consists of firms that have provided CapEx guidance concurrently with their earnings announcements

enriches prior evidence that firms learn from market feedback to their disclosures (Jayaraman and Wu (2019)): if they were not concerned with short-term price levels and remained silent instead, they could learn substantially more.

We aim to advance the literature in multiple ways. A large strand of literature has studied price feedback and how firms use it (e.g., Dow and Gorton (1997); Subrahmanyam and Titman (1999); Chen et al. (2006); Bakke and Whited (2010); Bond et al. (2012); Jayaraman and Wu (2018, 2019); Fox et al. (2026)). We believe this is the first empirical study that accounts for the "voluntary" nature of price feedback. Our modeling approach allows for both crowding-in and crowding-out of investors' information upon public disclosure, an important consideration when studying price feedback (Goldstein and Yang (2019)). This approach yields a valuable insight: silence, not only disclosure, can be very valuable.

Another important strand of literature is about the real efficiency implications of disclosure. Prior work examined the relationship between the quality of reporting and firm investment (Biddle et al. (2009)) and innovation (see Roychowdhury et al. (2019) and Simpson and Tamayo (2020) for reviews), and how reporting frequency affects investment efficiency (e.g., Kanodia and Lee (1998); Gigler et al. (2014)). More closely related to our paper is the growing literature on voluntary disclosure and investment efficiency (e.g., Beyer and Guttman (2012); Jayaraman and Wu (2018); Bae et al. (2022); Langberg and Sivaramakrishnan (2010); Guttman and Meng (2021); Schneemeier (2023); Lassak (2023)). We study another mechanism for how voluntary disclosure affects firms' real decisions – the regulation of feedback from prices. Our estimates suggest that non-disclosure can improve investment efficiency, even in the case when disclosure is voluntary. We also quantify investment efficiency gains and losses due to voluntary disclosure or non-disclosure of managers' capital productivity information.

1 A model of voluntary disclosure and market feedback

1.1 Model setup

The model entails two risk-neutral players: a manager and a representative capital market investor. The manager's incentives are tied to both short-term stock price and the long-term firm value. Following Guttman and Meng (2021), we assume that the manager's payoff, denoted by

at least once. The probability of disclosure would be lower in the entire universe of firms. Therefore, our study provides an upper bound of the real efficiency loss due to the interaction of managerial myopia and price feedback.

$\mathcal{U}$, is a convex combination of the short-term price, denoted by P, and the long-term cash flows, denoted by CF:

$$\mathcal{U} = \beta P + (1-\beta)\, CF. \tag{1}$$

The parameter $\beta \in [0,1]$ captures the extent of managerial myopia and we take β as exogenously given. The manager has access to a constant returns to scale production technology:

$$\tilde{Y} = \tilde{F} I,$$

where $\tilde{Y}$ is the firm output, $I \geq 0$ is the amount of investment made at a convex cost $\frac{r}{2} I^2$ with $r > 0$, and $\tilde{F}$ denotes the returns to the invested capital or the productivity factor. Therefore, the firm's long-term cash flows are given by:

$$CF = \tilde{F} I - \frac{r}{2} I^2. \tag{2}$$

As in Goldstein and Yang (2019), we assume that the productivity factor, $\tilde{F}$ is a product of two independent components, $\tilde{F}_1 \geq 0$ and $\tilde{F}_2 \geq 0$, such that

$$\tilde{F} = \tilde{F}_1 \cdot \tilde{F}_2,$$

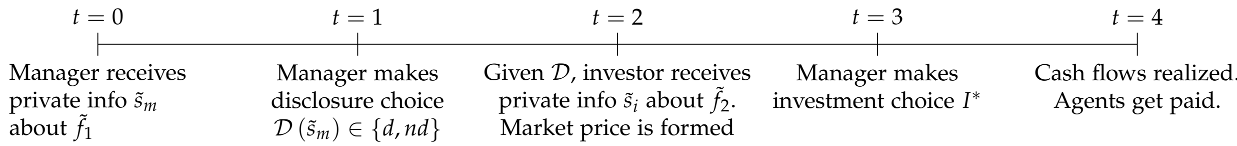
with $\tilde{f}_1 \equiv \log \tilde{F}_1 \sim \mathcal{N}\left(\overline{f}_1, \tau_{f_1}^{-1}\right)$ and $\tilde{f}_2 \equiv \log \tilde{F}_2 \sim \mathcal{N}\left(\overline{f}_2, \tau_{f_2}^{-1}\right)$. The two factors $\tilde{f}_1$ and $\tilde{f}_2$ represent the two dimensions of uncertainty that affect the productivity of the firm's investment. Factor $\tilde{f}_1$ can be interpreted as the firm-specific idiosyncratic component and factor $\tilde{f}_2$ as the common market component.

The model has five points in time. At $t = 0$, the manager receives a private noisy signal s_m about the idiosyncratic component of productivity:

$$\tilde{s}_m = \tilde{f}_1 + \tilde{\varepsilon}_m, \tag{3}$$

where $\tilde{\varepsilon}_m \sim \mathcal{N}\left(0, \tau_m^{-1}\right)$ and $\tau_m > 0$ denotes the precision of the manager's private information. We assume that the manager does not receive any private information regarding the common component $\tilde{f}_2$ and all their information about the common factor is summarized by the prior. The manager is likely to be more informed about particular aspects of the firm, as they have comparative advantage relative to investors in acquiring and processing firm-specific information. On

Figure 1: **Timeline**



the contrary, such comparative advantage is likely absent for the market component.

At $t=1$, the manager can disclose the private signal truthfully to the investors or strategically withhold it to maximize the expected utility (1). Let $\mathcal{D}(s_m) \in \{d, nd\}$ denote the disclosure choice where d refers to disclosure and nd refers to non-disclosure. We assume that if a disclosure is made, the manager incurs a fixed cost of disclosure denoted by $c > 0$.

At $t=2$, after observing the disclosure or lack thereof, the representative investor obtains private information about the common productivity component $\tilde{f}_2$:

$$\tilde{s}_i = \tilde{f}_2 + \tilde{\epsilon}_i \tag{4}$$

where $\tilde{\epsilon}_i \sim \mathcal{N}\left(0, \tau_i^{-1}\right)$ and $\tau_i > 0$ is the precision of the investor's private information.

We model the investor's information acquisition strategy in reduced form. Prior studies (e.g., Gao and Liang (2013); Goldstein and Yang (2015)) examine in detail how provision of public information affects investors' information acquisition, trading on that information, and resulting informativeness of price feedback. We could have explicitly modeled how the investor acquires private information. However, this step would substantially complicate the derivation and would not affect the model's key implications because what matters for the manager's decisions is, ultimately, the precision of the investor's private information reflected in the stock price upon disclosure versus upon withholding. Because our primary goal is to estimate the model, we model the effect of the manager's disclosure on the investor's information acquisition by assuming that the precision of the signal τ_i is correlated with the disclosure choice. Specifically, we assume that $\tau_i \equiv \tau_d$ if $\mathcal{D}(s_m) = d$ and $\tau_i \equiv \tau_{nd}$ otherwise. We do not make any assumptions about whether τ_d or τ_{nd} is higher and let our estimates indicate which one is the case. The case $\tau_d > \tau_{nd}$ $(\tau_{nd} > \tau_d)$ would imply that the manager's disclosure crowds in (crowds out) the investor's private information acquisition and improves (hurts) the quality of price feedback.

Further, we assume that the investor does not receive any private information about the firm-specific component of productivity $\tilde{f}_1$.

Based on the information set of the investor $\mathcal{I}_i$, the market sets the equilibrium price to equal the expected cash flows:

$$P(\mathcal{I}_i) = \mathbb{E}[CF \mid \mathcal{I}_i] \tag{5}$$

At $t = 3$, after observing the stock price, the manager makes the investment decision to maximize expected cash flows:

$$I^*(\mathcal{I}_M) = \arg\max_I \mathbb{E}\left[\tilde{F}I - \frac{r}{2}I^2 \mid \mathcal{I}_M\right] \tag{6}$$

where $\mathcal{I}_M$ denotes the manager's information set. Note that since the manager observes the price, $\mathcal{I}_M = \{s_m, P\}$. Finally, at $t = 4$, cash flows are realized and agents gets paid. Figure 1 summarizes the timing of the events.

1.2 Equilibrium Characterization

We solve the model by backward induction. We start by solving for manager's optimal investment policy at $t = 3$ conditional on their information set. Next, we derive the equilibrium price of the firm at $t = 2$ conditional on the observed disclosure choice and the private signal of the investor. Finally, we solve for the manager's optimal disclosure policy at $t = 1$ given their private signal.

1.2.1 Optimal investment policy

Let $\mathcal{I}_M$ denote manager's information set at $t = 3$. Because the market price is not influenced by the actual level of investment, manager chooses investment to maximize the long-term firm value according to (6). As a result, *conditional* on the information set, the manager chooses the first-best level of investment irrespective of their myopia as well as the strategic disclosure policy. Hence, the solution to (6) yields:

$$I^*(\mathcal{I}_M) = \frac{1}{r}\mathbb{E}\left[\tilde{F} \mid \mathcal{I}_M\right] = \frac{1}{r}\mathbb{E}\left[\exp\left(\tilde{f}_1 + \tilde{f}_2\right) \mid \mathcal{I}_M\right] \tag{7}$$

Since price is perfectly observable to the manager and there are no noise traders, we conjecture (and verify in Section 1.2.2) that the manager perfectly infers investor's private information s_i upon observing the price at time $t = 2$. Therefore, using $\mathcal{I}_M = \{s_m, P\} = \{s_m, s_i\}$ yields the optimal investment policy and the resulting expected cash flow as summarized in Lemma 1.

Lemma 1. *Conditional on the manager's information set $\mathcal{I}_M = \{s_m, s_i\}$, the optimal investment policy and expected cash flows are given by:*

$$I^*(s_m, s_i) = \frac{1}{r} \exp(c_0 + c_m s_m + c_i s_i) \tag{8}$$

$$\mathbb{E}[CF^*(s_m, s_i)] = \frac{1}{2r} \exp(2(c_0 + c_m s_m + c_i s_i)) \tag{9}$$

where $c_m = \frac{\tau_m}{\tau_{f_1} + \tau_m}$, $c_i = \frac{\tau_i}{\tau_{f_2} + \tau_i}$ *and* $c_0 = \frac{\overline{f}_1 \tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \frac{\overline{f}_2 \tau_{f_2} + 1/2}{\tau_{f_2} + \tau_i}$.

Proof. See Appendix A.1. ■

Lemma 1 states that log investment is a linear function of the manager's private information and the price signal.

The disclosure choice does not directly affect the optimal investment, however, it has an indirect effect through the quality of the price signal.

Corollary 1. *The weight placed on realized signals in the optimal investment policy is* (a) *strictly increasing in the informational quality of the respective signals, and* (b) *strictly decreasing in the precision of underlying fundamentals. In particular,*

$$\frac{\partial c_m}{\partial \tau_m} > 0, \quad \frac{\partial c_i}{\partial \tau_i} > 0 \qquad \text{and} \qquad \frac{\partial c_m}{\partial \tau_{f_1}} < 0, \quad \frac{\partial c_i}{\partial \tau_{f_2}} < 0.$$

Part (b) of Corollary 1 asserts that more precise fundamentals reduce the incremental value of information. When there is less uncertainty about the underlying productivity factors, the signals have less informational value, and as a result, investment becomes less sensitive to the signals. On the other hand, Part (a) implies that when signals are more precise, they have greater influence on the optimal investment decision.

1.2.2 Market price of the firm

Next, we derive the market price of the firm (5) conditional on the observed disclosure choice of the manager.

Price conditional on disclosure. If the manager discloses their private signal s_m, the investor's information set is $\mathcal{I}_d = \{s_m, s_d\}$. Because there is no more information asymmetry, market correctly anticipates the optimal investment scale (8) as well as the expected cash flows (9). Therefore, the price given disclosure, denoted by P^d is

$$P^d(s_m, s_d) = \mathbb{E}\left[CF^*(s_m, s_d) \mid \mathcal{I}_d\right] = \frac{1}{2r}\exp\left(2\left(c_0 + c_m s_m + c_d s_d\right)\right) \tag{10}$$

where the coefficients $c's$ are as given in Lemma 1. Because P^d is monotonic in s_d, the manager can perfectly infer the investor's signal from the price signal.

We define the ***price feedback*** as the reduction in the manager's uncertainty regarding $\tilde{f}_2$ after receiving the price signal. That is,

$$\Delta V_d = Var\left(\tilde{f}_2 \mid s_m\right) - Var\left(\tilde{f}_2 \mid s_m, P^d\right).$$

ΔV_d captures the incremental learning about the common productivity factor $\tilde{f}_2$ from the price relative to manager's own information. Re-writing market price as $\frac{1}{c_d}\left(\frac{\log 2r + \log P^d}{2} - c_0 - c_m s_m\right) = s_d$, we have

$$\Delta V_d = Var\left(\tilde{f}_2 \mid s_m\right) - Var\left(\tilde{f}_2 \mid s_m, s_d\right) = \tau_{f_2}^{-1} - \left(\tau_{f_2} + \tau_d\right)^{-1} = \frac{\tau_d}{\tau_{f_2}\left(\tau_{f_2} + \tau_d\right)} \tag{11}$$

Hence, the manager learns more from the price when the quality of the investor's information is higher.

Price conditional on non-disclosure. If the manager withholds the signal, the investor's information set is $\mathcal{I}_{nd} = \{s_m \in \mathcal{ND}, s_{nd}\}$ where $s_m \in \mathcal{ND}$ denotes the equilibrium non-disclosure set. When the manager withholds their private information, the market faces uncertainty regarding the optimal investment scale and consequently, the expected cash flows. In this case, the non-disclosure price, denoted by P^{nd}, is

$$P^{nd}(s_{nd}) = \mathbb{E}\left[CF^*(\tilde{s}_m, s_{nd}) \mid \mathcal{I}_{nd}\right] = \mathbb{E}\left[\mathbb{E}\left[CF^*(s_m, s_{nd}) \mid \mathcal{I}_{nd}, s_m\right] \mid \mathcal{I}_{nd}\right],$$

where the second equality uses the law of iterated expectations. Substituting the expected cash flow using (9) yields

$$P^{nd}(s_{nd}) = \mathbb{E}\left[\frac{1}{2r}\exp\left(2\left(c_0 + c_m s_m + c_{nd} s_{nd}\right)\right) \mid s_{nd}, s_m \in \mathcal{ND}\right].$$

Using the fact that s_m and s_{nd} are independent of each other in the above expression yields the non-disclosure price summarized in Lemma 2.

Lemma 2. *The market price of the firm conditional on non-disclosure is given by:*

$$P^{nd}(s_{nd}) = \frac{1}{2r} \exp\left(2\left(c_0 + c_{nd} s_{nd}\right)\right) \cdot \kappa \tag{12}$$

where $\kappa = \mathbb{E}\left[\exp\left(2 c_m s_m\right) \mid s_m \in \mathcal{ND}\right]$.

Lemma 2 states that non-disclosure price depends on the manager's optimal disclosure policy $\mathcal{ND}$ as well as the private information of the investor. When the manager chooses the optimal disclosure policy, they have to take into account how the investor's information acquisition might influence the non-disclosure price. Note that P^{nd} is monotonic in s_{nd} and therefore, observing the price is equivalent to observing the investor's private signal.

Further, the price feedback upon non-disclosure is

$$\Delta V_{nd} = Var\left(\tilde{f}_2 \mid s_m\right) - Var\left(\tilde{f}_2 \mid s_m, s_{nd}\right) = \frac{\tau_{nd}}{\tau_{f_2}\left(\tau_{f_2} + \tau_{nd}\right)}. \tag{13}$$

The price is more informative to the manager if the investor has higher quality information.

1.2.3 Optimal disclosure policy

Given the expected cash flows and market prices, the manager discloses the private signal s_m if and only if

$$\mathcal{U}^D(s_m) - c \geq \mathcal{U}^{ND}(s_m) \tag{14}$$

where $\mathcal{U}^D$ and $\mathcal{U}^{ND}$ denote the expected payoff of the manager in case of disclosure and non-disclosure, respectively.

Manager's payoff conditional on disclosure. In case of disclosure, using (1), the expected utility is given by:

$$\mathcal{U}^D(s_m) = \mathbb{E}\left[\beta P^D(s_m, s_d) + (1-\beta) CF(s_m, s_d) \mid s_m\right]$$

where the disclosure price $P^D(s_m, s_d)$ is given by (10) and the expected cash flows are given by (9). Note that when the manager discloses the private signal, there is no information asymmetry between the manager and the investors. Therefore, the expected disclosure price and the expected cash flows are identical. Hence,

$$\mathcal{U}^D(s_m) = \mathbb{E}\left[\frac{1}{2r}\exp\left(2\left(c_0 + c_m s_m + c_d s_d\right)\right) \mid s_m\right],$$

where s_d is the information acquired by the investor at $t = 2$. Since s_d and s_m are independent, we have $s_d \mid s_m \sim \mathcal{N}\left(\overline{f}_2, \tau_{f_2}^{-1} + \tau_d^{-1}\right)$. Therefore, expected utility conditional on disclosure is given by:

$$\mathcal{U}^D(s_m) = \frac{1}{2r}\exp\left(2\left(c_0 + c_m s_m\right) + 2c_d\overline{f}_2 + \frac{1}{2}\left(2c_d\right)^2\left(\tau_{f_2}^{-1} + \tau_d^{-1}\right)\right)$$

Simplifying the above equation yields the following lemma.

Lemma 3. *Conditional on the manager's information set $\mathcal{I}_M = \{s_m\}$, the expected disclosure utility is given by*

$$\mathcal{U}^D(s_m) = \frac{1}{2r}\exp\left(\alpha_0 + \Delta V_d + 2c_m s_m\right) \tag{15}$$

where $\alpha_0 = 2\left(\frac{\overline{f}_1\tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \overline{f}_2 + \frac{1}{2\tau_{f_2}}\right)$ is independent of τ_d, and ΔV_d is the manager's uncertainty reduction about $\tilde{f}_2$ given by (11).

Two observations about Lemma 3 are worth discussing. First, the manager's expected utility is strictly increasing in the private information given that $c_m > 0$. Second, the expected utility is increasing in the informativeness of the price signal. Therefore, all else equal, more precise investor's information incentivizes the manager to disclose their private information.

Manager's payoff conditional on non-disclosure. In case of non-disclosure, the expected cash flows are given by (9), where the signal coming from the market price is s_{nd}. Following derivation similar to Lemma 3, we get

$$\mathbb{E}\left[CF^{ND}(s_m, s_{nd}) \mid s_m\right] = \frac{1}{2r}\exp\left(\alpha_0 + \Delta V_{nd} + 2c_m s_m\right) \tag{16}$$

where ΔV_{nd} is given by (13). Similar to the case of disclosure, expected cash flows conditional on non-disclosure are increasing in the price feedback ΔV_{nd}.

Next, the non-disclosure price $P^{ND}(s_{nd})$ does not depend on s_m but depends on s_{nd} which is unobservable to the manager at the time they make their disclosure decision. As a result, the price upon non-disclosure is an expectation over the values of the investor's private signal s_{nd}. We summarize the expected non-disclosure price below.

Lemma 4. *The expected market price of the firm conditional on non-disclosure is given by:*

$$\mathbb{E}\left[P^{ND}\left(s_{nd}\right) \mid s_m\right] = \frac{1}{2r}\exp\left(\alpha_0 + \Delta V_{nd}\right)\cdot\kappa \tag{17}$$

where $\kappa = \mathbb{E}\left[\exp\left(2c_m s_m\right) \mid s_m \in \mathcal{ND}\right]$ *and* α_0 *is as defined in Lemma 3.*

Proof. See Appendix A.2. ∎

Lemma 4 states that the expected non-disclosure price depends on the manager's optimal disclosure policy $\mathcal{ND}$, through their choice of the non-disclosure set, as well as price feedback. Expected price increases in ΔV_{nd} because the manager learns more from the price, improving investment efficiency and thus expected cash flows of the firm.

Equilibrium Disclosure Policy Using the expected utility upon disclosure, (15), and expected non-disclosure cash flows and price, (16) and (17), the manager discloses private signal if and only if

$$\frac{1}{2r}\exp\left(\alpha_0 + \Delta V_d + 2c_m s_m\right) - c \geq \frac{\beta}{2r}\exp\left(\alpha_0 + \Delta V_{nd}\right)\cdot\kappa + \frac{1-\beta}{2r}\exp\left(\alpha_0 + \Delta V_{nd} + 2c_m s_m\right) \tag{18}$$

To see the trade-off the manager faces when deciding whether to disclose, re-write (18) as

$$\underbrace{\beta\left(e^{\Delta V_d}e^{2c_m s_m} - e^{\Delta V_{nd}}\cdot\kappa\right)}_{\text{Short-term price incentive}} + \underbrace{(1-\beta)\,e^{2c_m s_m}\left(e^{\Delta V_d} - e^{\Delta V_{nd}}\right)}_{\text{Long-term value incentive}} \geq \underbrace{2rc\cdot e^{-\alpha_0}}_{\text{Disclosure cost}}, \tag{19}$$

where $\kappa = \mathbb{E}\left[e^{2c_m s_m} \mid \mathcal{ND}\right]$. In the voluntary disclosure setup with market feedback, in addition to the classic short-term price incentive for disclosure, the manager has long-term informational benefit from disclosure. If, upon disclosure, the investor acquires a more precise signal (i.e., $e^{\Delta V_d} - e^{\Delta V_{nd}} > 0$), providing disclosure delivers more information about the firm's investment productivity to the manager. The manager, armed with a better price signal, makes a more efficient investment decision and thus obtains higher cash flows for the firm. Note that this disclosure incentive is present even if the manager is completely non-myopic ($\beta = 0$). On the other hand, if, upon disclosure, the investor's private information acquisition is crowded out (i.e., $e^{\Delta V_d} - e^{\Delta V_{nd}} < 0$), the manager's long-term incentive turns negative and discourages disclosure.

The short-term price incentive has two distinct forces. To see them, re-write the price term as

$$e^{\Delta V_d} e^{2c_m s_m} - e^{\Delta V_{nd}} \cdot \kappa = \underbrace{e^{2c_m s_m}\left(e^{\Delta V_d} - e^{\Delta V_{nd}}\right)}_{\text{Informational effect}} + \underbrace{e^{\Delta V_{nd}} \cdot \left(e^{2c_m s_m} - \kappa\right)}_{\text{Strategic pooling effect}}.$$

The first term represents the incremental price impact of disclosure arising from the investor's information acquisition upon disclosure and is identical to the informational effect in the long-term incentive. If, upon disclosure, price feedback is better (i.e., $e^{\Delta V_d} - e^{\Delta V_{nd}} > 0$), disclosure improves the manager's decision and increases ultimate firm cash flows.

The second term captures the manager's incremental benefit of separating their firm from firms with low productivity. If the manager does not disclose, the market's belief about the firm is proportional to κ, and if they do disclose, the market knows the manager's signal about the firm's productivity. For a sufficiently high manager's signal, disclosure dominates pooling as it raises the contemporaneous valuation.

Proposition 1. *Let $V = e^{\Delta V_d} - (1-\beta) e^{\Delta V_{nd}} > 0$. Then, there exists a unique equilibrium such that the optimal disclosure set is given by $\mathcal{D} = \{s_m \mid s_m \geq s_m^c\}$ where s_m^c solves*

$$s_m^c = \frac{1}{2c_m} \log\left(e^{-\alpha_0} \frac{\beta e^{\Delta V_{nd} + \Delta V_m} \cdot \gamma\left(s_m^c\right)\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 + 2rc}{V}\right) \tag{20}$$

with

$$\gamma\left(s_m^c\right) = \frac{\Phi\left(\frac{s_m^c - \bar{f}_1}{\sigma_m} - 2\sqrt{\Delta V_m}\right)}{\Phi\left(\frac{s_m^c - \bar{f}_1}{\sigma_m}\right)}$$

where $\sigma_m = \sqrt{\tau_m^{-1} + \tau_{f_1}^{-1}}$ and $\Delta V_m = \dfrac{\tau_m}{\tau_{f_1}\left(\tau_{f_1} + \tau_m\right)}$ represent the manager's reduction in uncertainty about $\tilde{f}_1$. If $V \leq 0$, the manager never discloses.

Proof. See Appendix A.3. ∎

Proposition 1 states that, when disclosure induces sufficiently more market feedback than non-disclosure, the manager follows a cutoff strategy where good signals are disclosed to the market.[2]

If the manager has no short-term incentives to maximize price, i.e. $\beta = 0$, then the only incentive for disclosure is improvement in the informativeness of the price signal. In this case, if

[2] We can re-write the condition as $\Delta V_d - \Delta V_{nd} > \log(1-\beta)$.

$\Delta V_{nd} \geq \Delta V_d$, the manager receives a more precise price signal if they do not disclose. As a result, the manager never discloses. On the other hand, if $\Delta V_d > \Delta V_{nd}$ the cutoff for disclosure is

$$s_m^c\left(\beta = 0\right) = \frac{1}{2c_m}\log\left(\frac{2rce^{-\alpha_0}}{e^{\Delta V_d} - e^{\Delta V_{nd}}}\right) \tag{21}$$

That is, the manager discloses as long as the incremental uncertainty reduction upon disclosure is sufficiently high to cover the disclosure costs.

On the other extreme, if the manager does not care about the long-term value, and hence the price feedback, i.e. $\beta = 1$, the disclosure rule collapses to the standard cutoff rule where the manager reveals high signals as long as the gain in the expected price is larger than the disclosure cost. Specifically,

$$s_m^c\left(\beta = 1\right) = \frac{1}{2c_m}\log\left(e^{-\alpha_0}\frac{e^{\Delta V_{nd}+\Delta V_m}\cdot\gamma\left(s_m^c\right)\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 + 2rc}{e^{\Delta V_d}}\right) \tag{22}$$

Given the disclosure cut-off, we compute the probability of disclosure as

$$Pr\left(\mathcal{D}\right) = Pr\left(s_m \geq s_m^c\right) = 1 - \Phi\left(\frac{s_m^c - \overline{f}_1}{\sigma_m}\right) \tag{23}$$

Figure 2 plots the probability of disclosure as a function of β for different values of price feedback ΔV_d and ΔV_{nd}.[3] First, for $V > 0$, the probability of disclosure increases in the degree of managerial myopia (β) for all cases. This is because higher myopia makes the short-term price incentives stronger and hence, the benefit from separating from low-type firms. Second, as price feedback upon disclosure improves relative to price feedback upon non-disclosure (moving from green to red to blue line), disclosure becomes more likely for any level of myopia. The intuition is that with improved price feedback upon disclosure relative to non-disclosure, the informational effect becomes stronger. As a result, both the short- and long-term objectives incentivize manager to disclose more.[4].

[3]In Appendix A.5, we prove the patterns of Figure 2 formally and show that these do not depend on specific parameter choices.

[4]For the short-term price inventive, information effect dominates the strategic pooling effect when ΔV_d is large relative to ΔV_{nd}

1.3 Real Efficiency

To understand the effect of strategic disclosure and price feedback on the real outcomes of the firm, we compute the ex-ante expected cash flow of the firm:

$$\mathbb{E}\left[CF\right] = Prob\left(\mathcal{D}\right)\mathbb{E}\left[CF\left(s_m, s_d\right) \mid s_m \in \mathcal{D}\right] + Prob\left(\mathcal{ND}\right)\mathbb{E}\left[CF\left(s_m, s_d\right) \mid s_m \in \mathcal{ND}\right] \tag{24}$$

Lemma 5. *Ex-ante expected firm-value is given by:*

$$\mathbb{E}\left[CF\right] = \frac{1}{2r}\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{\Delta V_m} \times \left(\left(1-\Lambda_m\right)e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}\right) \tag{25}$$

where $\Lambda_m = \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)$ *and* z_m^c *is the equilibrium disclosure cut-off.*

Proof. See Appendix A.4. ■

The firm's expected ultimate cash flow increases in (1) its fundamentals – levels of productivity $\left(\mathbb{E}\left[\tilde{F}\right]\right)$, (2) quality of the manager's private information $\left(\Delta V_m\right)$, and (3) expected quality of the information the manager obtains from the investor through price feedback, depending on their disclosure choice $\left(\left(1-\Lambda_m\right)e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}\right)$. As the disclosure threshold z_m^c increases, the ultimate cash flow becomes more sensitive to the price feedback upon non-disclosure.

To isolate the effect of different channels, we define two benchmarks. The first benchmark is the no myopia benchmark: $\beta = 0$. In this case, the disclosure policy maximizes the price feedback and, therefore, maximizes the long-term firm value. The second benchmark is the benchmark where the manager ignores the price feedback. In this case, the expected cash flows conditional on the manager's private information are

$$\mathbb{E}\left[CF^*\left(s_m\right) \mid s_m\right] = \frac{1}{2r}\exp\left(2\left(c_0^{nl} + c_m s_m\right)\right)$$

where $c_0^{nl} = \frac{\overline{f}_1\tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \overline{f}_2 + \frac{1}{2\tau_{f_2}}$ is the no-learning constant term. Hence, the ex-ante expected cash flows are given by:

$$\mathbb{E}^{nl}\left[CF^*\left(s_m\right)\right] = \frac{1}{2r}\exp\left(2c_0^{nl}\right)\mathbb{E}\left[\exp\left(2c_m s_m\right)\right] = \frac{1}{2r}\exp\left(2c_0^{nl} + 2c_m\overline{f}_1 + 2c_m^2\sigma_m^2\right)$$

which can be simplified as

$$\mathbb{E}^{nl}\left[CF^*\left(s_m\right)\right] = \frac{1}{2r}\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{\Delta V_m} \tag{26}$$

These two benchmarks help us understand the effect of the interaction between strategic disclosure and price feedback on the real efficiency. We summarize this effect below.

Proposition 2. *Let $V = e^{\Delta V_d} - (1-\beta)\, e^{\Delta V_{nd}}$. Then, in equilibrium, ex-ante expected firm value is:*

1. *Strictly higher than under the no-learning benchmark.*
2. *Independent of managerial myopia when $V \leq 0$. When $V > 0$, expected firm value is strictly increasing in myopia if $\Delta V_d > \Delta V_{nd}$, and strictly decreasing if $\Delta V_d < \Delta V_{nd}$.*

Proof. See Appendix A.5. ■

The first part of Proposition 2 simply states that real efficiency improves when the manager incorporates price feedback into their investment decision. This is intuitive since the price signal is publicly available and is informative about the firm's productivity as long as the precision of the investor's signal is positive. Incorporating price signal into the decision making reduces the uncertainty about the component of productivity for which the manager has no private information. Consequently, the real efficiency improves relative to the no-learning benchmark. Importantly, this holds for all levels of managerial myopia and for *any* disclosure strategy. The reason is that any information in the price feedback reduces the posterior uncertainty about $\tilde{f}_2$.

The second part of Proposition 2 reveals that the effect of managerial myopia on investment efficiency is non-monotonic and depends crucially on both the strategic disclosure and the price feedback effect. When $V \leq 0$, which happens when $\Delta V_d < \Delta V_{nd}$ and the myopia β is sufficiently weak, the manager strategically withholds any private information (See Proposition 1). As a result, a small increase in myopia is not sufficient enough for the short-term price incentives to dominate the long-term value incentives. Therefore, firm value remains constant in this region.

When the equilibrium leads to a partial disclosure, the differential price feedback upon disclosure relative to non-disclosure is the primary driver of the effect of myopia on firm value. First, when $V > 0$, an increase in myopia incentivizes manager to disclose more because of the stronger short-term price incentives. This holds for all $\Delta V_d > 0$ and $\Delta V_{nd} > 0$. However, if $\Delta V_{nd} > \Delta V_d$, more disclosure crowds-out the price feedback effect. This implies that the manager forgoes the uncertainty reduction about $\tilde{f}_2$ in favor of the myopic price incentives, thereby hurting the long-term firm value. Here, the short- and long-term incentives get misaligned for the manager when disclosure crowds-out market information with probability of disclosure and real efficiency being negatively correlated. On the other hand, if $\Delta V_d > \Delta V_{nd}$, a larger propensity to disclose crowds-in price feedback, therefore aligning the incentive to boost stock price with maximizing the long-term firm value.

Figure 3 represents the real efficiency result as a function of β for different values of ΔV_d and ΔV_{nd}.[5] We can observe that managerial myopia plays a very different role in driving the firm value. First, the expected value in the no-learning benchmark is below the equilibrium for all the cases. Next, for fixed $\Delta V_d < \Delta V_{nd}$ (green line), expected value is (weakly) decreasing in the myopia. For low levels of β, $V \leq 0$ leads to no disclosure and hence, a flat line. As disclosure increases for higher levels of myopia (See Figure 2), real efficiency declines due to the crowding-out effect. Finally, for fixed $\Delta V_d > \Delta V_{nd}$ (blue line), real efficiency monotonically increases as more myopia leads to crowding-in of information and thus a larger uncertainty reduction for the investment decision. In sum, the net effect of myopia on real efficiency depends on whether higher myopia induces crowding in or crowding out of the information via the strategic disclosure incentives.

2 Data

In order to estimate our model, we need to find a setting where (1) firms provide voluntary disclosure related to their investments, (2) stock market anticipates that a firm might provide a disclosure, and (3) stock market can provide meaningful feedback. We choose firms' annual CapEx forecasts bundled with their earnings announcements. First, a firm's CapEx forecast must represent the firm's information about productivity of its invested capital, and CapEx forecasts are voluntary. Second, we restrict our sample to firms that routinely bundle their annual CapEx forecasts with earnings announcements, and, therefore, we can exactly pin down on which day investors expect the disclosure to happen – on the earnings announcement day. Finally, prior work (Jayaraman and Wu (2019)) has shown that firms seem to take into account market reaction to their CapEx forecasts when choosing capital investment.

We use three sources to construct our main dataset for estimation – London Stock Exchange

[5]For $\Delta V_d = \Delta V_{nd}$ case, $\mathbb{E}\left[CF\right] = \frac{1}{2r}\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{\Delta V_m + \Delta V_d}$ is independent of β.

(LSEG) IBES for management forecasts and actual values of forecasted variables, Wharton Research Data Services (WRDS) event study tool for stock returns, and Compustat for firms' returns on invested capital. For IBES, we leave only annual CapEx forecasts and firms that provide CapEx forecasts on their earnings announcement days. We keep each firm only starting from the first year it provided a CapEx forecast because before that year investors might not expect a forecast from the firm. For stock returns, we compute cumulative abnormal returns in the $[-3,7]$ day window around the EPS announcement. We compute return on invested capital (ROIC) as operating income after depreciation divided by invested capital.

An important concern is that a stock return around an EPS announcement includes market reaction to the announcement itself. We address this problem by regressing the cumulative abnormal returns on the EPS surprise and taking the residuals from that regression as our measure of market reaction to the concurrent CapEx forecast or absence of it.[6]

To account for firms' different sizes, we normalize actual and forecasted values of CapEx by firms' total assets.

After removing firms that miss data on one or more variables, we are left with 1,812 U.S. firms, from 2005 to 2022, 13,758 observations in total.

Table 1 provides summary statistics on key financial variables for firms in our sample. A median firm has a book value of $1,065 million, a market value of $3,025 million, and total assets of $2,894 million. Its market-to-book ratio is 2.4, ROIC is about 0.121, and leverage ratio (the ratio of total debt to total assets) is 0.275.

Tables 2a-2c show summary statistics for key variables used in the estimation. A few important statistics are worth discussing. In our sample, two-thirds of firms provide an annual CapEx forecast on their EPS announcement days. When we split our sample into firms that do and do not provide a CapEx forecast with their EPS, we find that disclosing firms appear to have a higher cumulative abnormal return on the EPS announcement day and a higher level of actual CapEx. Interestingly, for firms that provide CapEx forecasts, actual CapEx levels seem lower than what was forecasted. These high-level observations suggest that (1) firms that do and do not provide CapEx guidance may be different from each other and (2) firms that provide CapEx guidance may be changing their plans in response to market reaction to their forecasts, consistent with Jayaraman and Wu (2019).

[6] In untabulated analyses, we also remove variation in cumulative abnormal returns explained by other forecasts a firm may have provided and show that our results do not change substantially.

3 Identification and estimation

In this section, we discuss the intuition behind identification of model parameters from our data and describe the estimation procedure. First, we calibrate the managerial myopia parameter β. Next, we estimate five model parameters. The first set of these consists of two parameters, τ_{f_1} and τ_{f_2}, that describe fundamental uncertainty about firms' productivity: variances of the idiosyncratic ($\tilde{f}_1$) and the common ($\tilde{f}_2$) components. The second set consists of three parameters describing the quality of information: τ_m is the quality of the manager's private information, and τ_d and τ_{nd} are the qualities of the investor's private information upon managerial disclosure and non-disclosure. [7]

3.1 Managerial myopia

We begin by calibrating the managerial myopia β by mapping the static utility (1) to an equivalent price-based representation as

$$\mathcal{U}' = P_0 + \beta_0 P_1. \tag{27}$$

where β_0 is the manager's subjective discount factor and P_1, the expected price of the firm at $t = 1$, equals the present value of future cash flows discounted at a market rate of return r_M:

$$P_1 = \sum_{t>1} \frac{\mathbb{E}\left[CF_{t+1}\right]}{\left(1+r_M\right)^t}. \tag{28}$$

Assuming that cash flows follow an $AR(1)$ process with persistence coefficient ρ, (28) gives $P_1 = \frac{\rho\delta}{1-\rho\delta} CF_1$ where $\delta = (1+r_M)^{-1}$. Substituting in (1) yields

$$\mathcal{U} = \beta P + (1-\beta)\left((\rho\delta)^{-1} - 1\right) P_1 = \beta\left(P + \left(\frac{1-\beta}{\beta}\right)\left((\rho\delta)^{-1} - 1\right) P_1\right). \tag{29}$$

[7] Our main results regarding the informativeness of managers' and investors' information are independent of the average firm productivity, $\bar{f}_1$ and $\bar{f}_2$, the costs of investment, r, and the cost of disclosure, c. Since the focus of our paper is on information, we do not estimate these parameters. However, the average productivity $\bar{f}_1$ and $\bar{f}_2$ can be estimated using the Kalman filter approach described below. The cost r can be estimated by targeting the cross-sectional mean of investment in the data since $\mathbb{E}\left[I^*\left(s_m, s_i\right)\right] = \frac{1}{r}\exp\left(\bar{f}_1 + \bar{f}_2 + \frac{1}{2\tau_{f_1}} + + \frac{1}{2\tau_{f_2}}\right)$. The cost c can be estimated using the disclosure equilibrium condition (20).

Comparing the coefficients of (29) with (27) up to a scaling factor, we get

$$\beta_0 = \left(\frac{1-\beta}{\beta}\right)\left((\rho\delta)^{-1} - 1\right) \implies \beta = \frac{(\rho\delta)^{-1} - 1}{\beta_0 + (\rho\delta)^{-1} - 1}. \tag{30}$$

We choose $\beta_0 = 1 - (1/3.29)$ based on the median vesting duration (e.g. Gopalan et al. (2014); Bertomeu et al. (2022)) and set the annual rate of return $r_M = 4\%$. We estimate ρ from an $AR(1)$ regression of cash flows using the pooled sample described in Section 2 and obtain $\rho = 0.60$,[8] yielding $\beta = 0.513$. Our estimate suggests that the manager's incentives make them put almost the same weight on the short-term prices and the long-term firm value.

3.2 Parameters describing the quality of information

The parameters describing the quality of information can be obtained from four model statistics: the disclosure threshold z_m^c, the informativeness of the manager's information ΔV_m (for τ_m), price feedback upon disclosure ΔV_d (for τ_d), and price feedback upon non-disclosure ΔV_{nd} (for τ_{nd}). The first step of our estimation is to estimate these four statistics. We use six moments, described in Appendix B.1: probability of disclosure, average investment level of non-disclosing firms relative to disclosing firms, variances of investment level of disclosing and non-disclosing firms, variance of the difference in actual and management-forecasted investment for disclosing firms, and volatility of market reaction to disclosures relative to non-disclosure.

First, the ratio of the average investment conditional on non-disclosure to that of disclosure helps identify ΔV_m because *conditional* on the disclosure strategy, this ratio is affected only by the quality of the manager's information.

Second, price feedback upon disclosure ΔV_d is identified from the variance of investment of disclosing firms, the variance of the difference in actual and management-forecasted investment for disclosing firms, and from the ratio of the variance of price returns upon disclosure to those upon non-disclosure. Intuitively, for a fixed quality of managers' private information, a higher variance of investment for disclosing firms implies that the feedback from the market is more informative for these firms. Similarly, for a fixed quality of managers' private information, a greater variance in how actual investment is different from manager-forecasted for disclosing firms implies that market reaction upon disclosure moves disclosing firms' investment decisions

[8] Specifically, we estimate the AR(1) regression for operating income after depreciation. We first remove firm and year fixed effects from the series. The estimated AR(1) coefficient is $\rho = 0.602$ with a standard error of 0.007.

more. Finally, if, conditional on the content of the manager's disclosed investment forecast, market returns vary more for disclosing firms, investors' must be receiving better private information upon disclosure.

Price feedback upon non-disclosure ΔV_{nd}, similarly to ΔV_d, is identified from the variance of investment of non-disclosing firms and from the ratio of the variance of price returns upon disclosure to those upon non-disclosure.

Third, once ΔV_m, ΔV_d, and ΔV_{nd} are identified, the disclosure threshold z_m^c primarily comes from the probability of disclosure. If the disclosure probability is higher, the threshold z_m^c is lower.

We estimate $(\Delta V_m, \Delta V_d, \Delta V_{nd}, z_m^c)$ using the Generalized Method of Moments (GMM). Intuitively, the method searches for the set of the parameters that minimize the distance between model-implied theoretical moments and their empirical counterparts. Since the number of moments is higher than the number of parameters, the model is over-identified. We describe the estimation procedure in detail in Appendix B.2.

3.3 Parameters describing firms' productivity

The second step of our estimation is to obtain the parameters that describe uncertainty about firms' productivity, τ_{f_1} and τ_{f_2}. In the data, we can observe the variance of overall productivity, i.e., ROIC, however, we cannot separately observe the idiosyncratic and common components. We estimate these components as dynamic processes using a linear Gaussian state-space model and the Kalman filter. Specifically, we assume that the idiosyncratic component for firm i and the common component follow stationary $AR(1)$ processes:

$$f_{1,it} = \mu_1 + \rho_1 f_{1,it-1} + \sigma_{\eta_1}\eta_{1,it}, \qquad \eta_{1,it} \sim \mathcal{N}(0,1), \tag{31}$$

$$f_{2,t} = \mu_2 + \rho_2 f_{2,t-1} + \sigma_{\eta_2}\eta_{2,t}, \qquad \eta_{2,t} \sim \mathcal{N}(0,1), \tag{32}$$

where $f_{1,it}$ denotes the firm-level idiosyncratic component in year t, and $f_{2,t}$ denotes the common component. We assume $\{\eta_{1,it}\}$ are independent across i and t, and independent of $\{\eta_{2,t}\}$. Since our model is stationary,

$$\bar{f}_1 = \frac{\mu_1}{1-\rho_1}, \qquad \bar{f}_2 = \frac{\mu_2}{1-\rho_2}, \tag{33}$$

$$\tau_{f_1}^{-1} = \frac{\sigma_{\eta_1}^2}{1-\rho_1^2}, \qquad \tau_{f_2}^{-1} = \frac{\sigma_{\eta_2}^2}{1-\rho_2^2}. \tag{34}$$

Because the return on investment that we observe (the logarithm of ROIC), f_{it}, is the sum of the two latent components:

$$f_{it} \;=\; f_{1,it} + f_{2,t}, \tag{35}$$

equations (31)–(32) and (35) can be represented as the linear Gaussian state-space system:

$$x_{i,t+1} = \mu + Ax_{it} + Cw_{i,t+1}, \qquad w_{i,t+1} \sim \mathcal{N}(0, I_2), \tag{36}$$

$$f_{it} = Gx_{it}, \tag{37}$$

where $x_{it} \equiv \begin{bmatrix} f_{1,it} & f_{2,t} \end{bmatrix}^\top$ is the latent state vector for firm i. Given the Gaussian linear state-space structure, the Kalman filter delivers the likelihood of the observed panel $\{f_{it}\}$ as a function of the parameter vector $\theta \equiv \left(\mu_1, \rho_1, \sigma_{\eta_1}, \mu_2, \rho_2, \sigma_{\eta_2}\right)$, and we estimate θ by maximum likelihood (see Appendix B.2.3 for details), which we then use to discipline $\left(\tau_{f_1}, \tau_{f_2}\right)$ using (34).

4 Estimation results

Table 3 shows estimates of our key parameters: volatilities of idiosyncratic and common components of firms' productivity, the quality of the manager's private information, and the quality of investors' private information upon the manager's disclosure and non-disclosure. Table 4 shows how well our model matches the targeted moments in the data.

First, the estimates suggest that the firm-specific component of firms' productivity has a smaller variance than the common component, i.e., $\tau_{f_1}^{-1} < \tau_{f_2}^{-1}$. Specifically, more than two-thirds of an individual firm's productivity is driven by the market-wide factor, and remaining less than one-third by its idiosyncratic circumstances.

Second, the precision of the manager's private information about the idiosyncratic component and the precision of the investors' private information about the common component are economically significant and comparable in magnitudes. The estimate of τ_m lies between the estimates of τ_d and τ_{nd}. Importantly, the precision of investors' private information upon non-disclosure τ_{nd} is meaningfully higher than the precision of investors' information upon disclosure τ_d. This result suggests that voluntary disclosure of investment forecasts on average **crowds out** investors' private information acquisition. When the manager discloses her information about the idiosyncratic component to investors, the manager loses the benefit of learning about the common component from price feedback. We evaluate these informational losses more precisely below.

4.1 The manager's and the market's information

Estimates of information precision are meaningful only when interpreted relative to the overall uncertainty about the underlying components, rather than in isolation. We introduce statistics capturing how well the managers' or the investors' information resolve uncertainty about the firm's productivity:

1. The usefulness of the manager's information, $\frac{\Delta V_m}{\sigma^2_{f_1}}$. This statistic captures how much uncertainty about the firm's idiosyncratic productivity factor is resolved by the manager's private information.

2. The usefulness of the investors' information upon non-disclosure, $\frac{\Delta V_{nd}}{\sigma^2_{f_2}}$. This statistic captures how much uncertainty about the firm's common productivity factor is resolved by the information investors privately acquire after they observe that the manager did not disclose her private information.

3. The usefulness of the investors' information upon disclosure, $\frac{\Delta V_d}{\sigma^2_{f_2}}$. This statistic captures how much uncertainty about the firm's common productivity factor is resolved by the information investors privately acquire after the manager discloses her private information.

Our estimates result in $\frac{\Delta V_m}{\sigma^2_{f_1}} = 29.3\%$, or firm managers' private knowledge of their firms' idiosyncratic circumstances resolves about one-third of the total uncertainty about firms' idiosyncratic productivity. Managers' private information is useful. However, a big part of the idiosyncratic productivity remains unpredictable.

As for the investors' information, $\frac{\Delta V_{nd}}{\sigma^2_{f_2}} = 56.0\%$ and $\frac{\Delta V_d}{\sigma^2_{f_2}} = 17.2\%$. Two important conclusions emerge from our estimates. First, it appears that managers' private information about firm-specific factors and investors' private information about common economic factors are of comparable importance for firms' investment decisions. This result is interesting given the typical belief in the literature that corporate managers possess superior information. We find that, while managers do have useful firm-specific information, firms need the market's knowledge to the same extent as they need the managers' expertise. This finding contrasts with the result in David et al. (2016) who find that firms primarily turn to internal sources as opposed to the market to learn information relevant for production decisions. Our results are consistent with the importance of price feedback in firms' decisions (Bakke and Whited (2010)).

Second, the substantial difference between the quality of investors' information upon disclosure and non-disclosure suggests that managers' voluntary disclosure of investment plans crowds out investors' private information acquisition. Managers' information does not improve price feedback but rather discourages traders from conducting their own research of the firm. Prior literature studied how provision of public information affects investors' information production and found mixed results (for instance, Gao and Huang (2019) find that investors start producing more information when more firm information is available publicly, while Jayaraman and Wu (2018) and Chen et al. (2020) find the opposite). We show that information about investment plans that voluntarily comes from firm management tends to discourage investors' information production. Importantly, price feedback is present when managers provide investment plans (Jayaraman and Wu (2019)), but it would be even better had the managers stayed silent.

4.2 Investment efficiency implications

In this section, we use our estimated parameters to evaluate real efficiency implications of the voluntary nature of investment plans disclosure. First, we quantify real efficiency gains because of learning and losses because of managerial myopia. Second, we evaluate which part of an average firm's long-term value is driven by the manager's and the investors' information.

4.2.1 Real Efficiency

We compare the actual long-term value of an average firm to two counterfactual benchmarks. The first benchmark is the no-learning benchmark, or the firm value if the manager did not receive any price feedback.

We divide the actual value (25) by the hypothetical no-earning value (26):

$$\frac{\mathbb{E}\left[CF\right]}{\mathbb{E}^{nl}\left[CF\right]} = (1 - \Lambda_m)\, e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}$$

Using the estimated parameters, we find that $\frac{\mathbb{E}[CF]}{\mathbb{E}^{nl}[CF]} = 1.27$. Price feedback improves the long-term value of an average firm by about 27%.

The second benchmark is the no-myopia benchmark, or the firm value if the manager's incentives did not make her care about the firm's short-term price at all. Recall from Proposition 1 that, if the manager is completely non-myopic ($\beta = 0$), the disclosure decision is driven solely by learning considerations. If the manager receives better price feedback upon disclosure (non-disclosure), she always discloses (withholds). Our estimates suggest that feedback is strictly better upon non-disclosure, so the non-myopic manager will never disclose, and the benchmark firm value is simply the value with price feedback upon non-disclosure. The ratio of actual to benchmark firm value is

$$\frac{\mathbb{E}[CF]}{\mathbb{E}^{\beta=0}[CF]} = \frac{(1-\Lambda_m)\, e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}}{e^{\Delta V_{nd}}}$$

Re-writing, we define the real efficiency loss due to managerial myopia as

$$1 - \frac{\mathbb{E}[CF]}{\mathbb{E}^{\beta=0}[CF]} = \underbrace{(1-\Lambda_m)}_{\substack{\text{Strategic Disclosure} \\ \text{Margin}}} \times \underbrace{\left(1 - e^{\Delta V_d - \Delta V_{nd}}\right)}_{\substack{\text{Relative price} \\ \text{feedback margin}}} \tag{38}$$

The equation (38) demonstrates that the real efficiency loss due to myopia is driven by (1) the strategic disclosure incentives and (2) the wedge in the price feedback upon disclosure relative to non-disclosure. Note that if the wedge is zero, i.e., $\Delta V_d = \Delta V_{nd}$, there is no loss in real efficiency due to the strategic disclosure margin. This is intuitive as no matter the disclosure strategy, the manager's reduction in uncertainty and hence the real decisions remain unchanged. Once $\Delta V_d \neq \Delta V_{nd}$, the magnitude of real efficiency loss (gain) is amplified by the strategic disclosure incentives.

Table 5 reports the estimated real efficiency loss due to myopia and its decomposition into the strategic disclosure and relative price feedback margins. Our results suggest that firms lose almost 29% of their value due to managerial myopia. Further, we find that the primary driver of this real efficiency loss is the strategic disclosure margin, while the price feedback wedge plays a relatively smaller role.

4.2.2 Information Share of Firm Value

Next, we decompose the (logarithm) of the actual firm value (25) into three components:

$$\log \mathbb{E}\left[CF\right] = C_0 + \underbrace{\Delta V_m}_{\substack{\text{Manager's}\\ \text{Information}}} + \underbrace{\log\left(\left(1-\Lambda_m\right)e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}\right)}_{\text{Price Feedback}} \tag{39}$$

where C_0 is a constant that depends on the expected fundamental productivity and the cost of investment. The next term, ΔV_m, represents the sensitivity of the firm's long-term value to the quality of the manager's information about the idiosyncratic component. Finally, the term $\log\left(\left(1-\Lambda_m\right)e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}\right)$ relates to the sensitivity of firm value to the quality of the price feedback. Since the price feedback depends both on the investor's information quality and the strategic disclosure incentives, the second term is influenced by the equilibrium disclosure cut-off via Λ_m.

We define the share of the firm value driven by the manager's private information as

$$\nu_m = \frac{\Delta V_m}{\Delta V_m + \log \Delta V_p}, \tag{40}$$

where $\Delta V_p = \left(1-\Lambda_m\right)e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}$. The share ν_m represents the share of firm value driven by the managerial information about the idiosyncratic productivity component. Note that it is solely a private information effect and is independent of the strategic disclosure incentives. Similarly, we define the share of firm value driven by price feedback conditional on disclosure (and non-disclosure) as

$$\nu_{p,i} = \underbrace{\left(\frac{\log \Delta V_p}{\Delta V_m + \log \Delta V_p}\right)}_{\substack{\text{Share of value driven}\\ \text{by price feedback}}} \times \underbrace{\left(\Lambda_{m,i} \cdot \frac{e^{\Delta V_i}}{\Delta V_p}\right)}_{\substack{\text{Strategic Disclosure}\\ \text{Weight}}} \tag{41}$$

for $i \in \{d, nd\}$ with $\Lambda_{m,d} = 1 - \Lambda_m$ and $\Lambda_{m,nd} = \Lambda_m$. The share $\nu_{p,d}$ $\left(\nu_{p,nd}\right)$ represents the fraction of (logarithm of) firm value that is attributable to the price feedback when firms disclose (withhold). This share is affected by three factors: (1) the *overall* informativeness of the price signal about the market factor, (2) the manager's disclosure strategy, and (3) the *relative* informativeness of the price signal conditional on disclosure vs. non-disclosure.

Table 6 presents the results using our estimated parameters. Note that our analyses in Section 4.1 focused on the quality of different types of information per se, while this section studies the contribution of each type of information for firm value **in equilibrium**. From the overall information-driven firm value, the share driven by managers' private information is about 36%. The share driven by market feedback upon disclosure is 53%, and the share driven by market feedback upon non-disclosure is about 11%. Even though in general price feedback is very informative in the absence of disclosure, because most firms (about two-thirds) choose to provide disclosure, the contribution of this high quality feedback for firms' value ends up small. These estimates highlight why structural estimation is needed to study our research question: the contribution of information for firm value and the quality of this information can be very different numbers when disclosure is voluntary.

5 Additional analyses

Firms' productivity and importance of managerial and investor information likely varies substantially with firms' business models. To examine this heterogeneity, we re-estimate our model for subsamples of firms in different industries. Table 7 presents the results.

We find that the firm managers' private information is most precise in Communication Services and Energy sectors. In contrast, it is very imprecise for firms in Financials, Utilities, and Health Care sectors.

As for the investors' information, first, in every sector, firms' voluntary disclosures appear to crowd out price feedback: $\Delta V_d < \Delta V_{nd}$ for all sectors. Second, investors' information about the common productivity factor is most precise in Real Estate, Health Care, and Industrial sectors and least precise in Utilities, Energy, Communication, and Consumer Staples.

6 Conclusion

Our paper studies how firms' voluntary disclosure of their investment plans affects the quality of information the firms learn from price feedback. We conclude that, on average, price feedback is better when a firm withholds its information. This crowding-out of investors' private information acquisition, coupled with firms' strategic disclosure incentives, substantially reduces firms' values.

We acknowledge that our study focuses on only two roles of voluntary disclosure: (1) to share managerial private information and (2) to trigger investors' private information acquisition. While these roles are important, there are other important functions of disclosures, coming from informing other firms, investors, and regulators about idiosyncratic and market-wide economic circumstances. Disclosure helps firms attract capital and discipline management. While our study highlights a potential downside of disclosure, we cannot claim that disclosed investment plans negatively affect overall welfare.

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Figures and Tables

Table 1: Characteristics of firms in our sample. All the variables are taken from or calculated from the Compustat database. *Book value* is the product of the book value per share and the number of shares. *Market-to-book ratio* is market value divided by book value. *ROIC* is operating income after depreciation divided by total invested capital. *Leverage ratio* is the total amount of debt divided by total assets. The number of observations for some variables is less than for others because some firms have missing data.

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Book value (in $ mil)	12,624	3,838	11,180	379	1,065	3,058
Market value (in $ mil)	12,566	12,423	38,670	1,061	3,025	9,525
Total assets (in $ mil)	13,746	11,123	29,204	1,046	2,894	8,792
Market-to-book ratio	12,413	2.811	42.393	1.505	2.405	4.027
ROIC	13,758	0.136	0.108	0.069	0.121	0.194
Leverage ratio	12,802	0.292	0.234	0.136	0.275	0.410

Table 2: Summary statistics for the variables used in estimation. All variables are winsorized at the 5% level. *CapEx guidance* is a binary variable equal to 1 if a firm provided CapEx guidance with its EPS report in a given year and 0 otherwise. *CAR full* is cumulative abnormal return in the $[-3,7]$ day window around the EPS announcement. We use a market-adjusted model to compute normal returns. *CAR clean* is the constant plus the residual from the regression of *CAR full* on the earnings surprise. *CapEx actual* is the actual value of CapEx of the firm. *CapEx forecast* is the forecasted CapEx (only for firms that provide forecasts). For *CapEx actual* and *CapEx forecast*, we normalize the CapEx value by the firm's total assets. Data on CapEx forecasts and actual values are from IBES, CAR is from WRDS Event Study Tool, total assets is from Compustat.

(a) Summary statistics for all firms in the sample.

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
CapEx guidance	13,758	0.667	0.471	0	1	1
CAR full	13,758	0.005	0.072	−0.041	0.004	0.051
CAR clean	13,758	0.002	0.071	−0.044	0.0003	0.047
CapEx actual	13,758	0.056	0.045	0.023	0.041	0.073

(b) Summary statistics for firms that provide CapEx disclosure on their EPS report day.

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
CapEx guidance	9,170	1.000	0.000	1	1	1
CAR full	9,170	0.005	0.073	−0.042	0.005	0.052
CAR clean	9,170	0.002	0.072	−0.045	0.001	0.048
CapEx actual	9,170	0.058	0.047	0.024	0.043	0.077
CapEx forecast	9,170	0.060	0.046	0.027	0.046	0.079

(c) Summary statistics for firms that do not provide CapEx disclosure on their EPS report day.

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
CapEx guidance	4,588	0.000	0.000	0	0	0
CAR full	4,588	0.004	0.070	−0.039	0.003	0.047
CAR clean	4,588	0.001	0.069	−0.041	−0.0002	0.044
CapEx actual	4,588	0.050	0.042	0.020	0.036	0.067

Table 3: Estimated model parameters. Standard errors are in parentheses. The estimation procedure and calculation of standard errors are described in Appendix B.

Panel A: Parameters describing uncertainty of firms' productivity

τ_{f_1} *precision of the idiosyncratic factor*	τ_{f_2} *precision of the common factor*
2.2366	0.9760
(0.0495)	(0.2909)

Panel B: Parameters describing information precision

τ_m *precision of the manager's private information*	τ_d *precision of investors' private information upon disclosure*	τ_{nd} *precision of investors' private information upon non-disclosure*
0.9278	0.2029	1.2432
(0.0496)	(0.1336)	(1.2129)

Panel C: Implied usefulness of information

$\frac{\Delta V_m}{\sigma^2_{f_1}}$ *usefulness of the manager's private information*	$\frac{\Delta V_d}{\sigma^2_{f_2}}$ *usefulness of investors' private information upon disclosure*	$\frac{\Delta V_{nd}}{\sigma^2_{f_2}}$ *usefulness of investors' private information upon non-disclosure*
29.3%	17.2%	56.0%

Table 4: Data moments and theoretical moments at the estimated parameters. The estimated parameters are in Table 3. A detailed description of how the theoretical moments are calculated is in Appendix B.1. Summary statistics for data used to calculate empirical moments are in Table 2. Bootstrapped standard errors of empirical moments are in parentheses.

	Moment	**Empirical value**	**Theoretical value**
1	Probability of non-disclosure	0.333 (0.010)	0.337
2	Mean investment for non-disclosing firms divided by mean investment for disclosing firms	0.863 (0.031)	0.545
3	Normalized variance of investment for non-disclosing firms	0.696 (0.031)	0.829
4	Normalized variance of investment for disclosing firms	0.644 (0.018)	0.285
5	Variance of investment surprises for disclosing firms	0.072 (0.008)	0.162
6	Relative volatility of stock returns upon disclosure to stock returns upon non-disclosure	1.054 (0.060)	1.177

Table 5: Real efficiency loss due to myopia. The real efficiency loss and the margins are defined in Equation (38). The estimated parameters used to compute the values of the loss are in Table 3.

$1 - \mathbb{E}[CF] / \mathbb{E}^{\beta=0}[CF]$ *Real Efficiency Loss*	$(1 - \Lambda_m)$ *Strategic disclosure margin*	$\left(1 - e^{\Delta V_d - \Delta V_{nd}}\right)$ *Relative price feedback margin*
28.7%	0.874	0.328

Table 6: Informational shares of firm value. The shared are defined in (40) and (41). The estimated parameters used to compute the shares are in Table 3.

ν_m *share driven by the manager's private information*	$\nu_{p,d}$ *share driven by investors' private information upon disclosure*	$\nu_{p,nd}$ *share driven by investors' private information upon non-disclosure*
35.7%	52.9%	11.4%

Table 7: Estimated implied usefulness of information for firms in different GICS sectors. Standard errors are in parentheses. The estimation procedure and calculation of standard errors are described in Appendix B.

Sector	$\frac{\Delta V_m}{\sigma^2_{f_1}}$ *usefulness of the manager's private information*	$\frac{\Delta V_d}{\sigma^2_{f_2}}$ *usefulness of investors' private information upon disclosure*	$\frac{\Delta V_{nd}}{\sigma^2_{f_2}}$ *usefulness of investors' private information upon non-disclosure*
Energy	27.8%	3.9%	36.1%
Materials	10.3%	7.7%	23.6%
Industrials	15.5%	19.7%	51.6%
Consumer Discretionary	17.0%	15.3%	42.0%
Consumer Staples	14.2%	6.7%	31.2%
Health Care	1.5%	44.3%	52.6%
Financials	0.1%	26.6%	36.8%
Information Technology	19.2%	17.9%	43.9%
Communication Services	34.3%	7.1%	47.1%
Utilities	0.7%	4.6%	9.5%
Real Estate	5.8%	57.8%	77.3%

Figure 2: **Probability of Disclosure**

Figure 2 plots the equilibrium probability of disclosure as a function of the manager's myopia. The plot uses a baseline set of parameters such that $\overline{f}_1 = \overline{f}_2 = 0$, $\tau_{f_1} = \tau_{f_2} = 1$, $\Delta V_m = 0.5$, $\Delta V_d = 0.5$, $r = c = 1$. For the three different cases, we use $\Delta V_{nd} = 0.1$ (blue line), $\Delta V_{nd} = 0.5$ (red line) and $\Delta V_{nd} = 0.9$ (green line).

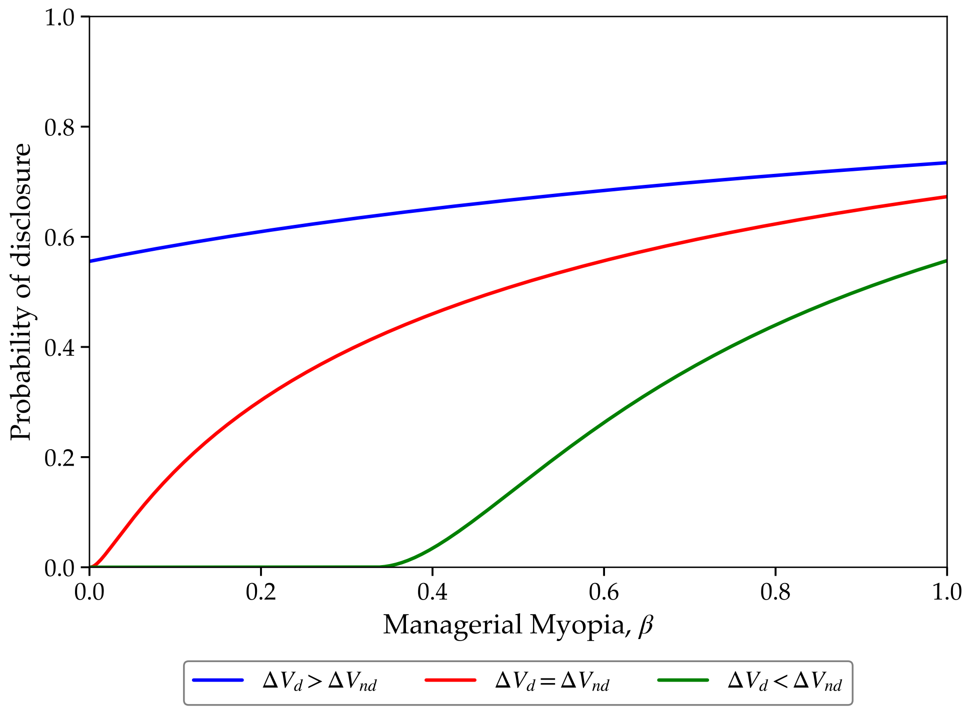
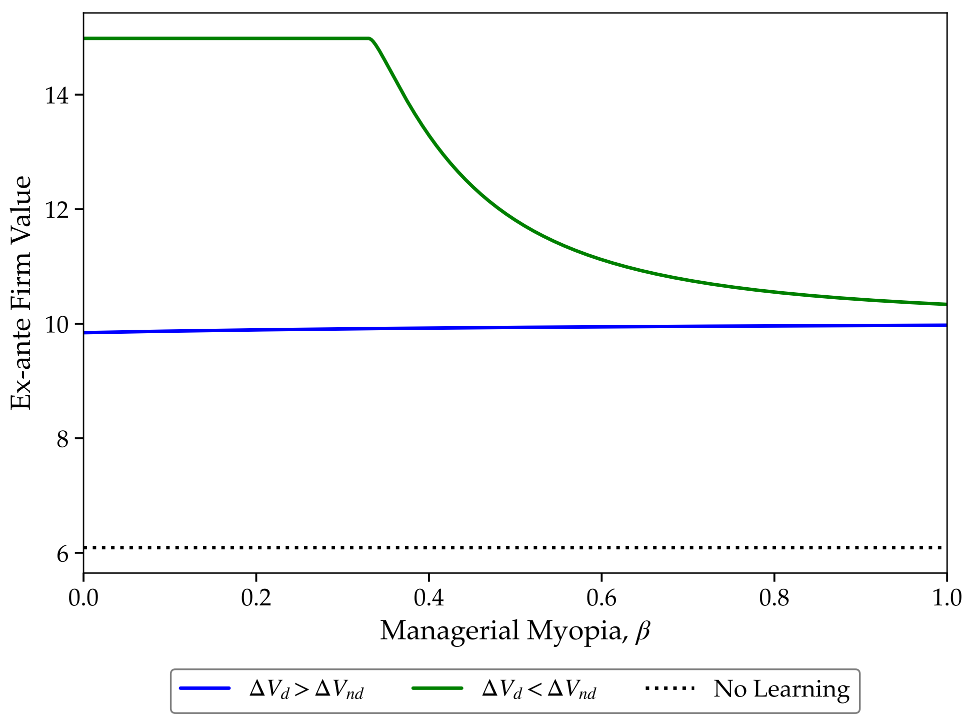


Figure 3: **Ex-ante firm value**

Figure 3 plots the ex-ante expected firm value as a function of the managerial myopia. The plot use a baseline set of parameters such that $\overline{f}_1 = \overline{f}_2 = 0$, $\tau_{f_1} = \tau_{f_2} = 1$, $\Delta V_m = 0.5$, $\Delta V_d = 0.5$, $r = c = 1$. We use $\Delta V_{nd} = 0.1$ (blue line) and $\Delta V_{nd} = 0.9$ (green line).



Appendix A. Proofs

A.1 Proof of Lemma 1

Proof. The joint distribution of the productivity components, manager's and investor's information is given by

$$\begin{pmatrix} \tilde{f}_1 \\ \tilde{f}_2 \\ \tilde{s}_m \\ \tilde{s}_d \\ \tilde{s}_{nd} \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} \overline{f}_1 \\ \overline{f}_2 \\ \overline{f}_1 \\ \overline{f}_2 \\ \overline{f}_2 \end{pmatrix}, \begin{pmatrix} \tau_{f_1}^{-1} & 0 & \tau_{f_1}^{-1} & 0 & 0 \\ 0 & \tau_{f_2}^{-1} & 0 & \tau_{f_2}^{-1} & \tau_{f_2}^{-1} \\ \tau_{f_1}^{-1} & 0 & \tau_{f_1}^{-1}+\tau_m^{-1} & 0 & 0 \\ 0 & \tau_{f_2}^{-1} & 0 & \tau_{f_2}^{-1}+\tau_d^{-1} & \tau_{f_2}^{-1} \\ 0 & \tau_{f_2}^{-1} & 0 & \tau_{f_2}^{-1} & \tau_{f_2}^{-1}+\tau_{nd}^{-1} \end{pmatrix}\right) \tag{A.1}$$

Since $\mathcal{I}_M = \{s_m, s_i\}$ at $t = 3$, standard Bayesian updating yields

$$\begin{pmatrix} \tilde{f}_1 \\ \tilde{f}_2 \end{pmatrix} \mid (s_m, s_i) \sim \mathcal{N}\left(\begin{pmatrix} \dfrac{\overline{f}_1 \tau_{f_1} + s_m \tau_m}{\tau_{f_1} + \tau_m} \\ \dfrac{\overline{f}_2 \tau_{f_2} + s_i \tau_i}{\tau_{f_2} + \tau_i} \end{pmatrix}, \begin{pmatrix} \dfrac{1}{\tau_{f_1} + \tau_m} & 0 \\ 0 & \dfrac{1}{\tau_{f_2} + \tau_i} \end{pmatrix}\right) \tag{A.2}$$

Substituting in the optimal investment policy (7), we have:

$$\begin{aligned} I^*(s_m, s_i) &= \frac{1}{r}\mathbb{E}\left[\exp\left(\tilde{f}_1 + \tilde{f}_2\right) \mid \mathcal{I}_M\right] \\ &= \frac{1}{r}\exp\left(\frac{\overline{f}_1 \tau_{f_1} + s_m \tau_m}{\tau_{f_1} + \tau_m} + \frac{\overline{f}_2 \tau_{f_2} + s_i \tau_i}{\tau_{f_2} + \tau_i} + \frac{1}{2}\left(\frac{1}{\tau_{f_1} + \tau_m} + \frac{1}{\tau_{f_2} + \tau_i}\right)\right) \end{aligned}$$

which we can re-write as

$$I^*(s_m, s_i) = \frac{1}{r}\exp\left(c_0 + c_m s_m + c_i s_i\right) \tag{A.3}$$

with $c_m = \dfrac{\tau_m}{\tau_{f_1} + \tau_m}$, $c_i = \dfrac{\tau_i}{\tau_{f_2} + \tau_i}$ and $c_0 = \dfrac{\overline{f}_1 \tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \dfrac{\overline{f}_2 \tau_{f_2} + 1/2}{\tau_{f_2} + \tau_i}$.

■

A.2 Proof of Lemma 4

Proof. Expected non-disclosure price, using (12), is given by

$$\mathbb{E}\left[P^{ND}(s_{nd}) \mid s_m\right] = \mathbb{E}\left[\frac{1}{2r}\exp\left(2\left(c_0 + c_{nd}s_{nd}\right)\right)\cdot\kappa \mid s_m\right]$$

Since s_{nd} and s_m are independent, we have $s_{nd} \mid s_m \sim \mathcal{N}\left(\overline{f}_2, \frac{1}{\tau_{f_2}} + \frac{1}{\tau_{nd}}\right)$. Therefore,

$$\begin{aligned}
\mathbb{E}\left[P^{ND}(s_{nd}) \mid s_m\right] &= \frac{1}{2r}\exp\left(2c_0\right)\cdot\kappa\cdot\mathbb{E}\left[\exp\left(2c_{nd}s_{nd}\right)\right] \\
&= \frac{1}{2r}\exp\left(2c_0\right)\cdot\kappa\exp\left(2c_{nd}\overline{f}_2 + \frac{1}{2}\left(2c_{nd}\right)^2\left(\frac{1}{\tau_{f_2}} + \frac{1}{\tau_{nd}}\right)\right) \\
&= \frac{1}{2r}\exp\left(2\left(c_0 + c_{nd}\overline{f}_2 + c_{nd}^2\left(\frac{1}{\tau_{f_2}} + \frac{1}{\tau_{nd}}\right)\right)\right)\cdot\kappa
\end{aligned}$$

Using the expressions for c_0 and c_{nd} from Lemma 1, we get:

$$\begin{aligned}
c_0 + c_{nd}\overline{f}_2 + c_{nd}^2\left(\frac{1}{\tau_{f_2}} + \frac{1}{\tau_{nd}}\right) &= c_0 + \frac{\tau_{nd}\overline{f}_2}{\tau_{f_2} + \tau_{nd}} + \left(\frac{\tau_{nd}}{\tau_{f_2} + \tau_{nd}}\right)^2\left(\frac{1}{\tau_{f_2}} + \frac{1}{\tau_{nd}}\right) \\
&= \frac{\overline{f}_1\tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \frac{\overline{f}_2\tau_{f_2} + 1/2}{\tau_{f_2} + \tau_{nd}} + \frac{\tau_{nd}\overline{f}_2}{\tau_{f_2} + \tau_{nd}} + \frac{\tau_{nd}}{\tau_{f_2}\left(\tau_{f_2} + \tau_{nd}\right)} \\
&= \frac{\overline{f}_1\tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \overline{f}_2 + \frac{1/2}{\tau_{f_2} + \tau_{nd}} + \frac{\tau_{nd}}{\tau_{f_2}\left(\tau_{f_2} + \tau_{nd}\right)} \\
&= \underbrace{\frac{\overline{f}_1\tau_{f_1} + 1/2}{\tau_{f_1} + \tau_m} + \overline{f}_2 + \frac{1}{2\tau_{f_2}}}_{\alpha_0/2} + \frac{1}{2}\frac{\tau_{nd}}{\tau_{f_2}\left(\tau_{f_2} + \tau_{nd}\right)}
\end{aligned} \tag{A.4}$$

where α_0 is given in Lemma 3. Substituting above, we get

$$\mathbb{E}\left[P^{ND}(s_{nd}) \mid s_m\right] = \frac{1}{2r}\exp\left(\alpha_0 + \Delta V_{nd}\right)\cdot\kappa$$

■

A.3 Proof of Proposition 1

Proof. From (18), the manager discloses the private signal iff

$$\exp\left(2c_m s_m\right)V \quad \geq B \tag{A.5}$$

where $V = \exp(\Delta V_d) - (1-\beta)\exp(\Delta V_{nd})$ and $B = \beta e^{\Delta V_{nd}} \cdot \kappa + 2rc \cdot e^{-\alpha_0} > 0$ because $c > 0$. We split the proof into different case below.

First, let $V > 0$. Because $c_m > 0$, the LHS of (A.5) is strictly increasing in s_m with

$$\lim_{s_m \to -\infty} \exp(2c_m s_m) V = 0$$

and

$$\lim_{s_m \to \infty} \exp(2c_m s_m) V = \infty$$

Therefore, there exists a unique cut-off such that $\exp(2c_m s_m^c) V = B$. Hence, in equilibrium the manager discloses iff $s_m \geq s_m^c$ where

$$s_m^c = \frac{1}{2c_m} \log\left(\frac{B}{V}\right) \tag{A.6}$$

Under non-disclosure $s_m < s_m^c$ and therefore,

$$\kappa = \mathbb{E}[\exp(2c_m s_m) \mid \mathcal{ND}] = \mathbb{E}[\exp(2c_m s_m) \mid s_m < s_m^c]$$

Because $s_m \sim \mathcal{N}\left(\overline{f}_1, \sigma_m^2\right)$ with $\sigma_m^2 = \tau_{f_1}^{-1} + \tau_m^{-1}$, we have

$$\mathbb{E}[\exp(tc_m s_m) \mid s_m < s_m^c] = \exp\left(tc_m \overline{f}_1 + \frac{1}{2}(tc_m)^2 \sigma_m^2\right) \times \frac{\Phi\left(\frac{s_m^c - \overline{f}_1}{\sigma_m} - t\sigma_m c_m\right)}{\Phi\left(\frac{s_m^c - \overline{f}_1}{\sigma_m}\right)} \tag{A.7}$$

Using $c_m = \dfrac{\tau_m}{\tau_{f_1} + \tau_m}$, note that

$$c_m^2 \sigma_m^2 = \left(\frac{\tau_m}{\tau_{f_1} + \tau_m}\right)^2 \left(\tau_{f_1}^{-1} + \tau_m^{-1}\right) = \frac{1}{\tau_{f_1}} - \frac{1}{\tau_{f_1} + \tau_m} = \underbrace{Var(\tilde{f}_1) - Var(\tilde{f}_1 \mid s_m)}_{\Delta V_m}$$

where ΔV_m represents the uncertainty reduction regarding the idiosyncratic component after receiving the signal s_m. Hence, (A.7) becomes

$$\mathbb{E}[\exp(tc_m s_m) \mid s_m < s_m^c] = \exp\left(tc_m \overline{f}_1 + \frac{t^2}{2}\Delta V_m\right) \times \frac{\Phi\left(\frac{s_m^c - \overline{f}_1}{\sigma_m} - t\sqrt{\Delta V_m}\right)}{\Phi\left(\frac{s_m^c - \overline{f}_1}{\sigma_m}\right)} \tag{A.8}$$

Letting $z\left(s_m^c\right)=\frac{s_m^c-\overline{f}_1}{\sigma_m}$, we get

$$\kappa\left(s_m^c\right)=\exp\left(2c_m\overline{f}_1+2\Delta V_m\right)\frac{\Phi\left(z\left(s_m^c\right)-2\sqrt{\Delta V_m}\right)}{\Phi\left(z\left(s_m^c\right)\right)} \tag{A.9}$$

Substituting (A.9) into (A.6) yields

$$s_m^c=\frac{1}{2c_m}\log\left(e^{-\alpha_0}\frac{\beta e^{\Delta V_{nd}+\alpha_0}\cdot\kappa\left(s_m^c\right)+2rc}{V}\right)$$

Using the expression of α_0 from Lemma 3 and collecting terms, we can write:

$$\begin{aligned}\alpha_0+2c_m\overline{f}_1+2\Delta V_m&=2\left(\frac{\overline{f}_1\tau_{f_1}+1/2}{\tau_{f_1}+\tau_m}+\overline{f}_2+\frac{1}{2\tau_{f_2}}\right)+2\frac{\tau_m}{\tau_{f_1}+\tau_m}\overline{f}_1+2\Delta V_m\\&=2\left(\overline{f}_1+\frac{1/2}{\tau_{f_1}+\tau_m}+\overline{f}_2+\frac{1}{2\tau_{f_2}}\right)+2\Delta V_m\\&=2\left(\overline{f}_1+\frac{1}{2\tau_{f_1}}+\overline{f}_2+\frac{1}{2\tau_{f_2}}\right)+\Delta V_m\end{aligned} \tag{A.10}$$

Using $\mathbb{E}\left[\tilde{F}\right]=\exp\left(\overline{f}_1+\overline{f}_2+\frac{1}{2\tau_{f_2}}+\frac{1}{2\tau_{f_1}}\right)$, we can summarize the disclosure-cutoff as:

$$s_m^c=\frac{1}{2c_m}\log\left(e^{-\alpha_0}\frac{\beta e^{\Delta V_{nd}+\Delta V_m}\cdot\gamma\left(s_m^c\right)\left(\mathbb{E}\left[\tilde{F}\right]\right)^2+2rc}{V}\right)$$

where

$$\gamma\left(s_m^c\right)=\frac{\Phi\left(z\left(s_m^c\right)-2\sqrt{\Delta V_m}\right)}{\Phi\left(z\left(s_m^c\right)\right)} \tag{A.11}$$

Next, if $V\leq 0$, then the LHS of (A.5) is non-positive. But $B>0$. Hence, the inequality (A.5) can never hold and the only equilibrium is to withhold the information with probability 1. ■

A.4 Proof of Lemma 5

Proof. From (9), we have

$$\mathbb{E}\left[CF\left(s_m,s_i\right)\mid s_m,s_i\right]=\frac{1}{2r}\exp\left(2\left(c_0+c_ms_m+c_is_i\right)\right)$$

Using Law of Iterated Expectations, we get

$$\mathbb{E}\left[CF\left(s_m, s_d\right) \mid s_m \in \mathcal{A}\right] = \frac{1}{2r} \exp\left(2c_0\right) \mathbb{E}\left[\exp\left(2\left(c_m s_m + c_i s_i\right)\right) \mid s_m \in \mathcal{A}\right]$$

Since s_m and s_i are independent of each other, we have $s_i \mid s_m \in \mathcal{A} \sim \mathcal{N}\left(\overline{f}_2, \tau_{f_2}^{-1} + \tau_i^{-1}\right)$. Hence,

$$\mathbb{E}\left[CF\left(s_m, s_d\right) \mid s_m \in \mathcal{A}\right] = \frac{1}{2r} \exp\left(2\left(c_0 + c_i\overline{f}_2 + c_i^2\left(\tau_{f_2}^{-1} + \tau_i^{-1}\right)\right)\right) \mathbb{E}\left[\exp\left(2c_m s_m\right) \mid s_m \in \mathcal{A}\right]$$

where $2\left(c_0 + c_i\overline{f}_2 + c_i^2\left(\tau_{f_2}^{-1} + \tau_i^{-1}\right)\right) = \alpha_0 + \Delta V_i$ as in (A.4).

Using the moment generating function of a truncating normal distribution with mean $\overline{f}_1$ and variance $\sigma_m^2 = \tau_{f_1}^{-1} + \tau_m^{-1}$, we have

$$\mathbb{E}\left[\exp\left(2c_m s_m\right) \mid s_m \in \mathcal{D}\right] = \exp\left(2\left(c_m\overline{f}_1 + \Delta V_m\right)\right) \frac{1 - \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)}{1 - \Phi\left(z_m^c\right)}$$
$$\mathbb{E}\left[\exp\left(2c_m s_m\right) \mid s_m \in \mathcal{ND}\right] = \exp\left(2\left(c_m\overline{f}_1 + \Delta V_m\right)\right) \frac{\Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)}{\Phi\left(z_m^c\right)}$$

Therefore, (24) is simplified to

$$\begin{aligned}\mathbb{E}\left[CF\right] = &\frac{1}{2r} \exp\left(\alpha_0 + 2\left(c_m\overline{f}_1 + \Delta V_m\right)\right) \times \\ &\left(\left(1 - \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)\right) \exp\left(\Delta V_d\right) + \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right) \exp\left(\Delta V_{nd}\right)\right)\end{aligned}$$

From (A.10), $\alpha_0 + 2\left(c_m\overline{f}_1 + \Delta V_m\right) = 2\mathbb{E}\left[\tilde{F}\right] + \Delta V_m$ giving

$$\begin{aligned}\mathbb{E}\left[CF\right] = &\frac{1}{2r} \left(\mathbb{E}\left[\tilde{F}\right]\right)^2 \exp\left(\Delta V_m\right) \times \\ &\left(\left(1 - \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)\right) \exp\left(\Delta V_d\right) + \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right) \exp\left(\Delta V_{nd}\right)\right)\end{aligned}$$

■

A.5 Proof of Proposition 2

Proof. **Part** i**):** Dividing (25) by (26) gives

$$\frac{\mathbb{E}\left[CF\right]}{\mathbb{E}^{nl}\left[CF\right]} = \left(1 - \Lambda_m\right) e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}}$$

where $\Lambda_m = \Phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)$. Since $\Delta V_d > 0$ and $\Delta V_{nd} > 0$, we have $e^{\Delta V_d} > 1$ and $e^{\Delta V_{nd}} > 1$. Therefore, the convex combination

$$(1 - \Lambda_m)\, e^{\Delta V_d} + \Lambda_m e^{\Delta V_{nd}} > 1$$

for all $\Lambda_m \in [0,1]$ giving $\mathbb{E}[CF] > \mathbb{E}^{nl}[CF]$.

Part *ii)***:** If $V \leq 0$, manager never discloses. Therefore, the expected firm value is independent of β. Next for $V > 0$, differentiate $\mathbb{E}[CF]$ given by (25) w.r.t β to get:

$$\frac{d\mathbb{E}[CF]}{d\beta} = \frac{1}{2r}\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{\Delta V_m} \times \left(-e^{\Delta V_d} + e^{\Delta V_{nd}}\right)\frac{d\Lambda_m}{d\beta} \tag{A.12}$$

where

$$\frac{d\Lambda_m}{d\beta} = \frac{\phi\left(z_m^c - 2\sqrt{\Delta V_m}\right)}{\sigma_m}\frac{ds_m^c}{d\beta}$$

and s_m^c is the equilibrium cut-off. Below, we show that $\dfrac{ds_m^c}{d\beta} < 0$.

The equilibrium cutoff s_m^c is defined implicitly by $F(s_m^c, \beta) = 0$ where

$$F(s, \beta) = s - \frac{1}{2c_m}\left(-\alpha_0 + \log\left(A\beta\gamma(s) + 2rc\right) - \log\left(V(\beta)\right)\right)$$

with $A = \left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{\Delta V_{nd} + \Delta V_m}$ and $V(\beta) = e^{\Delta V_d} - (1-\beta)\, e^{\Delta V_{nd}} > 0$. By the implicit function theorem,

$$\frac{ds_m^c}{d\beta} = -\frac{F_\beta\left(s_m^c, \beta\right)}{F_{s_m^c}\left(s_m^c, \beta\right)} \tag{A.13}$$

Differentiating F w.r.t s:

$$F_s(s, \beta) = 1 - \frac{1}{2c_m}\left(\frac{A\beta\gamma'(s)}{A\beta\gamma(s) + 2rc}\right) \tag{A.14}$$

where

$$\gamma'(s) = \frac{\gamma(s)}{\sigma_m}\left(\lambda\left(z(s) - 2\sqrt{\Delta V_m}\right) - \lambda\left(z(s)\right)\right) \tag{A.15}$$

with $\lambda(x) = \dfrac{\phi(x)}{\Phi(x)}$ is the inverse Mills ratio. Substituting (A.15) in (A.14) and using $c_m \sigma_m = \sqrt{\Delta V_m}$

yields

$$F_s(s,\beta) = 1 - \left(\frac{A\beta\gamma(s)}{A\beta\gamma(s) + 2rc}\right)\left(\frac{\lambda\left(z(s) - 2\sqrt{\Delta V_m}\right) - \lambda(z(s))}{2\sqrt{\Delta V_m}}\right)$$

The inverse Mills ratio $\lambda(x)$ is strictly decreasing and satisfies $\lambda'(x) \in (-1,0)$ for all x. Hence,

$$0 < \lambda(x-a) - \lambda(x) = \int_{x-a}^{x} -\lambda'(t)\,dt < \int_{x-a}^{x} 1dt = a$$

for any $a > 0$. It follows that

$$0 < \frac{\lambda\left(z(s) - 2\sqrt{\Delta V_m}\right) - \lambda(z(s))}{2\sqrt{\Delta V_m}} < 1$$

Since also $\dfrac{A\beta\gamma(s)}{A\beta\gamma(s) + 2rc} < 1$, we have $1 > F_s(s,\beta) > 0$ for all s and in particular,

$$F_{s_m^c}\left(s_m^c,\beta\right) > 0 \tag{A.16}$$

Next, differentiating F w.r.t β:

$$F_\beta(s,\beta) = -\frac{1}{2c_m}\left(\frac{A\gamma(s)}{A\beta\gamma(s) + 2rc} - \frac{e^{\Delta V_{nd}}}{V(\beta)}\right) \tag{A.17}$$

From (A.13), (A.16) and (A.17):

$$\operatorname{sgn}\left(\frac{ds_m^c}{d\beta}\right) = \operatorname{sgn}\left(\frac{A\gamma\left(s_m^c\right)}{A\beta\gamma\left(s_m^c\right) + 2rc} - \frac{e^{\Delta V_{nd}}}{V(\beta)}\right)$$

Simplifying after substituting $V(\beta) = e^{\Delta V_d} - (1-\beta)e^{\Delta V_{nd}}$ and $A = \left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{\Delta V_{nd} + \Delta V_m}$ yields

$$\operatorname{sgn}\left(\frac{ds_m^c}{d\beta}\right) = \operatorname{sgn}(\Lambda)$$

where

$$\Lambda = e^{\Delta V_m}\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 \gamma\left(s_m^c\right)\left(e^{\Delta V_d} - e^{\Delta V_{nd}}\right) - 2rc$$

If$\Delta V_d \leq \Delta V_{nd}$, then $\Lambda < 0$ immediately and therefore $\dfrac{ds_m^c}{d\beta} < 0$. Suppose therefore that $\Delta V_d > \Delta V_{nd}$, and define

$$\overline{\gamma} = \frac{2rc}{e^{\Delta V_m}\left(\mathbb{E}\left[\tilde{F}\right]\right)^2\left(e^{\Delta V_d} - e^{\Delta V_{nd}}\right)} \tag{A.18}$$

Then, $\Lambda < 0$ is equivalent to $\gamma\left(s_m^c\right) < \overline{\gamma}$ for all equilibrium cutoffs s_m^c.

The function $\lambda\left(x\right)$ is strictly decreasing in x, (A.15) implies that $\gamma\left(s\right)$ is strictly increasing in s. Further, as $s \to \infty$, $z\left(s\right) \to \infty$ and $\gamma\left(s\right) \to 1$. As $s \to -\infty$, $z\left(s\right) \to -\infty$. Using the left-tail Mills ratio approximation $\Phi\left(x\right) \approx \frac{\phi\left(x\right)}{\left(-x\right)} = \frac{e^{-x^2/2}}{\left(-x\right)\sqrt{2\pi}}$ for large negative x, we obtain:

$$\gamma\left(s\right) = \frac{\Phi\left(z\left(s\right) - 2\sqrt{\Delta V_m}\right)}{\Phi\left(z\left(s\right)\right)} \approx \exp\left(2\left(z\left(s\right)\sqrt{\Delta V_m} - \Delta V_m\right)\right)\left(1 - \frac{2\sqrt{\Delta V_m}}{z\left(s\right)}\right)$$

Hence, as $s \to -\infty$, $\gamma\left(s\right) \to 0$. Combining, we get that $\gamma\left(s\right) \in \left(0,1\right)$ for all s.

Now, if $\overline{\gamma} \geq 1, \gamma\left(s_m^c\right) < 1 \leq \overline{\gamma}$ for all s_m^c and $\Lambda < 0$. Otherwise, let s^* be the unique point such that $\gamma\left(s^*\right) = \overline{\gamma}$. We show that any equilibrium satisfies $s_m^c < s^*$ such that $\gamma\left(s_m^c\right) < \overline{\gamma}$ or equivalently $\Lambda < 0$.

Defining the fixed-point map $s_m^c = \Psi\left(s_m^c\right)$ where

$$\Psi\left(s\right) = \frac{1}{2c_m}\log\left(e^{-\alpha_0}\frac{A\beta\gamma\left(s\right) + 2rc}{V\left(\beta\right)}\right)$$

Since $\Psi\left(s\right) = s - F\left(s,\beta\right)$ and because $1 > F_s\left(s,\beta\right) > 0$, we get that $0 < \Psi'\left(s\right) < 1$ for all s. At $s = s^*$,

$$\Psi\left(s^*\right) = \frac{1}{2c_m}\log\left(\frac{2rce^{-\alpha_0}}{e^{\Delta V_d} - e^{\Delta V_{nd}}}\right) \tag{A.19}$$

Re-write $\gamma\left(s\right)$ as

$$\begin{aligned}
\gamma\left(s\right) &= \frac{\lambda\left(z\left(s\right)\right)}{\lambda\left(z\left(s\right) - 2\sqrt{\Delta V_m}\right)} \times \frac{\phi\left(z\left(s\right) - 2\sqrt{\Delta V_m}\right)}{\phi\left(z\left(s\right)\right)} \\
&= \frac{\lambda\left(z\left(s\right)\right)}{\lambda\left(z\left(s\right) - 2\sqrt{\Delta V_m}\right)}\exp\left(2\left(z\left(s\right)\sqrt{\Delta V_m} - \Delta V_m\right)\right) \\
&< \exp\left(2\left(z\left(s\right)\sqrt{\Delta V_m} - \Delta V_m\right)\right)
\end{aligned}$$

where last inequality follows from the fact that λ is strictly decreasing. Evaluating at $z\left(s^*\right) =$

$\dfrac{s^* - \overline{f}_1}{\sigma_m}$ and using $c_m\sigma_m = \sqrt{\Delta V_m}$ yields

$$s^* > \frac{\log\left(\overline{\gamma}\right) + 2\Delta V_m}{2c_m} + \overline{f}_1$$

Substituting (A.18) above gives:

$$F\left(s,\beta\right) = s - \frac{1}{2c_m}\left(-\alpha_0 + \log\left(A\beta\gamma\left(s\right) + 2rc\right) - \log\left(V\left(\beta\right)\right)\right)$$

$$s^* > \frac{\log\left(\dfrac{2rc}{e^{\Delta V_d} - e^{\Delta V_{nd}}}\right) + \Delta V_m - 2\log\mathbb{E}\left[\tilde{F}\right]}{2c_m} + \overline{f}_1$$

Using the identity $\left(\mathbb{E}\left[\tilde{F}\right]\right)^2 e^{-\alpha_0} = e^{2c_m\overline{f}_1 + \Delta V_m}$, we get:

$$s^* > \frac{\log\left(\dfrac{2rc}{e^{\Delta V_d} - e^{\Delta V_{nd}}}\right) - \alpha_0 - 2c_m\overline{f}_1}{2c_m} + \overline{f}_1 = \Psi\left(s^*\right)$$

Therefore, $\Psi\left(s^*\right) < s^*$. Since $0 < \Psi'\left(s\right) < 1$ for all s, for any equilibrium $s_m^c < s^*$, $s_m^c = \Psi\left(s_m^c\right) < \Psi\left(s^*\right) < s^*$. For $s \geq s^*$, let

$$g\left(s\right) = \Psi\left(s\right) - s$$

such that $g'\left(s\right) = \Psi'\left(s\right) - 1 \in \left(-1,0\right)$. Hence, $g\left(s\right)$ is strictly decreasing in s for all s with $g\left(s^*\right) < 0$. Therefore, for all $s \geq s^*$,

$$g\left(s\right) \leq g\left(s^*\right) < 0$$

so there is no fixed point $s_m^c = \Psi\left(s_m^c\right)$ with $s_m^c \geq s^*$ i.e. any equilibrium cut-off must satisfy $s_m^c < s^*$ and therefore, $\dfrac{ds_m^c}{d\beta} < 0$. From (A.12), we get that

$$\text{sgn}\left(\frac{d\mathbb{E}\left[CF\right]}{d\beta}\right) = \text{sgn}\left(e^{\Delta V_d} - e^{\Delta V_{nd}}\right)$$

■

Appendix B. Estimation

B.1 Theoretical moments

In this section, we derive the expressions for the moments used in the GMM estimation procedure.

We use six moments:

1. Probability of non-disclosure;
2. Mean investment for non-disclosing vs. disclosing firms;
3. (Normalized) variance of investment for non-disclosing firms;
4. (Normalized) variance of investment for disclosing firms;
5. Variance of investment surprises for disclosing firms;
6. Relative volatility of stock returns upon disclosure vs. non-disclosure.

Below we describe in detail how each theoretical moment is constructed.

B.1.1 Probability of non-disclosure (moment 1)

From the equilibrium cut-off policy as defined in Proposition 1, the probability of non-disclosure is

$$m_1\left(z_m^c\right) \equiv Pr\left(\mathcal{ND}\right) = Pr\left(s_m < s_m^c\right) = \Phi\left(z_m^c\right) \tag{B.1}$$

where $z_m^c = \dfrac{s_m^c - \overline{f}_1}{\sigma_m}$.

B.1.2 Relative expected investment (moment 2)

From (9),

$$\mathbb{E}\left[I^*\left(s_m, s_i\right) \mid \mathcal{A}\right] = \frac{1}{r}\exp\left(c_0\right)\mathbb{E}\left[\exp\left(c_m s_m + c_i s_i\right) \mid \mathcal{A}\right]$$

Since s_m and s_i are independent of each other, we have $s_i \mid s_m \in \mathcal{A} \sim \mathcal{N}\left(\overline{f}_2, \tau_{f_2}^{-1} + \tau_i^{-1}\right)$. Therefore, for $t > 0$:

$$\mathbb{E}\left[\exp\left(tc_i s_i\right) \mid \mathcal{A}\right] = \exp\left(tc_i\overline{f}_2 + \frac{t^2}{2}c_i^2\left(\tau_{f_2}^{-1} + \tau_d^{-1}\right)\right) = \exp\left(tc_i\overline{f}_2 + \frac{t^2}{2}\Delta V_i\right) \tag{B.2}$$

where last equality follows from simplifying $c_i^2\left(\tau_{f_2}^{-1} + \tau_d^{-1}\right)$ using expressions of c_i from Lemma 1 and ΔV_i from (11) and (13).

Next, using the moment generating function of a truncating normal distribution with mean $\overline{f}_1$ and variance $\sigma_m^2 = \tau_{f_1}^{-1} + \tau_m^{-1}$, and using $c_m^2\sigma_m^2 = \Delta V_m$, we get:

$$\mathbb{E}\left[\exp\left(tc_m s_m\right) \mid s_m \in \mathcal{D}\right] = \exp\left(tc_m\overline{f}_1 + \frac{t^2}{2}\Delta V_m\right)\frac{1 - \Phi\left(z_m^c - t\sqrt{\Delta V_m}\right)}{1 - \Phi\left(z_m^c\right)} \tag{B.3}$$

$$\mathbb{E}\left[\exp\left(tc_m s_m\right) \mid s_m \in \mathcal{ND}\right] = \exp\left(tc_m\overline{f}_1 + \frac{t^2}{2}\Delta V_m\right)\frac{\Phi\left(z_m^c - t\sqrt{\Delta V_m}\right)}{\Phi\left(z_m^c\right)} \tag{B.4}$$

Substituting above with $t = 1$, we get

$$\mathbb{E}\left[I^*\left(s_m, s_i\right) \mid \mathcal{A}\right] = \frac{1}{r}\exp\left(c_0 + c_m\overline{f}_1 + \frac{1}{2}\Delta V_m + c_i\overline{f}_2 + \frac{1}{2}\Delta V_i\right)\Omega^{\mathcal{A}}$$

Using the expressions for c_0 and c_i from Lemma 1, we get:

$$t\left(c_0 + c_m\overline{f}_1 + c_i\overline{f}_2 + \frac{t}{2}\Delta V_m + \frac{t}{2}\Delta V_i\right) = t\left(\overline{f}_1 + \overline{f}_2 + \frac{1}{2}\left(\frac{1}{\tau_{f_1} + \tau_m} + \frac{1}{\tau_{f_2} + \tau_i}\right) + \frac{t}{2}\left(\Delta V_m + \Delta V_i\right)\right)$$

Note that

$$\frac{1}{\tau_{f_1} + \tau_m} + t\Delta V_m = \frac{1}{\tau_{f_1} + \tau_m} + t\frac{\tau_m}{\tau_{f_1}\left(\tau_{f_1} + \tau_m\right)} = \frac{\tau_{f_1} + t\tau_m}{\tau_{f_1}\left(\tau_{f_1} + \tau_m\right)} = \frac{1}{\tau_{f_1}} + (t-1)\Delta V_m$$

and similarly

$$\frac{1}{\tau_{f_2} + \tau_i} + t\Delta V_i = \frac{1}{\tau_{f_2}} + (t-1)\Delta V_i$$

we get,

$$t\left(c_0 + c_m\overline{f}_1 + c_i\overline{f}_2 + \frac{t}{2}\Delta V_m + \frac{t}{2}\Delta V_i\right) = t\left(\overline{f}_1 + \overline{f}_2 + \frac{1}{2}\left(\frac{1}{\tau_{f_1}} + \frac{1}{\tau_{f_2}}\right) + \frac{t-1}{2}\left(\Delta V_m + \Delta V_i\right)\right)$$

Using $\overline{f} = \overline{f}_1 + \overline{f}_2$ and $\tau_f^{-1} = \tau_{f_1}^{-1} + \tau_{f_2}^{-1}$, we have:

$$t\left(c_0 + c_m\overline{f}_1 + c_i\overline{f}_2 + \frac{t}{2}\Delta V_m + \frac{t}{2}\Delta V_i\right) = t\left(\overline{f} + \frac{1}{2\tau_f} + \frac{t-1}{2}\left(\Delta V_m + \Delta V_i\right)\right) \tag{B.5}$$

Hence, using $t = 1$, we get that

$$\mathbb{E}\left[I^*\left(s_m, s_i\right) \mid \mathcal{A}\right] = \underbrace{\frac{1}{r}\exp\left(\overline{f} + \frac{1}{2\tau_f}\right)}_{\text{Expected Investment}} \times \underbrace{\Omega_1^{\mathcal{A}}}_{\substack{\text{Strategic Disclosure}\\ \text{Factor}}} \tag{B.6}$$

Hence,

$$m_2\left(\Delta V_m, z_m^c\right) \equiv \frac{\mathbb{E}\left[I^*\left(s_m, s_i\right) \mid \mathcal{ND}\right]}{\mathbb{E}\left[I^*\left(s_m, s_i\right) \mid \mathcal{D}\right]} = \frac{\Omega_1^{\mathcal{ND}}}{\Omega_1^{\mathcal{D}}} \tag{B.7}$$

where $\Omega_t^{\mathcal{ND}} = \dfrac{\Phi\left(z_m^c - t\sqrt{\Delta V_m}\right)}{\Phi\left(z_m^c\right)}$ and $\Omega_t^{\mathcal{D}} = \dfrac{1 - \Phi\left(z_m^c - t\sqrt{\Delta V_m}\right)}{1 - \Phi\left(z_m^c\right)}$.

B.1.3 Normalized variance of investment (moments 3 and 4)

Conditional variance of investment is:

$$Var\left[I^*\left(s_m, s_i\right) \mid \mathcal{A}\right] = E\left[\left(I^*\left(s_m, s_i\right)\right)^2 \mid \mathcal{A}\right] - \left(E\left[I^*\left(s_m, s_i\right) \mid \mathcal{A}\right]\right)^2$$

where

$$\mathbb{E}\left[\left(I^*\left(s_m, s_i\right)\right)^2 \mid \mathcal{A}\right] = \frac{1}{r^2}\exp\left(2c_0\right)\mathbb{E}\left[\exp\left(2c_m s_m + 2c_i s_i\right) \mid \mathcal{A}\right]$$

Using (B.2) and (B.3)-(B.4), we get

$$\mathbb{E}\left[\left(I^*\left(s_m, s_i\right)\right)^2 \mid \mathcal{A}\right] = \frac{1}{r^2}\exp\left(2c_0 + 2c_m\overline{f}_1 + \frac{4}{2}\Delta V_m + 2c_i\overline{f}_2 + \frac{4}{2}\Delta V_i\right)\Omega_2^{\mathcal{A}}$$

Using (B.5) with $t = 2$, we get:

$$\mathbb{E}\left[\left(I^*\left(s_m, s_i\right)\right)^2 \mid \mathcal{A}\right] = \frac{1}{r^2}\exp\left(2\left(\overline{f} + \frac{1}{2\tau_f} + \frac{1}{2}\left(\Delta V_m + \Delta V_i\right)\right)\right)\Omega_2^{\mathcal{A}} \tag{B.8}$$

Substituting expected investment from (B.6), we get:

$$\mathbb{E}\left[\left(I^*\left(s_m,s_i\right)\right)^2 \mid \mathcal{A}\right] = \left(\mathbb{E}\left[I^*\left(s_m,s_i\right) \mid \mathcal{A}\right]\right)^2 \exp\left(\Delta V_m + \Delta V_i\right) \frac{\Omega_2^{\mathcal{A}}}{\left(\Omega_1^{\mathcal{A}}\right)^2}$$

Therefore,

$$Var\left[I^*\left(s_m,s_i\right) \mid \mathcal{A}\right] = \left(\mathbb{E}\left[I^*\left(s_m,s_i\right) \mid \mathcal{A}\right]\right)^2 \left(\exp\left(\Delta V_m + \Delta V_i\right) \frac{\Omega_2^{\mathcal{A}}}{\left(\Omega_1^{\mathcal{A}}\right)^2} - 1\right)$$

Hence, we get:

$$m_3\left(\Delta V_m, \Delta V_{nd}, z_m^c\right) \equiv \frac{Var\left[I^*\left(s_m,s_{nd}\right) \mid \mathcal{ND}\right]}{\left(\mathbb{E}\left[I^*\left(s_m,s_{nd}\right) \mid \mathcal{ND}\right]\right)^2} = \exp\left(\Delta V_m + \Delta V_{nd}\right) \frac{\Omega_2^{\mathcal{ND}}}{\left(\Omega_1^{\mathcal{ND}}\right)^2} - 1 \tag{B.9}$$

$$m_4\left(\Delta V_m, \Delta V_d, z_m^c\right) \equiv \frac{Var\left[I^*\left(s_m,s_d\right) \mid \mathcal{D}\right]}{\left(\mathbb{E}\left[I^*\left(s_m,s_d\right) \mid \mathcal{D}\right]\right)^2} = \exp\left(\Delta V_m + \Delta V_d\right) \frac{\Omega_2^{\mathcal{D}}}{\left(\Omega_1^{\mathcal{D}}\right)^2} - 1 \tag{B.10}$$

B.1.4 Normalized variance of investment surprise (moment 5)

We define investment surprise as the difference between the realized investment and investment guidance. In the model, the guidance is in terms of the managerial signal s_m. Hence, the investment guidance is $\mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right]$ and therefore, the variance of investment surprise is

$$\begin{aligned} Var\left(I^*\left(s_m,s_d\right) - \mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right] \mid \mathcal{D}\right) &= \mathbb{E}\left[\left(I^*\left(s_m,s_d\right) - \mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right]\right)^2 \mid \mathcal{D}\right] \\ &\quad - \mathbb{E}\left[I^*\left(s_m,s_d\right) - \mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right] \mid \mathcal{D}\right] \\ &= \mathbb{E}\left[\left(I^*\left(s_m,s_d\right) - \mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right]\right)^2 \mid \mathcal{D}\right] \end{aligned}$$

where the second equality follows from the Law of Iterated Expecation. First, we have

$$\mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right] = \frac{1}{r}\mathbb{E}\left[\exp\left(c_0 + c_m s_m + c_d s_d\right) \mid s_m\right]$$

Again, since s_m and s_d are independent, using (B.2), we have

$$\mathbb{E}\left[I^*\left(s_m,s_d\right) \mid s_m\right] = \frac{1}{r}\exp\left(c_0 + c_m s_m + c_d \overline{f}_2 + \frac{1}{2}\Delta V_d\right)$$

Hence, the investment surprise is

$$
\begin{aligned}
I^*(s_m,s_d) - \mathbb{E}\left[I^*(s_m,s_d) \mid s_m\right] &= \frac{1}{r}\exp\left(c_0 + c_m s_m + c_d s_d\right) - \frac{1}{r}\exp\left(c_0 + c_m s_m + c_d \overline{f}_2 + \frac{1}{2}\Delta V_d\right) \\
&= \frac{1}{r}\exp\left(c_0 + c_m s_m\right)\left(\exp\left(c_d s_d\right) - \exp\left(c_d \overline{f}_2 + \frac{1}{2}\Delta V_d\right)\right)
\end{aligned}
$$

and therefore,

$$
\begin{aligned}
Var\left(I^*(s_m,s_d) - \mathbb{E}\left[I^*(s_m,s_d) \mid s_m\right] \mid \mathcal{D}\right) = {} & \frac{1}{r^2}\exp\left(2c_0\right)\mathbb{E}\left[\exp\left(2c_m s_m\right)\right] \\
& \times \left(\mathbb{E}\left[\exp\left(2c_d s_d\right)\right] + \exp\left(2c_d \overline{f}_2 + \frac{2}{2}\Delta V_d\right)\right. \\
& \left. -2\exp\left(c_d \overline{f}_2 + \frac{1}{2}\Delta V_d\right)\mathbb{E}\left[\exp\left(c_d s_d\right)\right]\right)
\end{aligned}
$$

Using (B.2), we get $\mathbb{E}\left[\exp\left(tc_d s_d\right) \mid \mathcal{D}\right] = \exp\left(tc_d \overline{f}_2 + \frac{t^2}{2}\Delta V_d\right)$ and from (B.3),

$$
\mathbb{E}\left[\exp\left(2c_m s_m\right) \mid s_m \in \mathcal{D}\right] = \exp\left(2c_m \overline{f}_1 + \frac{4}{2}\Delta V_m\right)\Omega_2^{\mathcal{D}}
$$

Substituting and simplifying yields

$$
\begin{aligned}
Var\left(I^*(s_m,s_d) - \mathbb{E}\left[I^*(s_m,s_d) \mid s_m\right] \mid \mathcal{D}\right) = {} & \frac{1}{r^2}\exp\left(2c_0 + 2c_m \overline{f}_1 + \frac{4}{2}\Delta V_m + 2c_d \overline{f}_2 + \frac{4}{2}\Delta V_d\right)\Omega_2^{\mathcal{D}} \\
& \times \left(1 - \exp\left(-\Delta V_d\right)\right)
\end{aligned}
$$

Using (B.5), we have:

$$
\begin{aligned}
Var\left(I^*(s_m,s_d) - \mathbb{E}\left[I^*(s_m,s_d) \mid s_m\right] \mid \mathcal{D}\right) &= \frac{1}{r^2}\exp\left(2\left(\overline{f} + \frac{1}{2\tau_f} + \frac{1}{2}\left(\Delta V_m + \Delta V_d\right)\right)\right)\Omega_2^{\mathcal{D}} \\
& \quad \times \left(1 - \exp\left(-\Delta V_d\right)\right) \\
&= \mathbb{E}\left[\left(I^*(s_m,s_d)\right)^2 \mid \mathcal{D}\right] \times \left(1 - \exp\left(-\Delta V_d\right)\right)
\end{aligned}
$$

where the last line follows from (B.8). Hence, the normalized variance of investment surprise is:

$$
m_5\left(\Delta V_d\right) \equiv \frac{Var\left(I^*(s_m,s_d) - \mathbb{E}\left[I^*(s_m,s_d) \mid s_m\right] \mid \mathcal{D}\right)}{\mathbb{E}\left[\left(I^*(s_m,s_d)\right)^2 \mid \mathcal{D}\right]} = 1 - \exp\left(-\Delta V_d\right) \tag{B.11}
$$

B.1.5 Relative volatility of returns (moment 6)

Let P_0 be the ex-ante firm value. Hence, the stock returns are given by $\frac{P^{\mathcal{A}}(s_m, s_i)}{P_0} - 1$ and therefore, the variance of returns is

$$Var\left(\frac{P^{\mathcal{A}}(s_m, s_i)}{P_0} - 1 \mid \mathcal{A}\right) = \frac{1}{P_0^2} Var\left(P^{\mathcal{A}}(s_m, s_i) \mid \mathcal{A}\right)$$

where $P^{\mathcal{A}}(s_m, s_i) = \mathbb{E}[CF(s_m, s_i) \mid \mathcal{A}, s_i]$ is given by (10) for $\mathcal{A} = \mathcal{D}$ and by (12) for $\mathcal{A} = \mathcal{ND}$.

For $\mathcal{A} = \mathcal{ND}$, we have

$$\begin{aligned} Var\left(P^{\mathcal{ND}}(s_m, s_{nd}) \mid \mathcal{ND}\right) &= \frac{\kappa^2}{4r^2} \exp(4c_0)\, Var\left(\exp(2c_{nd}s_{nd}) \mid \mathcal{ND}\right) \\ &= \frac{\kappa^2}{4r^2} \exp(4c_0) \left(\mathbb{E}\left[\exp(4c_{nd}s_{nd}) \mid \mathcal{ND}\right] - \left(\mathbb{E}\left[\exp(2c_{nd}s_{nd}) \mid \mathcal{ND}\right]\right)^2\right) \end{aligned}$$

Using (B.2), we can simplify this as

$$\begin{aligned} Var\left(P^{\mathcal{ND}}(s_m, s_{nd}) \mid \mathcal{ND}\right) &= \frac{\kappa^2}{4r^2} \exp(4c_0) \left(\exp\left(4c_{nd}\overline{f}_2 + \frac{4^2}{2}\Delta V_{nd}\right) - \exp\left(4c_{nd}\overline{f}_2 + 2\frac{2^2}{2}\Delta V_{nd}\right)\right) \\ &= \frac{\kappa^2}{4r^2} \exp\left(4c_0 + 4c_{nd}\overline{f}_2 + \frac{4^2}{2}\Delta V_{nd}\right)\left(1 - \exp(-4\Delta V_{nd})\right) \\ &= \frac{1}{4r^2} \exp\left(4c_0 + 4c_{nd}\overline{f}_2 + \frac{4^2}{2}\Delta V_{nd} + 4c_m\overline{f}_1 + \frac{4^2}{2}\Delta V_m\right) \exp(-4\Delta V_m) \\ &\times \left(1 - \exp(-4\Delta V_{nd})\right) \times \left(\Omega_2^{\mathcal{ND}}\right)^2 \end{aligned}$$

where the last line uses $\kappa = \mathbb{E}\left[\exp(2c_m s_m) \mid \mathcal{ND}\right] = \exp\left(2c_m\overline{f}_1 + \frac{2^2}{2}\Delta V_m\right)\Omega_2^{\mathcal{ND}}$. Finally, substituting using (B.5) gives

$$\begin{aligned} Var\left(P^{\mathcal{ND}}(s_m, s_{nd}) \mid \mathcal{ND}\right) &= \frac{1}{4r^2} \exp\left(4\left(\overline{f} + \frac{1}{2\tau_f} + \frac{3}{2}(\Delta V_m + \Delta V_{nd})\right)\right) \exp(-4\Delta V_m) \\ &\times \left(1 - \exp(-4\Delta V_{nd})\right) \times \left(\Omega_2^{\mathcal{ND}}\right)^2 \end{aligned} \tag{B.12}$$

Next, for $\mathcal{A} = \mathcal{D}$, we have

$$Var\left(P^{\mathcal{D}}(s_m, s_d) \mid \mathcal{D}\right) = \frac{1}{4r^2} \exp(4c_0)\, Var\left(\exp(2c_m s_m + 2c_d s_d) \mid \mathcal{D}\right)$$

where

$$Var\left(\exp\left(2c_m s_m + 2c_d s_d\right) \mid \mathcal{D}\right) = \mathbb{E}\left[\exp\left(4c_m s_m\right) \mid \mathcal{D}\right] \mathbb{E}\left[\exp\left(4c_d s_d\right) \mid \mathcal{D}\right] \\ - \left(\mathbb{E}\left[\exp\left(2c_m s_m\right) \mid \mathcal{D}\right] \mathbb{E}\left[\exp\left(2c_d s_d\right) \mid \mathcal{D}\right]\right)^2$$

Using (B.2) and (B.3), we can simplify above as

$$Var\left(\exp\left(2c_m s_m + 2c_d s_d\right) \mid \mathcal{D}\right) = \exp\left(4c_m \overline{f}_1 + \frac{4^2}{2}\Delta V_m + 4c_d \overline{f}_2 + \frac{4^2}{2}\Delta V_d\right) \\ \times \left(\Omega_4^{\mathcal{D}} - \exp\left(-4\Delta V_m - 4\Delta V_d\right)\left(\Omega_2^{\mathcal{D}}\right)^2\right)$$

Hence,

$$Var\left(P^{\mathcal{D}}\left(s_m, s_d\right) \mid \mathcal{D}\right) = \frac{1}{4r^2}\exp\left(4c_0 + 4c_m \overline{f}_1 + \frac{4^2}{2}\Delta V_m + 4c_d \overline{f}_2 + \frac{4^2}{2}\Delta V_d\right) \\ \times \left(\Omega_4^{\mathcal{D}} - \exp\left(-4\Delta V_m - 4\Delta V_d\right)\left(\Omega_2^{\mathcal{D}}\right)^2\right)$$

Using (B.5) above and simplifying yields

$$Var\left(P^{\mathcal{D}}\left(s_m, s_d\right) \mid \mathcal{D}\right) = \frac{1}{4r^2}\exp\left(4\left(\overline{f} + \frac{1}{2\tau_f} + \frac{3}{2}\left(\Delta V_m + \Delta V_d\right)\right)\right) \\ \times \left(\Omega_4^{\mathcal{D}} - \exp\left(-4\Delta V_m - 4\Delta V_d\right)\left(\Omega_2^{\mathcal{D}}\right)^2\right) \tag{B.13}$$

Dividing (B.13) by (B.12) gives the relative volatility of returns:

$$m_6\left(\Delta V_m, \Delta V_{nd}, \Delta V_d, z_m^c\right) \equiv \frac{Var\left(P^{\mathcal{D}}\left(s_m, s_d\right) \mid \mathcal{D}\right)}{Var\left(P^{\mathcal{ND}}\left(s_m, s_{nd}\right) \mid \mathcal{ND}\right)} \\ = \frac{\exp\left(2\left(\Delta V_d - \Delta V_{nd}\right)\right)}{\exp\left(4\Delta V_{nd}\right) - 1} \times \frac{\exp\left(4\left(\Delta V_m + 4\Delta V_d\right)\right)\Omega_4^{\mathcal{D}} - \left(\Omega_2^{\mathcal{D}}\right)^2}{\left(\Omega_2^{\mathcal{ND}}\right)^2} \tag{B.14}$$

B.2 Estimation procedure

B.2.1 Calculation of differences between empirical and theoretical moments

In this section of the Appendix, we explain how the empirical moments used to fit the model are computed. The paper uses moments listed in Appendix B.1: ...

The data used in the estimation is described in Section 2.

We treat the data as cross-sectional, i.e. every firm-year is an independent draw from a population of firm-years described by one distribution function. For each firm i on year t, we have...

1.

B.2.2 Parameter search algorithm

The objective of the GMM procedure is to minimize the distance between the theoretical moments, which are functions of the model parameters, and empirical moments, which are calculated from the data. In other words, the goal is to find a set of parameters $\hat{\boldsymbol{\theta}}$ such that

$$\hat{\boldsymbol{\theta}} = \text{argmin}_{\boldsymbol{\theta}} \quad (M(Y_i,\theta))^T \hat{W} (M(Y_i,\theta)), \tag{B.15}$$

where $M(Y_i,\theta) = m(d) - \hat{m}(\boldsymbol{\theta})$ is the vector of differences between moments computed from the data $m(d)$ – a function of data d – and their counterparts computed from the model $\hat{m}(\theta)$ the model – a function of the model's parameters θ. The matrix W is the weighting matrix.

The calculation of data moments is independent from the calculation of the model moments. The data moments are computed from the data, and the model moments are computed by solving the model analytically and deriving the moments.

We use the optimal weighting matrix, which is the inverse variance-covariance matrix of the empirical moments, $\hat{W} = \hat{\Omega}^{-1}, \hat{\Omega} \equiv M(Y_i,\theta)M(Y_i,\theta)^T$, computed using bootstrap. We create 1,000 randomly drawn subsamples of size 2000 from our original dataset and calculate vectors of moment differences $M(Y_i^k,\hat{\theta}_1), k = 1,2,...,1,000$ for each of these subsamples. Next, we calculate the covariance matrix of moments based on these 1,000 observations, $\hat{\Omega}$.

We calculate standard errors of the estimates using the formula for the asymptotic covariance matrix of estimates:

$$\mathbf{V} \equiv \frac{1}{N}\left[\hat{G}\hat{\Omega}^{-1}\hat{G}^T\right]^{-1}, \tag{B.16}$$

where $\hat{G} \equiv \frac{\partial\left(\frac{1}{N}\sum_{i=1}^N g(Y_i,\theta)\right)}{\partial\theta}$ is the Jacobian matrix, evaluated at $\hat{\theta}$. The derivative of moment k with respect to parameter p, $\frac{\partial\left(\frac{1}{N}\sum_{i=1}^N g(Y_i,\theta)\right)_k}{\partial\theta_p}$, is calculated by varying the parameter $\hat{\theta}_p$ by 1% up and down (keeping other parameters constant) and dividing the difference between the new value of the moment at the 1% higher parameter and the new value of the moment at the 1% lower parameter $\hat{\theta}_p$, by 2% of $\hat{\theta}_p$.

B.2.3 Kalman Filter Estimation

For firm i, the linear Gaussian state-space system is represented by (36)-(37). We stack all N firms vertically to represent the cross-section of firms as a *single* state-space system:

$$x_{t+1} = \mu + Ax_t + Cw_{t+1}, \qquad w_{t+1} \sim \mathcal{N}(0, I_N), \tag{B.17}$$

$$f_t = Gx_t, \tag{B.18}$$

where

$$x_t \equiv \begin{bmatrix} f_{2,t} & f_{1,1t} & f_{2,1t} & \dots & f_{N,1t} \end{bmatrix}^\top_{(N+1)\times 1}$$

is the latent state vector for N firms with $f_{i,1t}$ being the idiosyncratic component of firm i and $f_{2,t}$ is the common factor. Further,

$$f_t \equiv \begin{bmatrix} f_{1t} & f_{2t} & \dots & f_{Nt} \end{bmatrix}^\top_{(N)\times 1}$$

is the observed return on invested capital with $f_{it} = f_{i,1t} + f_{2,t}$. Above the structural parameters are $\mu \equiv \begin{bmatrix} \mu_2 & \mu_1 & \mu_1 & \dots & \mu_1 \end{bmatrix}^\top_{(N+1)\times 1}$,

$$A = \begin{bmatrix} \rho_2 & 0 & 0 & \dots & 0 \\ 0 & \rho_1 & 0 & \dots & 0 \\ 0 & 0 & \rho_1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & \rho_1 \end{bmatrix}_{(N+1)\times(N+1)} \qquad C = \begin{bmatrix} \sigma_{\eta_2} & 0 & 0 & \dots & 0 \\ 0 & \sigma_{\eta_1} & 0 & \dots & 0 \\ 0 & 0 & \sigma_{\eta_1} & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & \sigma_{\eta_1} \end{bmatrix}_{(N+1)\times(N+1)}$$

and

$$G = \begin{bmatrix} 1 & 1 & 0 & \dots & 0 \\ 1 & 0 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & 0 \\ 1 & 0 & 0 & 0 & 1 \end{bmatrix}_{N\times(N+1)}$$

To estimate the parameter vector $\theta = (\mu_1, \mu_2, \rho_1, \rho_2, \sigma_{\eta_1}, \sigma_{\eta_2})$, we maximize the joint likelihood function of observed productivity $(f_1, f_2, \ldots, f_T)$ as

$$\hat{\theta} = \arg\max_{\theta} \mathcal{L}(f_1, f_2, \ldots, f_T; \theta) = \arg\max_{\theta} \prod_{t=1}^{T} \phi(f_t \mid f_1, f_2, \ldots, f_{t-1}; \theta) \tag{B.19}$$

where $\phi(f_t \mid f_1, f_2, \ldots, f_{t-1}; \theta)$ represent the conditional density of f_t given measurable information till time $t-1$ with the initial condition ϕ_0 assumed to be the stationary distribution of the system.

For a given set of parameter set θ, we compute the likelihood function using the standard Kalman Filter procedure. Note that because our data is unbalanced, we dynamically update the observation equation (B.18) using only the firms for which we observe the data at time t. To do so, we subset G as $G_t \subseteq G$ and drop the rows of G corresponding the firms that have missing ROIC at time t. This allows us to use the standard "predict" and "update" steps of Kalman Filter in an efficient manner.

Because $\sigma^2_{f_1} = \dfrac{\sigma^2_{\eta_1}}{1-\rho_1^2}$ and $\Delta V_m = \sigma^2_{f_1} - \left(1/\sigma^2_{f_1} + 1/\sigma^2_m\right)^{-1} < \sigma^2_{f_1}$ must hold. Similarly, $\Delta V_d < \sigma^2_{f_2}$ and $\Delta V_{nd} < \sigma^2_{f_2}$ must hold in equilibrium. Therefore, while estimating the parameters θ, we impose two constraints in (B.19) as

$$\begin{aligned} \hat{\theta} = \arg\max_{\theta} \prod_{t=1}^{T} \phi(f_t \mid f_1, f_2, \ldots, f_{t-1}; \theta) \\ \text{s.t.} \quad \frac{\sigma^2_{\eta_1}}{1-\rho_1^2} > \Delta\hat{V}_m, \quad \frac{\sigma^2_{\eta_2}}{1-\rho_2^2} > \max\left\{\Delta\hat{V}_d, \Delta\hat{V}_{nd}\right\} \end{aligned} \tag{B.20}$$

where $\Delta\hat{V}_m, \Delta\hat{V}_d$ and $\Delta\hat{V}_{nd}$ are estimated parameters from GMM. We solve for θ using Matlab's genetic algorithm for global maximization.

To compute the standard errors of estimated parameters, we rely on the standard regularity conditions under which the MLE estimator satisfies

$$\sqrt{T}\left(\hat{\theta} - \theta_0\right) \to^d \mathcal{N}\left(0, \mathcal{I}(\theta_0)^- 1\right)$$

where $\mathcal{I}(\theta_0)$ is the Fisher Information matrix. The $(j,k)^{th}$ element is

$$\mathcal{I}_{jk} = \mathbb{E}\left[-\frac{\partial^2 \ell_t(\theta_0)}{\partial\theta_j \theta_k}\right]$$

where $\ell_t(\cdot)$ is the period t log-likelihood. We estimate $\mathcal{I}(\theta_0)$ as the Hessian of the sample negative log-likelihood evaluated as $\hat{\theta}$ as

$$\mathcal{I}\left(\hat{\theta}\right) = \frac{1}{T}\sum_{t=1}^{T}\left[-\frac{\partial^2 \ell_t\left(\hat{\theta}\right)}{\partial\theta\partial\theta'}\right]$$

using numerical approximation. The estimated covariance matrix of $\hat{\theta}$ is then $V = \left(\mathcal{I}\left(\hat{\theta}\right)\right)^{-1}$ and the standard errors are given by the square roots of the diagonal elements.

Finally, we compute the fundamental parameters using (33)-(34). To calculate the standard errors, we use the delta method.