The Real Costs of Financial Efficiency When Some Information Is Soft*

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Abstract

This paper shows that improving financial efficiency may reduce real efficiency. While the former depends on the *total* amount of information available, the latter depends on the *relative* amounts of hard and soft information. Disclosing more hard information (e.g. earnings) increases total information, raising financial efficiency and reducing the cost of capital. However, it induces the manager to prioritize hard information over soft by cutting intangible investment to boost earnings, lowering real efficiency. The optimal level of financial efficiency is non-monotonic in investment opportunities. Even if low financial efficiency is desirable to induce investment, the manager may be unable to commit to it. Optimal government policy may involve upper, not lower, bounds on financial efficiency.

Keywords: Financial efficiency, real efficiency, managerial myopia, investment, disclosure, cost of capital.
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"If the capital market is to function smoothly in allocating resources, prices of securities must be good indicators of value." – Fama (1976)

The link between financial efficiency and real efficiency is one of the most important questions in financial economics. Morck, Shleifer, and Vishny (1990) proposed that stock markets may be a "sideshow" that merely reflect the real economy but do not affect it. However, a long literature since has identified numerous channels through which greater strong-form financial efficiency – prices better reflecting private information – improves real decisions. Focusing on primary financial markets, Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) show that information asymmetries hinder capital raising and thus investment. Turning to secondary financial markets, the survey of Bond, Edmans, and Goldstein (2012) discusses how financial efficiency allows decision makers to learn more information from prices (e.g., Boot and Thakor (1997), Dow and Gorton (1997), Subrahmanyam and Titman (1999)), and also increases the incentives of decision makers, whose contracts are tied to prices, to improve fundamental value (e.g., Fishman and Hagerty (1989), Holmstrom and Tirole (1993)).

In the above models, financial efficiency improves real efficiency. As a result, many policies are evaluated based on their likely effects on financial efficiency.[1] For example, some commentators advocated the increased disclosure requirements of Sarbanes-Oxley to raise financial efficiency; others oppose trading restrictions (such as the scheduled EU transaction tax) arguing they will reduce it. Relatedly, financial efficiency is often taken as a measure of economic effectiveness. For example, Bai, Philippon, and Savov (2016) measure changes in financial efficiency over time to evaluate whether the increasing size of the financial sector has benefited the real economy.

This paper reaches a different conclusion. It shows that increasing financial efficiency can, surprisingly, reduce real efficiency. Central to our argument is the idea that financial markets can never be fully efficient, because certain types of information are difficult to incorporate into prices through standard channels such as disclosure. For example, "hard" (quantitative and verifiable) information, e.g. on a firm's short-term earnings, can be credibly disclosed, but "soft" (nonverifiable) information, e.g. on a firm's intangible assets such as human capital and customer satisfaction, cannot be. It may seem that this distinction does not matter: even though financial efficiency can

[1] In 2009, Securities and Exchange Commission ("SEC") chairman Mary Schapiro stated that "regulation should be designed to facilitate fair and efficient financial markets." The SEC itself argues that "only through the steady flow of timely, comprehensive, and accurate information can people make sound investment decisions." The Financial Accounting Standards Board states that "investors benefit from increased transparency because it enables them to make more informed investment decisions."

never be perfect (due to the existence of soft information), firms should still increase it as much as possible. However, we show that real efficiency depends not on *total* financial efficiency, i.e. the aggregate amount of information in prices, but the *relative* amounts of hard versus soft information. While incorporating more hard information into prices increases total information, it also distorts the relative amount of hard versus soft information. This skews the manager's real decisions towards improving hard measures of performance at the expense of soft measures of performance – for example, cutting intangible investment to increase current earnings. Thus, it is not the case that any increase in financial efficiency augments real efficiency – the *source* of the increase (whether it stems from hard or soft information) is important.

Our model features a firm run by a manager, who raises funds from an outside investor. As in Diamond and Verrecchia (1991), the investor may subsequently suffer a liquidity shock which forces him to sell his shares. Also present is a speculator (such as a hedge fund) who has private information on whether firm quality is high or low, and a market maker. The investor expects to lose to the speculator if he suffers a liquidity shock and thus demands a larger stake when contributing funds, raising the cost of capital. The manager may commit to disclosing a hard signal (such as earnings) that is partially informative about fundamental value. By increasing the precision of this signal, the manager can augment financial efficiency, which reduces the investor's information disadvantage and the cost of capital. However, high earnings precision has a real cost. A high-quality firm has the option to undertake an intangible investment that improves the firm's long-run value, but also raises the probability of delivering low earnings. If precision is high, these low earnings are disclosed precisely and the firm's stock price rationally falls since a low-quality firm also delivers low earnings. The manager's objective function places weight on both the short-term stock price and long-term firm value. This is the standard myopia problem, first modeled by Stein (1988, 1989), in which strong-form financial efficiency typically increases real efficiency (e.g. Edmans (2009)).

We start with a benchmark case in which the firm's long-run value is hard information. Thus, the manager has the option to disclose not only earnings, but also fundamental value directly, and so can achieve perfect financial efficiency by fully disclosing fundamental value. Such a policy minimizes the cost of capital and maximizes real efficiency – since the stock price equals firm value, the manager invests efficiently. This is similar to the standard benefit of financial efficiency featured in prior literature.

We then move to the more realistic case when long-run value is soft information –

since it is not realized until the future, it cannot be credibly disclosed. The manager can only disclose earnings, which are only partially informative about fundamental value, and so financial efficiency cannot be perfect. This case leads to very different implications for the desirability of financial efficiency. Since investment improves soft information (which cannot be disclosed) but worsens hard information (which can be), more precise earnings induce underinvestment. For example, at the time of its initial public offering, Google announced that it would not provide earnings guidance as such disclosure would induce short-termism. Similarly, Porsche was expelled from the M-DAX index in August 2001, for refusing to comply with its requirement for quarterly reporting, arguing that it leads to myopia, and Unilever has stopped reporting quarterly earnings for the same reason. As a result, real efficiency is non-monotonic in financial efficiency. When long-run value is hard information, the manager invests efficiently if it is perfectly disclosed (in which case financial efficiency is maximized). When long-run value cannot be disclosed, he invests efficiently if earnings are not disclosed either (in which case financial efficiency is minimized). Increased earnings precision raises financial efficiency but reduces real efficiency. It may be better for prices to contain no information than partial information.[2]

The optimal level of disclosure is a trade-off between increased financial efficiency (a lower cost of capital) and reduced real efficiency (lower investment). Thus, the model predicts how disclosure (and thus financial efficiency) should vary across firms. Intuition might suggest that firms with better growth opportunities will disclose less, since investment dominates the trade-off, but we show that the relationship is non-monotonic. When investment opportunities are weak, the cost of capital dominates the trade-off and disclosure is precise to minimize it. When investment opportunities are strong, the manager will exploit them fully even with precise disclosure. Thus, disclosure is precise for firms with weak or strong growth opportunities, and imprecise for firms with intermediate growth opportunities. We find a similar non-monotonic effect on disclosure of uncertainty (the difference in value between high- and low-quality firms): surprisingly, when uncertainty is high, it need not be the case that the manager

[2] This result echoes the theory of the second best, where it may be optimal to tax all goods rather than a subset. Holmstrom and Milgrom (1991) show that difficulties in measuring one task may lead to the principal optimally offering weak incentives for all tasks. Paul (1992) shows that an efficient financial market weights information according to its informativeness about asset value, but to incentivize efficient real decisions, information should be weighted according to its informativeness about the manager's actions. Both papers study optimal contracts based on exogenously available information. Here, the information in prices is an endogenous decision of the firm, and we study the firm's optimal choice which trades off financial and real efficiency.

discloses more information in response.

The above analysis assumes that the manager can commit to a disclosure policy when raising funds, as in the literature on mandatory disclosure. We next consider the case in which commitment is impossible, as in the literature on voluntary disclosure. Here, the manager is able to observe whether earnings are likely to be high or low before deciding the precision with which to report them. If the growth opportunity is intermediate, the manager would like to commit to imprecise disclosure to maximize real efficiency. However, if he invests and gets lucky, i.e., still delivers high earnings, he will renege and disclose the high earnings precisely anyway. Then, if the market receives an uninformative disclosure, it rationally infers that earnings are low, else the manager would have disclosed them precisely, akin to the "unraveling" result of Grossman (1981) and Milgrom (1981). The only dynamically consistent policy is maximum precision, and real efficiency suffers. Government intervention to cap disclosure (e.g. by allowing scope for earnings management) can allow the firm to implement the optimal policy. This conclusion contrasts earlier research which argues that regulation should increase disclosure due to externalities (Foster (1979), Dye (1990), Admati and Pfleiderer (2000), and Lambert, Leuz, and Verrecchia (2007)).

Our paper is not the first to recognize that financial efficiency need not coincide with real efficiency.[3] Stein (1989) shows that, if managers cut investment to inflate earnings, a rational market will anticipate such behavior and discount earnings. Thus, markets are semi-strong-form efficient, but managers are trapped into behaving inefficiently. Dow and Gorton (1997) show that, if speculators do not produce information, the manager does not learn from prices and does not invest. Prices are semi-strong-form efficient since they reflect the fact that no investment will occur, but real efficiency is low. In Brandenburger and Polak (1996), managers maximize the stock price by taking decisions that conform to market priors and ignoring their own superior information; prices correctly reflect the action that is eventually taken.[4] In these papers, semi-

[3] Bond, Edmans, and Goldstein (2012) term the traditional notion of financial efficiency – the extent to which prices reflect fundamental values – as "forecasting price efficiency". This is the notion of financial efficiency studied in the present paper. Bond et al. argue that real efficiency instead depends on "revelatory price efficiency": the extent to which prices reveal the information necessary for decision-makers to take value-maximizing actions. In our setting, this is information about the firm's long-run value – but since it cannot be disclosed, the notion of revelatory price efficiency is moot. We show that, even though disclosure does not improve revelatory price efficiency, it still improves real efficiency. The distinction between forecasting price efficiency and revelatory price efficiency echoes Hirshleifer's (1971) distinction between "foreknowledge" and "discovery".

[4] In Kyle and Vila (1991), Kahn and Winton (1998), and Maug (1998), if the stock price is less effiicient, i.e. reflects expected activism to a lower extent, the activist is more likely to acquire a stake to begin with, increasing real efficiency. However, these papers do not feature the learning or

strong-form financial efficiency is an outcome of the model which decision makers have no control over. In contrast, we study the manager's choice of strong-form financial efficiency – through his disclosure policy – and analyze the optimal choice, which involves the trade-off with real efficiency. The intuition of Stein (1989) would suggest that greater growth opportunities reduce disclosure, but we show that disclosure is non-monotonic in growth opportunities. We also analyze mandatory versus voluntary disclosure and demonstrate a role for regulation.

As noted above, Bond, Edmans, and Goldstein (2012) identify two channels through which financial markets can have real effects. While we study the contracting channel, Goldstein and Yang (2014) show that the learning channel can also imply a disconnect between strong-form financial efficiency and real efficiency. Greater price efficiency may cause decision makers to inefficiently underweight their private signals. In addition, financial efficiency may arise from prices incorporating information that capital providers already have, rather than would like to learn, and thus also not boost real efficiency. Through studying different mechanisms, our papers have different empirical predictions. For example, we show how disclosure and investment depend on the manager's contract, growth opportunities, and liquidity shocks. Our paper also studies the manager's optimal choice of financial efficiency through selecting a disclosure policy.

This paper is also related to the disclosure literature, reviewed by Verrecchia (2001), Dye (2001), Beyer, Cohen, Lys, and Walther (2010), and Goldstein and Sapra (2014). This literature studies the disclosure of hard information, because soft information by definition cannot be disclosed. One may think that the existence of soft information is therefore moot, and so managers should simply apply the insights of disclosure theories to hard information. We show that the existence of soft information reduces the optimal disclosure of hard information. Gigler, Kanodia, Sapra, and Venugopalan (2014) study a regulator's choice between two discrete disclosure regimes (with and without an interim signal). An interim signal induces the manager to choose short-term projects, and greater growth opportunities lead the regulator to choose less disclosure. In contrast, we study the firm's optimal choice from a continuum of policies where disclosure affects the cost of capital as well as investment, and show that disclosure is non-monotonic in growth opportunities. We also analyze the voluntary disclosure case where commitment is not possible. Ferreira, Manso, and Silva (2014) analyze a firm's choice between two discrete ownership structures: staying private (where short-term cash flows are not disclosed), and going public (where they are), and show that

contracting channels through which financial markets typically have positive real effects.

the former spurs more innovative investment. In addition to studying the optimal choice of disclosure from a continuum, and demonstrating non-monotonic effects, we also show how a firm can encourage investment even if it has chosen to go public (e.g. to raise capital) – by changing its disclosure policy. In Hermalin and Weisbach (2012), disclosure induces the manager to engage in manipulation, but there is no trade-off with financial efficiency; we solve for the optimal disclosure policy. In their model, the manager prefers less disclosure ex post; here, he discloses too much where disclosure is voluntary. In Strobl (2013), greater disclosure increases the manager's incentive to engage in manipulation, but is an exogenous parameter rather than a choice variable.

In standard disclosure models (e.g. Verrecchia (1983), Diamond (1985), Dye (1986)), disclosure is limited because it involves a direct cost. Here, even though the actual act of disclosure is costless, a high quality disclosure policy is costly. More recent models also feature indirect costs of disclosure, but in those papers disclosure is costly because it reduces financial efficiency and financial efficiency increases real efficiency[5]; here, disclosure increases financial efficiency which reduces real efficiency.

Finally, while we model disclosure as the specific channel through which firms or regulators can affect financial efficiency, the same principles apply to other determinants of financial efficiency. For example, trading regulations, such as short-sales constraints, transactions taxes, or limits on high-frequency trading, will likely reduce financial efficiency. However, if such trading would be on the basis of hard information, then the reduction in financial efficiency may increase real efficiency. Our paper cautions against policymakers supporting blanket increases in financial efficiency. Such a view would suggest that any channel of increasing total financial efficiency (e.g. any informative disclosure, or any informed trade) is desirable. Instead, what matters for real decisions is the type of information in the stock price.

1 The Model

The model consists of four players. The *manager* initially owns the firm and chooses its disclosure and investment policies. The *investor* contributes equity financing and

[5] Disclosing information may reduce speculators' incentives to acquire private information (Gao and Liang (2013)), deter speculators from trading on private information (Bond and Goldstein (2016)), or attract noise traders (Han et al. (2013)), reducing the information in prices from which the manager can learn. In Fishman and Hagerty (1989), traders can only acquire a signal in one firm, and so disclosure draws traders away from one's rivals. Thus, disclosure can be socially suboptimal as it reduces financial efficiency in other firms. Fishman and Hagerty (1990) advocate limiting the set of signals from which the firm may disclose, to increase financial and thus real efficiency.

may subsequently suffer a liquidity shock. The *speculator* has private information on firm value and trades on this information. The *market maker* clears the market and sets prices. All players are risk-neutral and there is no discounting.

There are five periods. At $t = 0$, the manager must raise financing of K, which is injected into the firm. He first commits to a disclosure policy $\sigma \in [0, 1]$ and then sells a stake α to the investor, which is chosen so that the investor breaks even. We normalize the total number of shares to one, so $\alpha \in [0, 1]$.

At $t = 1$, the firm's type θ is realized, where $\theta \in \Theta \equiv \{L, H\}$, with equal probability. Type L (H) corresponds to a low- (high-) quality firm. We will sometimes refer to a firm of type θ as a "θ-firm" and its manager as a "θ-manager". We consider a standard myopia problem. An L-manager has no investment decision and his firm is worth $V_L = R_L + K$ at $t = 4$, where R_L are the assets in place of an L-firm, net of the new funds raised. An H-manager invests a fraction $\lambda \in [0, 1]$ of the new capital and his firm is worth $V_H = R_H + (1 - \lambda) K + \lambda\gamma K$ at $t = 4$, where $\gamma > 1$ parameterizes the desirability of investment and $R_H \geq R_L$ are the assets in place.[6] The remaining $(1 - \lambda) K$ is invested in zero-NPV projects (e.g. held as cash). We can thus write $V_H = R_H + K + \lambda g K$, where $g = \gamma - 1$. The type θ and investment level λ are observable to both the manager and speculator (and so both know firm value), but neither is observable to the investor or market maker.

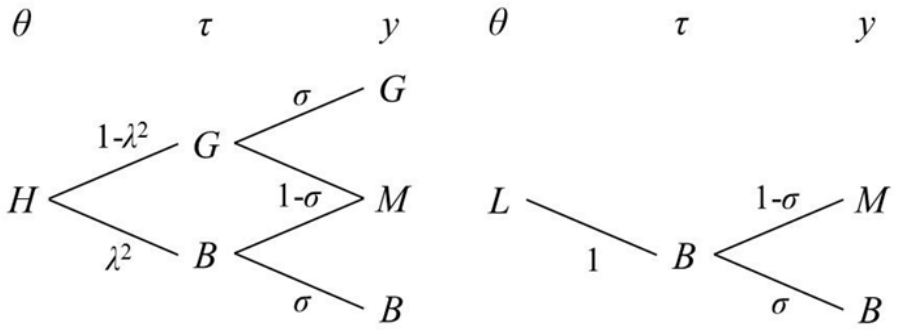

Figure 1: Signal structure

At $t = 2$, "true" short-term earnings $\tau \in \{G, B\}$ are realized. Figure 1 illustrates

[6] The results continue to hold if the investment level is independent of the amount of financing raised (e.g. the funds K are required to repay debt, rather than to fund the growth opportunity) so that $V_H = R_H + K + \lambda\gamma$. In this case, an upper bound to investment λ arises because there is a finite number of positive net present value projects available to the firm.

how earnings depend on the firm's type and the manager's investment decision. An L-firm always generates low true earnings, i.e. $\tau = B$. An H-firm generates low earnings $\tau = B$ with probability ("w.p.") λ^2 and high earnings $\tau = G$ w.p. $1 - \lambda^2$. Investment increases the probability of low true earnings: for example, intangible investment is typically expensed and thus difficult to distinguish from losses made by a low-quality firm. While true earnings are unobservable, the firm discloses a hard (verifiable) signal $y \in \{G, M, B\}$, such as a quarterly earnings statement, that is informative about τ. We call this signal "disclosed" earnings; for brevity and where there is no confusion, we will use the term "earnings" to refer to disclosed earnings. Disclosure σ increases the informativeness of disclosed earnings for true earnings. As shown in Figure 1, w.p. σ, $y = \tau$ (disclosed earnings equal true earnings) and w.p. $1-\sigma$, $y = M$, an uninformative signal that is equally likely to stem from $\tau = B$ and $\tau = G$.[7] Note that signals G and B are informative not only about true earnings, but also about fundamental value, as $y = G$ fully reveals that a firm is of type H, and $y = B$ increases the likelihood that it is of type L. Thus, σ increases the probability of an informative signal. It therefore reflects disclosure precision, as is standard in the disclosure literature (e.g. Diamond (1985), Fishman and Hagerty (1989), Diamond and Verrecchia (1991)). A firm can increase the precision of its disclosures by spending more resources on their production, improving the quality of its auditor, or (cross)-listing in a country that mandates greater disclosure (as in the Porsche example in the introduction).

At $t = 3$, the investor suffers a liquidity shock w.p. $\frac{1}{2}$, which forces him to sell β shares. W.p. $\frac{1}{2}$, he suffers no shock; he will not trade voluntarily as he is uninformed. His trade is given by $I \in \{-\beta, 0\}$. If $y = G$, the public signal is fully informative and so the speculator will not trade, but if $y \in \{M, B\}$, it is imperfect and she will take advantage of her private information on V by trading an endogenous amount S. As in Kyle (1985), the market maker observes the total order flow $Q = I + S$ but not the individual trades. He is competitive and sets a price P equal to expected firm value conditional upon Q. He clears any excess demand or supply from his own inventory.

At $t = 4$, firm value $V \in \{V_H, V_L\}$ becomes known and payoffs are realized. We consider two versions of the model. In a preliminary benchmark, V is hard information and can be credibly disclosed at $t = 2$. In the core model, V is soft information prior to $t = 4$ and thus cannot be credibly disclosed.[8] Note that soft information is still present

[7] Since signal M is uninformative, it can also be interpreted as no disclosure (rather than an uninformative disclosure). In this case, the disclosure policy σ can be interpreted as the probability of disclosing, as in Gao and Liang (2013).

[8] In Almazan, Banerji, and De Motta (2008), the signal is soft but disclosure matters because it

in the model, because the speculator has information on V and trades on it.

The manager's objective function is $(1-\alpha)(\omega P + (1-\omega) V)$. After raising financing, the manager's stake in the firm is $(1-\alpha)$. The concern for the short-term stock price $\omega \in (0,1)$ is standard in the myopia literature and can arise from a number of sources introduced by prior research. For example, learning models endogenously show that the manager's reputation (which affects the likelihood of receiving better job offers) depends on short-term performance (Narayanan (1985), Holmstrom and Ricart I Costa (1986), Scharfstein and Stein (1990)). In addition, poor stock performance increases the likelihood that the manager loses his job (as modeled by Stein (1988) and documented empirically by Jenter and Lewellen (2015)) and thus any private benefits of control.[9] Moreover, the private benefits of control (such as speaking engagements, media coverage, and prestige) are likely increasing in the stock price; in addition, it is more pleasant to work for a well-performing company. If the manager is indifferent between different disclosure policies, we assume that he chooses the highest σ.

Before solving the model, we discuss its assumptions to clarify the settings to which it applies. First, investment is unobservable to outsiders. The primary interpretation is intangible investment that cannot be separated out from other corporate expenses, such as investment in product quality, organizational capital, corporate culture, or employee training. Investors cannot distinguish whether high expenses ($y = B$) are due to desirable investment (an H-firm choosing a high λ) or low firm quality (an L-firm). Indeed, Stocken and Verrecchia (2004) write that "there are indicators of the firm's economic performance for a period, such as employee attitude, customer satisfaction, or product quality, that are not immediately recognized in its financial reporting system, irrespective of which accounting policies the firm adopts." The model also applies to intangible investment separated out in an income statement (such as R&D or advertising), or tangible investment separated out in a cash flow statement (such as capital expenditure). Even though the quantity of these expenditures is observable, their quality is not, since the benefits of investment do not manifest until the long-run. Indeed, Cohen, Diether, and Malloy (2013) find that "the stock market appears unable to distinguish between "good" and "bad" R&D investment". As a result, the market

may induce a speculator to investigate the disclosure. In Thakor (2014), the signal is soft but there is disagreement: a signal perceived as good by the manager may not be perceived as good by investors. Here, any disclosure of V is non-verifiable and high V is unambiguously good.

[9] Under these interpretations, an alternative objective function is $(1-\alpha) V + \xi P$ where $(1-\alpha) V$ is the value of the manager's stake and ξP represents his short-term concerns from these additional sources. The objective function of $(1-\alpha)(\omega P + (1-\omega) V)$ is simply $1-\omega$ times this objective function, where $\xi = \frac{(1-\alpha)\omega}{1-\omega}$.

typically responds positively to an increase in earnings even if caused by an R&D cut; prior literature finds that managers use R&D cuts to increase short-run earnings and thus the stock price.[10] A similar interpretation is that λ represents the proportion that the H-firm invests in high-NPV projects that deliver low true earnings in the short-run, and $(1-\lambda)$ the proportion in low-NPV projects that deliver high true earnings in the short-run. The total level of investment is independent of λ and so appears the same in financial statements. In sum, our model applies to investment decisions where the quality of investment is not immediately observable, even if its quantity is.

Second, investment has a linear effect on fundamental value (it improves it by λgK) and a convex effect on the likelihood of low true earnings (λ^2), similar to Stein (1989). This specification reflects the fact that a firm's investment opportunities range in quality. When a firm increases investment from 0 to ξ (raising fundamental value by ξgK), it will use its best investment opportunity, which achieves the gain of ξgK at little cost to true earnings. Subsequent increases in fundamental value by ξgK require the manager to use the next-best project, which costs more in terms of true earnings and thus increases the probability of $y = B$ by more. The results will continue to hold under a concave benefit to investment and a linear cost, although the model will be less tractable. We have studied the model under linear costs and benefits and the results continue to hold, although we obtain bang-bang solutions (investment is often 1 or 0). We have also studied a model in which the L-firm also has an investment decision. The results strengthen in that disclosure now reduces investment by the L-firm as well as the H-firms. Both results are available upon request.

Third, outside investors have no information on the firm's type, and the speculator has perfect information. This assumption can be weakened: we only require the speculator to have some information advantage over outside investors.[11] In addition, while the speculator has private information over θ and λ (and thus V), the results are identical she instead only observes θ (and thus assets in place R_θ) and not investment λ. Her trading strategy is exactly the same: she buys if $\theta = H$ (rather than $V = V_H$) and sells if $\theta = L$ (rather than $V = 0$). The results would also continue to hold if the

[10] Graham, Harvey, and Rajgopal (2005) report that 80% of managers would cut discretionary expenditure on R&D, advertising, and maintenance to meet an earnings target. Bushee (1998) finds that short-term investors induce managers to cut R&D to meet earnings targets. Roychowdhury (2006) shows that firms cut discretionary expenditure to avoid reporting losses. Bhojraj, Hribar, Picconi, and McInnis (2009) find that firms that beat analyst forecasts by reducing discretionary expenditure enjoy a short-term stock price gain that is reversed in the long-run.

[11] Her information can stem from holding a block, which gives her either greater incentives to gather information (Edmans (2009)) or greater access to information; alternatively, it could stem from her expertise, as with a hedge fund.

speculator's private information were on true earnings τ, as she would make trading profits at the expense of the investor if $y = M$. We only require the speculator to have private information; it does not matter what the private information is on as long as its value is reduced by public disclosure. In sum, our model applies to firms in which investors are concerned with information asymmetry. This is the case even for large public firms: Balakrishnan, Billings, Kelly, and Ljungqvist (2014) use a natural experiment to show that greater disclosure increases liquidity and thus reduces the cost of capital for U.S. public firms.

The above assumptions are as in the myopia model of Edmans (2009): the specification of investment the same, the speculator here is analogous to the blockholder in Edmans (2009) (both have private information on fundamental value and trade in a discretionary manner), and the investor here is analogous to the noise traders in Edmans (2009) (both lack private information, and their trades are driven by liquidity shocks). However, while he shows a positive link between financial and real efficiency, we find the opposite for reasons we will soon make clear.

We now formally define a Perfect Bayesian Equilibrium as our solution concept.

Definition 1 *The manager's disclosure policy σ, the H-manager's investment strategy λ, the speculator's trading strategy S, the market maker's pricing strategy P, the market maker's belief μ about $\theta = H$, and his belief $\hat{\lambda}$ about the H-manager's investment level constitute a Perfect Bayesian Equilibrium, if*

1. *given μ and $\hat{\lambda}$, P causes the market maker to break even for any $\sigma \in [0, 1]$, $y \in \{G, M, B\}$, and $Q \in \mathbb{R}$;*
2. *given $\hat{\lambda}$ and P, S maximizes the speculator's payoff for any V, $\sigma \in [0, 1]$, and $y \in \{G, M, B\}$;*
3. *given S and P, λ maximizes the H-manager's payoff given $\sigma \in [0, 1]$;*
4. *given λ, S, and P, σ maximizes the manager's payoff;*
5. *given σ, λ, S, and P, α makes the investor break even;*
6. *the belief μ is consistent with the strategy profile; and*
7. *the belief $\hat{\lambda} = \lambda$, i.e., is correct in equilibrium.*

We are interested in the trade-off between financial and real efficiency. Since investment increases fundamental value, we use λ as a measure of real efficiency. We measure financial efficiency as follows:

Definition 2 *Financial efficiency is measured by*

$$-E\left[\Lambda\left(P\right)\right] = -E\left[\frac{Var\left[V|P\right]}{Var\left[V\right]}\right]. \tag{1}$$

Our measure of financial efficiency is price informativeness: the negative of the variance of fundamental value conditional on the price, as in Kyle (1985), scaled by the unconditional variance of fundamental value to obtain a relative measure. Note that we distinguish the information content of a specific price realization, $-\Lambda\left(P\right)$, from the expected information content, $-E\left[\Lambda\left(P\right)\right]$.

2 Analysis

2.1 First-Best Benchmark

As a benchmark, we first assume that V is hard information and so the manager has the option of disclosing it. Specifically, at $t = 0$, in addition to committing to a disclosure precision σ of the signal y, he also chooses $\sigma_V \in \{0, 1\}$, where $\sigma_V = 1$ entails perfect disclosure of V at $t = 2$, and $\sigma_V = 0$ entails no disclosure.[12] In this case, perfect financial efficiency can be achieved. If $\sigma_V = 1$, then $P = V$ regardless of order flow and financial efficiency is maximized: $-E\left[\Lambda\left(P\right)\right] = 0$. The investor makes no trading losses and so the stake α that the manager must give up is minimized. Real efficiency is also maximized: the H-manager faces no trade-off between stock price and fundamental value, and so chooses the first-best investment level $\lambda = 1$ as this maximizes both. Since y is uninformative conditional upon V, the manager is indifferent between any $\sigma \in [0, 1]$, and so by our earlier assumption, he chooses $\sigma = 1$. This result is given in Lemma 1 below.

Lemma 1 *(Disclosure of fundamental value): If fundamental value V is hard information, the manager chooses $\sigma_V = \sigma = 1$ and $\lambda^* = 1$.*

[12] Since the manager always chooses $\sigma_V = 1$ (as we will shortly show), the analysis would be unchanged by making σ_V continuous (i.e. the choice of a precision). However, we would have to complicate the model by introducing a second signal of V for which σ_V measures its precision.

We now turn to the core model in which V is soft information and cannot be disclosed. As a result, perfect financial efficiency cannot be achieved. Despite this, one might think that the manager will still try to increase financial efficiency as much as possible by setting $\sigma = 1$, but we will show that this is not always the case.

We solve the model by backward induction. We first determine the stock price at $t = 3$, given the market's belief about the manager's investment, and then move to the manager's $t = 2$ investment decision. Finally, we turn to the manager's choice of disclosure at $t = 0$, which takes into account the impact on financial efficiency (and thus the cost of capital) and real efficiency (his investment decision).

2.2 Trading Stage

The trading game at $t = 3$ is played by the speculator and the market maker. At this stage, the manager's investment decision λ (if $\theta = H$) has been undertaken, but is unknown to the market maker. Thus, he sets the price using his equilibrium belief $\hat{\lambda}$.

There are three cases to consider. If $y = G$, the signal fully reveals that $\theta = H$. As a result, the speculator has no private information and thus motive to trade; the market maker sets $P = \widehat{V_H} = R_H + K + \hat{\lambda} g K$. When $y \in \{M, B\}$, the signal is imperfect and so the speculator will trade on her private information on V.[13] Since the investor sells either β or 0, to hide her information the speculator will choose a δ so that she buys δ shares if $V = V_H$ and $\delta - \beta$ shares if $V = V_L$. Thus, the set of total order flows is given by $Q \in \{\delta - 2\beta, \delta - \beta, \delta\}$. Given the speculator's equilibrium strategy, the market maker's equilibrium pricing function is given by Bayes' rule in Lemma 2.

Lemma 2 *(Prices): Upon observing signal y and the order flow Q, the prices set by the market maker are given by the following table:*

Q	δ	$\delta - \beta$	$\delta - 2\beta$
$P(y = B)$	$\widehat{V_H}$	$\frac{\hat{\lambda}^2 \widehat{V_H} + V_L}{1 + \hat{\lambda}^2}$	V_L
$P(y = M)$	$\widehat{V_H}$	$\frac{1}{2}\left(\widehat{V_H} + V_L\right)$	V_L
$P(y = G)$	$\widehat{V_H}$		

. (2)

We use $P(Q, y)$ to denote the price of a firm for which signal y has been disclosed and the total order is Q. The price is perfectly informative ($\Lambda(P) = 0$) except in two

[13] Hayn (1995), Basu (1997), and Beaver et al. (2012) find that the earnings response coeficient is stronger for positive earnings changes than negative earnings changes, consistent with the market learning more from $y = G$ than $y = B$.

cases, which we denote $P' \equiv P(\delta - \beta, M)$ and $P'' \equiv P(\delta - \beta, B)$. We have $\Lambda(P') = 1$ and $\Lambda(P'') = 4\frac{\lambda^2}{(1+\lambda^2)^2}$ (since in equilibrium, $\hat{\lambda} = \lambda$). Thus, financial efficiency is given by

$$\begin{aligned} -E[\Lambda(P)] &= -\frac{1}{2}(1-\sigma)\Lambda(P') - \frac{1}{4}\sigma\left(1+\lambda^2\right)\Lambda(P'') \\ &= -\left(\frac{1}{2}(1-\sigma) + \frac{\lambda^2}{1+\lambda^2}\sigma\right). \end{aligned} \tag{3}$$

There are two effects of an increase in disclosure σ on financial efficiency. First, it directly increases financial efficiency since $\frac{\lambda^2}{1+\lambda^2} < \frac{1}{2}$: the signal y is informative about true earnings and thus fundamental value. Second, Proposition 1 will show that σ reduces investment λ, which lowers the difference in value between H and L firms and thus also increases financial efficiency.

2.3 Investment Stage

We now move to the H-manager's investment decision at $t = 2$. At this stage, the disclosure policy σ is known. Given a σ, the manager's investment decision is given in Proposition 1 below, where we define $\Omega \equiv \frac{\omega}{1-\omega}$ as the relative weight on the stock price and $\Delta \equiv R_H - R_L$ as the uncertainty of the firm's assets in place. (All proofs are in Appendix A).

Proposition 1 *(Investment): For any $\sigma \in [0,1]$, there is a unique equilibrium investment level in the subgame following σ, which is given by:*

$$\lambda^* = \begin{cases} r(\sigma), & \text{if} \quad \sigma > X; \\ 1, & \text{if} \quad \sigma \leq X, \end{cases}$$

where

$$X \equiv \frac{2}{\Omega}\frac{gK}{\Delta + gK}, \tag{4}$$

and $r(\sigma)$ is the root of the quadratic

$$\Psi(\lambda, \sigma) \equiv \left(\frac{1}{\Omega} - \sigma\right)\lambda^2 - \sigma\frac{\Delta}{gK}\lambda + \frac{1}{\Omega} = 0, \tag{5}$$

for which $\Psi'(r, \sigma) < 0$. It is strictly decreasing and strictly convex. If $\sigma > X$, the partial investment level $r(\sigma)$ is increasing in g and K and decreasing in σ, ω,and Δ.

The threshold X is increasing in g and K and decreasing in ω and Δ.

The intuition is as follows. The cost of investment is that it increases the probability of low true earnings, which leads to a bad signal w.p. σ. Thus, the manager fully invests if and only if σ is sufficiently low. As is intuitive, $\sigma \leq X$ is more likely to be satisfied if ω is low (the manager is less concerned with the stock price), g and K are high (investment opportunities are superior), and Δ is low (there is less incentive to be revealed as H by reporting a good signal).

When $\sigma > X$, the manager invests below the first-best. Additional increases in σ reduce investment $r(\sigma)$ further. Indeed, Cheng, Subrahmanyam, and Zhang (2007) document that firms that issue quarterly earnings guidance invest less in R&D. Ernstberger, Link, Stich, and Vogler (2015) find that the European Union's new mandatory quarterly reporting requirements led to firms reducing investment, improving operating performance in the short-term but lowering it in the long-term. Kraft, Vashishtha, and Venkatachalam (2015) find that the transition from annual to semi-annual, and from semi-annual to quarterly reporting in the US led to a decline in investment.

The negative link between financial efficiency and real efficiency contrasts Edmans (2009), who demonstrates a positive link. In his model, financial efficiency is increased by blockholders gathering information on V and incorporating it into stock prices by trading. They do not gather information on y as it is public. Here, financial efficiency is increased by the manager disclosing a more precise signal y; he cannot credibly disclose V as it is soft information. (Note that soft information is still present in our model as it is possessed and traded on by the speculator).[14] Hence, it is not the case that any channel that increases financial efficiency also increases real efficiency – the *source* of the increase in financial efficiency is important. While both information about V and τ (signaled through y) increase financial efficiency, they have opposite effects on real efficiency: information about fundamental value (earnings) in prices increases (reduces) real efficiency. Relatedly, while informed trading can incorporate soft information on V into the stock price, disclosure can only incorporate hard information on τ. Thus, informed trading and disclosure are not equivalent channels for increasing financial efficiency.

[14] Communication of soft information requires the recipient to spend resources to verify it; thus, while soft information can be gathered (by an investor willing to spend the required resources), it cannot be credibly disclosed without recipients engaging in such expenditure.

2.4 Disclosure Stage

We finally turn to the manager's disclosure decision at $t = 0$. He chooses σ to maximize his expected payoff, net of the stake sold to outside investors:

$$\begin{aligned}\max_{\sigma} \Pi(\sigma) &= (1 - \alpha(\sigma))(\omega \mathbb{E}(P) + (1 - \omega)\mathbb{E}[V]) \\ &= (1 - \alpha(\sigma))\mathbb{E}[V]. \end{aligned} \tag{6}$$

It is simple to show that, at $t = 2$, $\mathbb{E}(P) = \mathbb{E}(V)$ (a consequence of market efficiency) which leads to the final equality.

The manager takes into account two effects of σ. First, it increases financial efficiency and thus reduces α, because the investor's stake must be sufficient to compensate for his trading losses. Second, it affects λ and thus $V_H = R_H + K + \lambda g K$, as shown in Proposition 1, reducing real efficiency. Lemma 3 addresses the first effect.[15]

Lemma 3 *(Stake sold to investor): The stake α sold to the investor is given by*

$$\alpha(\sigma) = \frac{2K}{V_H + V_L} + \kappa, \tag{7}$$

where

$$\kappa = \frac{1}{2}\beta \frac{V_H - V_L}{V_H + V_L} E[\Lambda(P)]. \tag{8}$$

The partial derivative of κ is negative with respect to σ.

Lemma 3 shows that the stake α comprises two components. The "baseline" component $\frac{2K}{V_H+V_L}$ is the investor's contribution K as a fraction of expected firm value. The second term κ is the additional stake that he demands to compensate for his expected trading losses. An increase in σ reduces these losses and thus α. We will refer κ as the (excess) "cost of capital". It is increasing in the magnitude of the liquidity shock β, the difference in the value between H- and L-firms relative to the average value and, most importantly, the negative of financial efficiency $E[\Lambda(P)]$. In turn, financial efficiency is increasing in disclosure σ. Plugging (7) into (6) yields

$$\Pi(\sigma) = \left(\frac{V_H + V_L}{2} - K\right) - \beta \frac{V_H - V_L}{4}\left(\frac{1}{2}(1 - \sigma) + \frac{\lambda^2}{1 + \lambda^2}\sigma\right), \tag{9}$$

[15] The stake demanded by the investor depends on his conjecture for the manager's investment decision, $\widehat{\lambda}$. In equilibrium, $\widehat{\lambda} = \lambda$, and so λ appears in Lemma 3.

where the first term is expected firm value and the second term represents the investor's expected trading losses.

We now solve for the manager's choice of disclosure policy. There are two cases to consider. The first is $X \geq 1$. Since $\sigma \in [0,1]$, $\sigma \leq X$. From Proposition 1, we have $\lambda^* = 1 \ \forall \ \sigma$. Since there is no trade-off between disclosure and investment, the manager chooses maximum disclosure, $\sigma^* = 1$. Thus, financial and real efficiency can be simultaneously maximized. This result is stated in Proposition 2.

Proposition 2 *(Financial and real efficiency): If $X \geq 1$, the model has a unique equilibrium, in which the disclosure policy is $\sigma^* = 1$ and the investment level is $\lambda^* = 1$.*

The condition $X \geq 1$ is equivalent to

$$\frac{\Omega}{2}\frac{\Delta + gK}{gK} \leq 1. \tag{10}$$

The manager invests efficiently even with full disclosure when g and K are high, and ω and Δ are low. The intuition is the same as in the discussion of Proposition 1.

The second case is $X < 1$. In this case, we solve for the manager's choice of disclosure policy in two steps. First, we solve for the optimal disclosure policy in the set $[0, X]$ (i.e., if the manager implements full investment), and then in $[X, 1]$ (i.e., if the manager implements partial investment).[16] Second, we solve for the optimal disclosure policy overall, which involves comparing the manager's payoffs under the best outcome in $[0, X]$ with full investment, to the best outcome in $[X, 1]$ with partial investment.

We first analyze optimal disclosure in $[0, X]$. From Proposition 1, full investment $\lambda^*(\sigma) = 1$ arises for all $\sigma \in [0, X]$. Thus, the manager chooses the highest σ that supports full investment, which is X. This result is stated in Lemma 4 below:

Lemma 4 *(Disclosure under real efficiency): In an equilibrium where $\sigma \in [0, X]$ and $X < 1$, the disclosure policy is $\sigma^* = X$ and the investment level is $\lambda^* = 1$.*

We next turn to optimal disclosure in $[X, 1]$, in which case $\lambda = r(\sigma)$. From $\Psi(\lambda, \sigma) = 0$, the disclosure policy σ that implements a given λ is:

$$\sigma = \frac{gK\left(1 + \lambda^2\right)}{\lambda\Omega\left(\Delta + \lambda gK\right)}. \tag{11}$$

The equilibrium is given in Lemma 5 below.

[16] Since $r(\sigma)$ is continuous at $\sigma = X$ ($r(X) = 1$), X lies in both sets. This implies that both sets are compact and thus an optimal disclosure policy exists in each.

Lemma 5 *(Financial efficiency or real efficiency): When $\sigma \in [X, 1]$, the equilibrium is either $(\lambda^* = r(1),\ \sigma^* = 1)$, in which case financial efficiency is maximized, or $(\lambda^* = 1,\ \sigma^* = X)$, in which case real efficiency is maximized.*

The equilibrium either involves full investment or full disclosure. The intuition is as follows. From (9), the benefits of investment are linear in λ, but the cost is convex, because disclosure is convex in investment as shown by (11) (which in turn arises because $r(\sigma)$ is strictly decreasing and strictly convex, from Proposition 1). Raising investment requires disclosure to fall, but at a decreasing rate. Intuitively, when disclosure is already low, further decreases in disclosure have a large relative effect, and so an increase in investment only requires a small decrease in disclosure. The convexity is likely common to all functional forms: since investment is bounded below by zero, an increase in disclosure must reduce investment at a declining rate. Hence, if it is optimal for the manager to increase disclosure from X to $X + \xi$, it is optimal to increase it all the way to 1. Thus, he chooses either full investment or full disclosure.

We now move to the second step. Having found the optimal disclosure policy in $[0, X]$ and in $[X, 1]$, we now solve for the optimal policy overall, by comparing the manager's payoff across these two sets ($\Pi(r(1), 1)$ versus $\Pi(1, X)$). In doing so, we formally prove existence of an equilibrium in the model and characterize it. The equilibrium is given by Proposition 3 below:

Proposition 3 *(Trade-off between financial efficiency and real efficiency): If $X < 1$, the equilibrium is given as follows:*

(i) *If $\beta > \widetilde{\beta}$, the manager chooses full disclosure ($\sigma^* = 1$) and partial investment ($\lambda^* = r(1) < 1$). Financial efficiency is maximized but real efficiency is not.*

(ii) *If $\beta < \widetilde{\beta}$, the manager chooses partial disclosure ($\sigma^* = X$) and full investment ($\lambda^* = 1$). Real efficiency is maximized but financial efficiency is not.*

(iii) *If $\beta = \widetilde{\beta}$, both ($\lambda^* = r(1)$, $\sigma^* = 1$) and ($\lambda^* = 1$, $\sigma^* = X$) are equilibria.*

The threshold $\tilde{\beta}$ is given by

$$\widetilde{\beta} = \frac{1 - r(1)}{\frac{1}{4}\frac{\Delta + gK}{gK} - \frac{1}{2}\frac{r(1)}{\Omega}} > 0. \tag{12}$$

It increases in g and K, decreases in Δ, and is U-shaped in ω.

When $X < 1$, the manager chooses between financial and real efficiency. He chooses the former if and only if the liquidity shock β is sufficiently large (above a threshold $\widetilde{\beta}$), as then cost of capital considerations dominate the trade-off.[17]

The intuition behind the comparative statics for the threshold $\widetilde{\beta}$ arises because changes in parameters have up to three effects. First, as investment opportunities gK rise and the value difference Δ falls, (4) shows that the maximum disclosure X that implements full investment is higher. Full investment becomes more attractive to the manager, as it can be sustained with a lower cost of capital. Second, the same changes also increase the partial investment level $r(1)$ implemented by full disclosure. Full disclosure also becomes more attractive as it leads to less underinvestment. These two effects work in opposite directions. This ambiguity is resolved through a third effect: a rise in gK, and a fall in Δ, make investment more important relative to the cost of capital. Thus, they raise the cutoff $\widetilde{\beta}$, making it more likely that full investment is chosen.

In contrast, ω affects neither the value of the growth opportunity nor the cost of capital. Thus, the third effect is absent, and so the impact of ω on $\widetilde{\beta}$ is non-monotonic. The manager prefers the full investment equilibrium either when ω is very low (since full investment can be sustained with high disclosure) or when ω is very high (since full disclosure leads to substantial underinvestment).

We now combine the comparative static analyses of cases of $X < 1$ and $X \geq 1$ to the global comparative statics for disclosure and investment. These are given in Proposition 4.

Proposition 4 *(Global comparative statics):*

(i) *Investment λ^* is weakly increasing in the profitability of investment g. Disclosure σ^* is first weakly decreasing and then weakly increasing in g.*

(ii) *Investment λ^* is weakly increasing in the amount of capital raised K. Disclosure σ^* is first weakly decreasing and then weakly increasing in K.*

(iii) *Investment λ^* is weakly decreasing in the difference in firm values Δ. Disclosure σ^* is first weakly increasing and then weakly decreasing in Δ.*

(iv) *Investment λ^* is weakly decreasing in the size of the liquidity shock β. Disclosure σ^* is weakly increasing in β.*

[17] Importantly, the partial investment level $r(1)$ is independent of $\widetilde{\beta}$, which is why we use β as the cut-off parameter.

(v) *Investment λ^* is weakly decreasing in the manager's short-term concerns ω. Disclosure σ^* is non-monotonic in ω.*

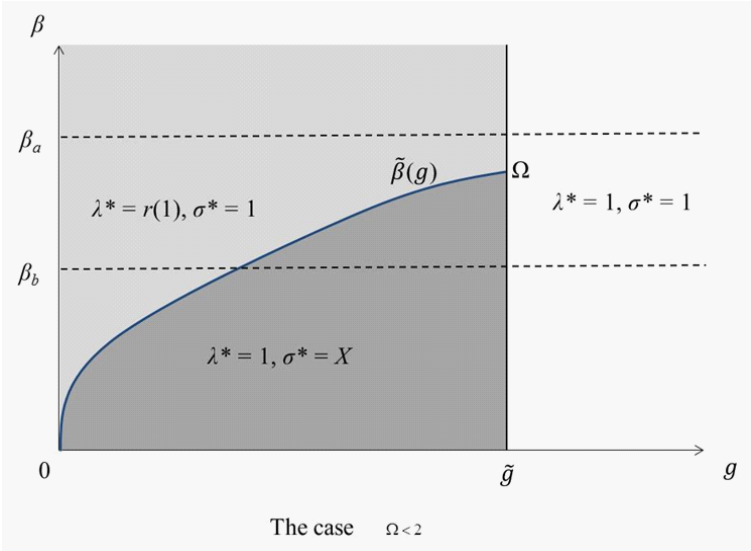

Figure 2: Global comparative statics for g

More precise details on the comparative statics are given in the proof of Proposition 4. Figure 2 illustrates the comparative statics for g when $\Omega < 2$. In this case, there exists $\widetilde{g}$ such that, if $g \geq \widetilde{g}$, then $X \geq 1$ and so we have $(\lambda^* = 1, \sigma^* = 1)$: both financial and real efficiency are maximized. For $g < \widetilde{g}$ we have two cases. If $\beta > \Omega$ (e.g., at β_a in Figure 2), the manager chooses partial investment for all $g < \widetilde{g}$. If $\beta < \Omega$ (e.g., at β_b), he chooses partial investment only when g is low. Within the partial investment regime, increases in g raise the partial investment level, but do not affect disclosure which remains fixed at 1. When g crosses above the solid curve, investment becomes sufficiently attractive that we move to full investment. Investment rises discontinuously to 1 and disclosure drops discontinuously from 1 to X. Further increases in g *increase* disclosure, because investment is sufficiently attractive that the manager invests fully even with high disclosure. The case of $\Omega \geq 2$ (so that $X < 1 \ \forall \ g$) is similar except that we never reach the $(\lambda^* = 1, \sigma^* = 1)$ equilibrium.

Overall, investment is weakly increasing in g. As investment becomes more attractive, the manager increases it (within the full disclosure regime), and after a point switches to full investment. The effect of g on disclosure is more surprising. Increases in g make investment more important, and so the manager reduces disclosure to implement full investment. However, within the full investment regime, increases in g raise

disclosure. When $\lambda = 1$, the manager is already investing all the capital available. Thus, further increases in g do not raise investment, but instead allow the manager to implement full investment with more disclosure.

The intuition for K (Δ) is the same (opposite), because g, K, and Δ appear together as the ratio $\frac{\Delta+gK}{gK}$ in both X and $\tilde{\beta}$. The manager trades off the benefits of investment gK with the incentive to be revealed as an H-firm, Δ. The intuition for β is straightforward: when β crosses above $\widetilde{\beta}$, the manager moves from full investment to full disclosure: intuitively, when the liquidity shock is large, the cost of capital becomes more important relative to investment. We defer the discussion of the global comparative statics for ω to the proof.[18]

In sum, Proposition 4 yields empirical predictions for how investment, disclosure, and the cost of capital vary across firms. Starting with investment, it is increasing in growth opportunities g and decreasing in the manager's short-term concerns ω, in common with other myopia models. More unique to our framework is how investment depends on asset pricing variables, in addition to the above corporate finance variables. When liquidity shocks β are larger, the cost of capital is more important relative to investment, and the manager increases disclosure, which reduces investment. Information asymmetry Δ reduces investment through two channels. Holding disclosure constant, higher information asymmetry increases the manager's incentives to be revealed as type H by delivering high earnings. In addition, it makes the cost of capital relatively more important and induces the manager to increase disclosure, in turn reducing investment.

Turning to disclosure, the empirical predictions are generally non-monotonic. Starting with growth opportunities g, one might expect that, since disclosure is a trade-off between financial and real efficiency, better growth opportunities mean that investment dominates the trade-off, and so disclosure is lower. Instead, firms with intermediate growth opportunities disclose the least. Firms with weak growth opportunities have disclose fully, because financial efficiency dominates the trade-off. Firms with strong growth opportunities disclose fully for a different reason – the manager invests efficiently even with high disclosure. For similar reasons, we should see greatest disclosure for firms with very high and very low uncertainty Δ. It may seem that, when uncertainty Δ rises, the manager should disclose more to offset the greater uncertainty.

[18] If the amount of capital raised K were a choice variable, the firm would wish to raise as much capital as possible since investment opportunities are gK. In reality, there is a limit to the amount of capital that a firm can raise while continuing to invest all of it in positive-NPV projects; if so, the model is unchanged with K set to this optimal level. If we instead assume that raising more funds increases the liquidity shock β suffered by investors since it reduces their financial slack, there is sometimes an interior solution for K but the results (available upon request) remain unchanged.

However, this effect only manifests when uncertainty becomes so high that the cost of capital becomes more important than investment and so the manager switches from full investment to full disclosure. If it remains optimal to implement full investment, despite the increase in uncertainty, the manager must *reduce* disclosure to do so. The effects of K and ω are similarly non-monotonic. The non-monotonic effects of firm characteristics on disclosure contrast prior theories. For example, Gao and Liang (2013) predict that higher growth opportunities monotonically reduce disclosure. Thus, in addition to relatively clear (monotonic) empirical *predictions* on the determinants of investment, our model provides empirical *guidance* on the determinants of disclosure, potentially explaining why empiricists may not find unambiguous relationships in the data and cautioning against standard linear regressions.

Note that not all disclosure models actually generate empirical predictions regarding disclosure. For example, in Boot and Thakor (2001), Easley and O'Hara (2004), and Lambert, Leuz, and Verrecchia (2007), disclosure has only benefits and not costs, and so they do not solve for the optimal policy (and thus generate empirical predictions regarding disclosure) as it would be infinite. The strand of literature that Verrecchia's (2001) survey dubs "association-based disclosure" studies the effect of disclosure on investors' trading behavior and prices (as in this paper), but does not solve for the optimal disclosure policy – its empirical predictions are on the effects, rather than determinants, of disclosure.

Other disclosure models (e.g. Verrecchia (1983), Diamond (1985), and Dye (1986)) do feature costs of disclosure (and thus can generate empirical predictions), justified by several motivations. First, the actual act of communicating information may be costly. While such costs were likely significant at the time of writing, when information had to be mailed to shareholders, nowadays these costs are likely much smaller due to electronic communication. Second, there may be costs of producing information. However, firms already produce copious information for internal or tax purposes. Third, the information may be proprietary (i.e., business sensitive) and disclosing it will benefit competitors (e.g., Verrecchia (1983) and Dye (1986)). However, while likely important for some types of disclosure (e.g., the stage of a patent application), proprietary considerations are unlikely to be for others (e.g., earnings). Perhaps motivated by the view that, nowadays, the costs of disclosure are small relative to the benefits, recent government policies have increased disclosure requirements, such as Sarbanes-Oxley, Regulation FD, and Dodd-Frank. Our model does not require a direct cost of disclosure to generate an optimal disclosure policy and thus empirical predictions:

even if the actual act of disclosure is costless (e.g. due to electronic communication), a high-disclosure policy can still be costly because of its effect on real investment.

Finally, we discuss empirical predictions for the determinants of the cost of capital. Since the manager chooses disclosure endogenously in response to underlying parameters, changes in these parameters affect the cost of capital not only directly, but also indirectly through changing disclosure, and so their overall effect on the cost of capital is ambiguous. For example, larger liquidity shocks directly increase the cost of capital (equation (8)). However, the manager may disclose more in response (equation (12)) and so the overall effect is ambiguous. Similarly, greater information asymmetry about assets in place Δ reduces investment; this in turn lowers information asymmetry about fundamental value V and thus the cost of capital. On the other hand, higher Δ requires a manager to disclose less if he wishes to continue to implement full investment, again rendering the overall effect on the cost of capital ambiguous. In contrast, the model of Diamond and Verrecchia (1991) predicts that the cost of capital is monotonically increasing in information asymmetry and monotonically decreasing in the magnitude of liquidity shocks. Our model suggests that, in reality, these effects will be ambiguous and so (as with disclosure) an empiricist should not expect a clear relationship. More broadly, the model emphasizes that disclosure, investment, and the cost of capital are all simultaneously determined by underlying parameters, rather than affecting each other.

3 Voluntary Disclosure

This section considers the case of voluntary disclosure, where the manager cannot commit to a disclosure policy and thus a level of financial efficiency. We focus on the interesting case where $X < 1$, so that there is a trade-off between financial and real efficiency. We model voluntary disclosure as follows. At $t = 0$, the manager announces a disclosure policy but cannot commit to it. Before making his final disclosure choice at $t = 2$, the manager first observes "true" earnings $\tau \in \{G, B\}$, such as the report from an internal audit process. In other words, he knows whether true earnings are high or low before deciding how precisely to disclose them.[19]

This knowledge may cause him to renege on the disclosure policy that he announced at $t = 0$. There are a number of channels that a manager can influence to change the

[19] Our model thus generalizes the standard way of modeling voluntary disclosure, which restricts σ to 0 or 1 (the manager chooses to disclose or not).

precision of information transmitted to outsiders. For example, Loughran and McDonald (2014) suggest that the length of a 10-K report is associated with informativeness; the accounting literature frequently uses the Fog index of Gunning (1952) to measures readability by the complexity of words and sentence length; and Li and Yermack (2014) show that managers hold shareholder meetings in remote locations to reduce their accessibility to investors.

If true earnings are good, the manager will renege and disclose earnings with full precision ($\sigma = 1$) so that $y = G$ for sure. If true earnings are bad, the manager will renege and minimize precision ($\sigma = 0$) so that $y = M$ for sure, since $\widetilde{P}(M) \geq P(B)$. Since a manager who has observed $\tau = G$ never discloses an "uninformative" report, $y = M$ is now fully informative that $\tau = B$ and thus tantamount to disclosing $y = B$. Indeed, Li and Yermack (2014) find that a shareholder meeting in a remote location (which reduces information transmission) signals negative future performance. The manager cannot claim that an uninformative report is the result of his pre-announced low-precision disclosure policy, because the market knows that he would have reneged on the policy if the signal were good. No news is bad news – the "unraveling" result of Grossman (1981) and Milgrom (1981).

Since the public signal is now effectively either G or B, the manager knows that effectively $\sigma = 1$. He will thus choose $\lambda^* = r(1)$ irrespective of the preannounced policy, and so the voluntary disclosure model is equivalent to the mandatory disclosure model with $\sigma = 1$. Even if $\Pi(1, X) > \Pi(r(1), 1)$, and so the manager would like to commit to low disclosure, he is unable to do so. This result is stated in Proposition 5.

Proposition 5 *(Voluntary Disclosure): Consider the case in which the manager observes true earnings τ before deciding his disclosure policy. The unique Perfect Bayesian Equilibrium involves $\lambda^* = r(1)$ and $\sigma^* = 1$: full financial efficiency and real inefficiency.*

Proposition 5 implies a potential role for government intervention. Assume now that the government is able to mandate disclosure precision σ. To be effective, such a regulation must prevent precision not only falling below σ, but also exceeding σ. For example, the government could limit the types of information that can be reported in official (e.g., SEC) filings, which investors may view as more truthful than information disseminated through (say) company press releases. Allowing scope for earnings management has a similar effect as investors attach less weight to a voluntary disclosure of high earnings. Alternatively, the government could audit disclosures with sufficient

intensity that the manager chooses not to disclose the maximum information possible: even if disclosure is always truthful, so there is no risk of a fine, responding to an audit is costly. It could also ban disclosure at certain times, similar in spirit to the "quiet period" that precedes an initial public offering.

If the government mandates precision σ, the manager will choose $\lambda^* = \lambda(\sigma)$. Therefore, if its goal is to maximize firm value to existing shareholders (i.e., the manager's payoff), it will choose a disclosure policy $\sigma = X$, thus implementing the $(\lambda^* = 1, \sigma = X)$ equilibrium. The government implements less disclosure than the manager would choose himself, since he cannot commit to $\sigma < 1$. This conclusion contrasts some existing models (e.g., Foster (1979), Dye (1990), Admati and Pfleiderer (2000), Lambert, Leuz, and Verrecchia (2007)) which advocate that regulators should set a floor for disclosure, because firms have insufficient incentives to release information. If caps on disclosure are difficult to implement, a milder implication of our model is that regulations to increase financial efficiency by raising disclosure (such as Sarbanes-Oxley) may have real costs.

However, government regulation may not maximize firm value. First, the value-maximizing policy varies from firm to firm. Even if all managers wish to implement full investment, the disclosure policy $\sigma = X \equiv \frac{2}{\Omega}\frac{gK}{\Delta+gK}$ depends on firm characteristics. An economy-wide policy of σ will induce suboptimally low disclosure in a firm for which $X > \sigma$, since $\sigma = X$ is sufficient to implement full investment. In contrast, if $X < \sigma$, a policy of σ will be too lax and the manager will invest only $r(\sigma) < 1$. Moreover, some managers will not wish to maximize real efficiency if $\Pi(1, X) < \Pi(r(1), 1)$ for their firm. Thus, a regulation aimed at inducing full investment will reduce firm value.

Second, the government's goal may not be to maximize firm value, but total surplus. In this case, it ignores the benefits of disclosure, since the investor's trading losses are a pure transfer to the speculator, and will choose $\sigma = X$ to implement $\lambda^* = 1$. Such a policy will be suboptimal for the manager if $\Pi(1, X) < \Pi(r(1), 1)$.

Third, the government may have distributional considerations and aim to maximize financial efficiency, to minimize trading profits and losses. One example is the SEC's focus on "leveling the playing field" between investors. Under this objective function, it will minimize the investor's trading losses[20] and ignore investment, which is achieved with $\sigma = 1$. Such disclosure is excessive and reduces firm value if $\Pi(1, X) > \Pi(r(1), 1)$.

These results are stated in Proposition 6 below.

[20] Note that minimizing the investor's trading losses is not the same as maximizing his objective function. The investor breaks even in all scenarios, since the initial stake that he requires takes into account his trading losses.

Proposition 6 *(Regulation): If the government wishes to maximize firm value, it will set a policy of* $\sigma = X$ *if* $\Pi(1, X) > \Pi(r(1), 1)$ *and* $\sigma = 0$ *otherwise. If the government wishes to maximize total surplus, it will choose* $\sigma = X$*, which will implement* $\lambda^* = 1$*. If the government wishes to minimize the investor's trading losses, it will choose* $\sigma = 1$*, which will implement* $\lambda^* = r(1)$*.*

4 Conclusion

Conventional wisdom is that financial efficiency increases real efficiency, by providing the manager with greater information or reflecting his actions in the stock price. We consider a standard myopia model that captures the second channel, and show that, surprisingly, financial efficiency can reduce real efficiency.

Central to our model is the notion that perfect financial efficiency cannot be achieved, because some information (such as long-run firm value) is soft and thus cannot be disclosed, in contrast to hard information such as earnings. It may seem that this observation is moot: firms should simply try to achieve the highest feasible level of financial efficiency. We reach a different conclusion. Actions to increase the amount of hard information in prices, such as disclosure, raise the total amount of information in prices and thus financial efficiency. However, they also distort the relative amount of hard versus soft information, and thus encourage the manager to take decisions – such as cutting investment – that improve hard information at the expense of soft. Thus, real efficiency is non-monotonic in financial efficiency – the manager invests efficiently if fundamental value could, hypothetically, be fully disclosed (in which case financial efficiency is maximized) or if neither earnings nor fundamental value are disclosed (in which case financial efficiency is minimized).

The optimal disclosure policy is a trade-off between its benefits (reduced cost of capital) and costs (reduced investment). Thus, if the manager can commit to a disclosure policy, it may seem that disclosure should be decreasing in investment opportunities, but we show that it is non-monotonic. If the manager cannot commit to a disclosure policy, then even if a "high-investment, low-disclosure" policy is optimal, he may be unable to implement it as he will opportunistically increase disclosure precision if he knows that the signal is likely to be good. Thus, there may be a role for regulation to reduce disclosure.

More broadly, our model suggests that real efficiency is not necessarily increasing in financial efficiency, and so measures of financial efficiency do not fully capture the

efficacy of the financial sector or its contribution to the real economy. Relatedly, policymakers should pursue blanket policies to increase financial efficiency, nor evaluate policy proposals based on their expected effect on financial efficiency. While our paper specifically models disclosure as the tool to affect financial efficiency, its insights also apply to other channels that increase the amount of short-term information in prices. Examples include reducing short-sales constraints, transactions taxes, and limits on high-frequency trading. Many practitioners argue for reductions in these restrictions to increase financial efficiency, but if the trades thus encouraged are likely to be based on information about earnings, the increase in financial efficiency may actually harm real efficiency. Similarly, while we have modeled the specific agency problem of managerial myopia, our theory illustrates a more general point – as long as some information is soft, the information in prices cannot fully reflect the manager's actions and so attempts to increase this information (and thus financial efficiency) can reduce real efficiency. Put differently, information can increase financial efficiency even if it is only partially informative about fundamental value. Thus, increasing this information may cause the manager to forsake the dimensions of fundamental value that it does not reflect, potentially reducing real efficiency.

In addition to the literature on financial and real efficiency, the model has implications for the disclosure literature. This literature studies the disclosure of hard information, because only it can be credibly disclosed. One may think that the existence of soft information does not change its conclusions: the disclosure of soft information is moot and so firms should simply apply the insights of disclosure theories to hard information. This paper reaches a different conclusion – the existence of soft information reduces the optimal disclosure of hard information. As a result, even though the actual act of disclosure is costless, a high-disclosure policy may be costly.

References

[1] Admati, Anat R. and Paul Pfleiderer (2000): "Forcing Firms to Talk: Financial Disclosure Regulation and Externalities." *Review of Financial Studies* 13, 479–519.

[2] Almazan, Andres, Sanjay Banerji and Adolfo de Motta (2008): "Attracting Attention: Cheap Managerial Talk and Costly Market Monitoring." *Journal of Finance* 63, 1399–1436.

[3] Bai, Jennie, Thomas Philippon, and Alexi Savov (2016): "Have Financial Markets Become More Informative?" *Journal of Financial Economics*, forthcoming.

[4] Balakrishnan, Kartik, Mary Brooke Billings, Bryan Kelly, and Alexander Ljungqvist (2014): "Shaping Liquidity: On the Causal Effects of Voluntary Disclosure." *Journal of Finance* 69, 2237–2278.

[5] Basu, Sudipta (1997): "The Conservatism Principle and the Asymmetric Timeliness of Earnings." *Journal of Accounting and Economics* 24, 3–37.

[6] Beaver, William H., Wayne R. Landsman, and Edward L. Owens (2012): "Asymmetry in Earnings Timeliness and Persistence: A Simultaneous Equations Approach." *Review of Accounting Studies* 17, 781–806.

[7] Beyer, Anne, Daniel A. Cohen, Thomas Z. Lys, and Beverly R. Walther (2010): "The Financial Reporting Environment: Review of the Recent Literature." *Journal of Accounting and Economics* 50, 296–343.

[8] Bernanke, Ben and Mark Gertler (1989): "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review* 79, 14–31.

[9] Bhojraj, Sanjeev, Paul Hribar, Marc Picconi, and John McInnis (2009): "Making Sense of Cents: An Examination of Firms That Marginally Miss or Beat Analyst Forecasts." *Journal of Finance* 64, 2361–2388.

[10] Bond, Philip, Alex Edmans, and Itay Goldstein (2012): "The Real Effects of Financial Markets." *Annual Review of Financial Economics* 4, 339–60.

[11] Bond, Philip and Itay Goldstein (2016): "Government Intervention and Information Aggregation by Prices." *Journal of Finance*, forthcoming.

[12] Boot, Arnoud W. A. and Anjan V. Thakor (1997): "Financial System Architecture." *Review of Financial Studies* 10, 693–733.

[13] Boot, Arnoud W. A. and Anjan V. Thakor (2001): "The Many Faces of Information Disclosure." *Review of Financial Studies* 14, 1021–1057.

[14] Brandenburger, Adam and Ben Polak (1996): "When Managers Cover Their Posteriors: Making the Decisions the Market Wants to See." *RAND Journal of Economics* 27, 523–541.

[15] Bushee, Brian J. (1998): "The Influence of Institutional Investors on Myopic R&D Investment Behavior." *The Accounting Review* 73, 305–333.

[16] Cheng, Mei, K. R. Subrahmanyam, and Yuan Zhang (2007): "Earnings Guidance and Managerial Myopia." Working Paper, University of Arizona.

[17] Cohen, Lauren, Karl Diether, and Christopher Malloy (2013): "Misvaluing Innovation." *Review of Financial Studies* 26, 635–666.

[18] Diamond, Douglas W. (1985): "Optimal Release of Information By Firms." *Journal of Finance* 40, 1071–1094.

[19] Diamond, Douglas W. and Robert E. Verrecchia (1991): "Disclosure, Liquidity, and the Cost of Capital." *Journal of Finance* 46, 1325–1359.

[20] Dow, James and Gary Gorton (1997): "Stock Market Efficiency and Economic Efficiency: Is There A Connection?" *Journal of Finance* 52, 1087–1129.

[21] Dye, Ronald A. (1986): "Proprietary and Nonproprietary Disclosures." *Journal of Business* 59, 331–366.

[22] Dye, Ronald A. (1990): "Mandatory versus Voluntary Disclosures: The Cases of Financial and Real Externalities." *The Accounting Review* 65, 1–24.

[23] Dye, Ronald A. (2001): "An Evaluation of "Essays on Disclosure" and the Disclosure Literature in Accounting." *Journal of Accounting and Economics* 32, 181–235.

[24] Easley, David and Maureen O'Hara (2004). "Information and the Cost of Capital." *Journal of Finance* 59, 1553–1583.

[25] Edmans, Alex (2009): "Blockholder Trading, Market Efficiency, and Managerial Myopia." *Journal of Finance* 64, 2481–2513.

[26] Ernstberger, Jurgen, Benedikt Link, Michael Stich, and Oliver Vogler (2015): "The Real Effects of Mandatory Quarterly Reporting." Working Paper, Ruhr-University Bochum.

[27] Fama, Eugene F. (1976): *Foundations of Finance*. Basic Books, New York.

[28] Ferreira, Daniel, Gustavo Manso and André C. Silva (2014): "Incentives to Innovate and the Decision to Go Public or Private." *Review of Financial Studies* 27, 256–300.

[29] Fishman, Michael J. and Kathleen Hagerty (1989): "Disclosure Decisions by Firms and the Competition for Price Efficiency." *Journal of Finance* 44, 633–646.

[30] Fishman, Michael J. and Kathleen Hagerty (1990): "The Optimal Amount of Discretion to Allow in Disclosure." *Quarterly Journal of Economics* 105, 427–444.

[31] Foster, George (1979): "Externalities and Financial Reporting." *Journal of Finance* 35, 521–533.

[32] Gao, Pingyang and Pierre J. Liang (2013): "Informational Feedback Effect, Adverse Selection, and the Optimal Disclosure Policy." *Journal of Accounting Research* 51, 1133–1158.

[33] Gigler, Frank, Chandra Kanodia, Haresh Sapra, and Raghu Venugopalan (2014): "How Frequent Financial Reporting Causes Managerial Short-Termism: An Analysis of the Costs and Benefits of Reporting Frequency." *Journal of Accounting Research* 52, 357–387.

[34] Goldstein, Itay and Haresh Sapra (2014): "Should Banks' Stress Test Results Be Disclosed? An Analysis of the Costs and Benefits." *Foundations and Trends in Finance* 8, 1–54.

[35] Goldstein, Itay and Liyan Yang (2014): "Market Efficiency and Real Efficiency: The Connect and Disconnect Via Feedback Effects." Working Paper, University of Pennsylvania.

[36] Graham, John R., Campbell R. Harvey, and Shiva Rajgopal (2005): "The Economic Implications of Corporate Financial Reporting." *Journal of Accounting and Economics* 40, 3–73.

[37] Grossman, Sanford J. (1981): "The Role of Warranties and Private Disclosure About Product Quality." *Journal of Law and Economics* 24, 461–483.

[38] Gunning, Robert (1952): "The Technique of Clear Writing." McGraw-Hill, New York.

[39] Hayn, Carla (1995): "The Information Content of Losses." *Journal of Accounting and Economics* 20, 125–153.

[40] Hermalin, Benjamin E. and Michael S. Weisbach (2012): "Information Disclosure and Corporate Governance." *Journal of Finance* 67, 195–233.

[41] Hirshleifer, Jack (1971): "The Private and Social Value of Information and the Reward to Inventive Activity." *American Economic Review* 61, 561–574.

[42] Holmstrom, Bengt and Paul Milgrom (1991): "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design" *Journal of Law, Economics, and Organization* 7, 24–52.

[43] Holmstrom, Bengt and Joan Ricart I Costa (1986): "Managerial Incentives and Capital Management." *Quarterly Journal of Economics* 101, 835–860.

[44] Holmstrom, Bengt and Jean Tirole (1993): "Market Liquidity and Performance Monitoring." *Journal of Political Economy* 101, 678–709.

[45] Jenter, Dirk and Katharina A. Lewellen (2015): "Performance-Induced CEO Turnover." Working Paper, London School of Economics.

[46] Kiyotaki, Nobuhiro and John Moore (1997): "Credit Cycles." *Journal of Political Economy* 105, 211–248.

[47] Kraft, Arthur G., Rahul Vashishtha and Mohan Venkatachalam (2015): "Real Effects of Frequent Financial Reporting." Working Paper, City University.

[48] Kyle, Albert S. (1985): "Continuous Auction and Insider Trading." *Econometrica* 53, 1315–1335.

[49] Kyle, Albert S. and Jean-Luc Vila (1991): "Noise Trading and Takeovers." *Rand Journal of Economics* 22, 54–71.

[50] Lambert, Richard, Christian Leuz, and Robert E. Verrecchia (2007): "Accounting Information, Disclosure, and the Cost of Capital." *Journal of Accounting Research* 45, 385–420.

[51] Li, Yuanzhi and David Yermack (2014): "Evasive Shareholder Meetings." Working Paper, Temple University.

[52] Loughran, Tim and Bill McDonald (2014): "Measuring Readability in Financial Disclosures." *Journal of Finance* 69, 1643–1671.

[53] Maug, Ernst (1998): "Large Shareholders as Monitors: Is There a Trade-Off Between Liquidity and Control?" *Journal of Finance* 53, 65–98.

[54] Milgrom, Paul (1981): "Good News and Bad News: Representation Theorems and Applications." *Bell Journal of Economics* 12, 380–391.

[55] Morck, Randall, Andrei Shleifer, and Robert W. Vishny (1990): "The Stock Market and Investment: Is the Market a Sideshow?" *Brookings Papers on Economic Activity* 2, 157–215.

[56] Narayanan, M. P. (1985): "Managerial Incentives for Short-term Results." *Journal of Finance* 40, 1469–1484.

[57] Paul, Jonathan (1992): "On the Efficiency of Stock-Based Compensation." *Review of Financial Studies* 5, 471–502.

[58] Roychowdhury, Sugata (2006): "Earnings Management Through Real Activities Manipulation." *Journal of Accounting and Economics* 42, 335–370

[59] Scharfstein, David and Jeremy Stein (1990): "Herd Behavior and Investment." *American Economic Review* 80, 465–479.

[60] Stein, Jeremy C. (1988): "Takeover Threats and Managerial Myopia." *Journal of Political Economy* 46, 61–80.

[61] Stein, Jeremy C. (1989): "Efficient Capital Markets, Inefficient Firms: A Model of Myopic Corporate Behavior." *Quarterly Journal of Economics* 104, 655–669.

[62] Stocken, Phillip C. and Robert E. Verrecchia (2004): "Financial Reporting System Choice and Disclosure Management." *The Accounting Review* 79, 1181–1203.

[63] Strobl, Günter (2013): "Earnings Manipulation and the Cost of Capital." *Journal of Accounting Research* 51, 449–479.

[64] Subrahmanyam, Avanidhar and Sheridan Titman (1999): "The Going-Public Decision and the Development of Financial Markets." *Journal of Finance* 54, 1045–1082.

[65] Thakor, Anjan V. (2014): "Strategic Information Disclosure When There Is Fundamental Disagreement." *Journal of Financial Intermediation*, forthcoming.

[66] Verrecchia, Robert E. (1983): "Discretionary Disclosure." *Journal of Accounting and Economics* 5, 365–380.

[67] Verrecchia, Robert E. (2001): "Essays on Disclosure." *Journal of Accounting and Economics* 32, 97–180.

A Proofs

Proof of Proposition 1

The manager chooses λ to maximize his expected payoff

$$\max_{\lambda} U_m\left(\lambda, \widehat{\lambda}\right) = (1-\alpha)\left(\omega \mathbb{E}\left(P|\theta = H\right) + (1-\omega)V_H\right), \tag{13}$$

where the expected price of an H-firm is

$$\mathbb{E}\left(P|\theta = H\right) = \sigma\left(1-\lambda^2\right)P\left(G|\theta = H\right) + \sigma\lambda^2\tilde{P}\left(B|\theta = H\right) + (1-\sigma)\tilde{P}\left(M|\theta = H\right) \tag{14}$$

and $\widetilde{P}\left(y|\theta = H\right)$ denotes the expected stock price of an H-firm for which signal y has been disclosed, where the expectation is taken over order flow. We have

$$\begin{aligned}
P\left(G|\theta = H\right) &= \widehat{V_H}, \\
\tilde{P}\left(B|\theta = H\right) &= \widehat{V_H} - \frac{1}{1+\hat{\lambda}^2}\frac{\widehat{V_H} - V_L}{2}, \text{ and} \\
\tilde{P}\left(M|\theta = H\right) &= \widehat{V_H} - \frac{1}{2}\frac{\widehat{V_H} - V_L}{2},
\end{aligned}$$

where we suppress the tilde on $P\left(G|\theta = H\right)$ as the price is independent of order flow.

Substituting into (14) yields:

$$\mathbb{E}\left(P|\theta = H\right) = \widehat{V_H} - \left(\frac{1}{2}(1-\sigma) + \frac{\lambda^2}{1+\hat{\lambda}^2}\sigma\right)\frac{\widehat{V_H} - V_L}{2}.$$

The manager's first-order condition is given by

$$\frac{\partial U_m\left(\lambda, \widehat{\lambda}\right)}{\partial \lambda} = (1-\alpha)\left(-\omega\frac{\lambda}{1+\widehat{\lambda}^2}\sigma\frac{\widehat{V_H} - V_L}{2} + (1-\omega)gK\right) = 0. \tag{15}$$

Since $\frac{\partial^2 U_m\left(\lambda,\widehat{\lambda}\right)}{\partial \lambda^2} < 0$, the manager's objective function is strictly concave and so equation (15) is sufficient for a maximum. Plugging $\lambda = \widehat{\lambda}$ into (15) yields the quadratic $\Psi\left(\lambda, \sigma\right) = 0$, where $\Psi\left(\lambda, \sigma\right)$ is defined in (5).

Fix any $\sigma \in [0, 1]$. The quadratic $\Psi(\lambda, \sigma)$ has real roots if and only if the discrimi-

nant is non-negative, i.e.,

$$z(\sigma) \equiv \left(\frac{\Delta\sigma}{gK}\right)^2 - 4\left(\frac{1}{\Omega} - \sigma\right)\frac{1}{\Omega} \geq 0. \tag{16}$$

The quadratic $z(\sigma)$ is a strictly convex function of σ with two roots. Since $z(0) < 0$, it has one positive root which is given by

$$Z \equiv \left(\frac{gK}{\Delta}\right)^2 \left(\frac{2}{\Omega}\sqrt{1 + \frac{\Delta^2}{(gK)^2}} - \frac{2}{\Omega}\right).$$

Since $\sigma \in [0,1]$, for (16) to hold, σ must be weakly larger than the positive root Z. Thus, $\sigma \geq Z$ is necessary and sufficient for Ψ to have real roots.

Since $\Psi(0,\sigma) = \frac{1}{\Omega} > 0$ and $\Psi'(0,\sigma) < 0$, Ψ may have up to two positive roots. One root, r, is such that $\Psi'(r,\sigma) < 0$. The second root, r', is such that $\Psi'(r',\sigma) \geq 0$. This second root, r', lies in $[0,1]$ if and only if $\Psi'(1,\sigma) \geq 0$, i.e.,:

$$\sigma \leq \frac{2gK}{\Omega(2gK + \Delta)}. \tag{17}$$

However, further algebra shows that

$$X > Z > \frac{2gK}{\Omega(2gK + \Delta)}. \tag{18}$$

Thus, if roots exist ($\sigma \geq Z$), (17) is violated and so the second root r' cannot lie in $[0,1]$. Therefore, the quadratic form of $\Psi(\lambda,\sigma)$ implies that there is at most one interior solution to the equation $\Psi(\lambda,\sigma) = 0$ for any $\sigma \in [0,1]$.

First, consider $\sigma \leq X$. Then $\Psi(1,\sigma) \geq 0$ by definition of X. Suppose there is $r' \in (0,1)$ such that $\Psi(r',\sigma) = 0$. The quadratic form of $\Psi(\lambda,\sigma)$ and $\Psi(0,\sigma) > 0$ implies that $\Psi'(1,\sigma) > 0$, which contradicts equation (18). Therefore, when $\sigma \leq X$, $\Psi(\lambda,\sigma) \geq 0$ (with equality only when $\lambda = 1$ and $\sigma = X$). Thus, the manager always wants to increase investment, and the unique equilibrium investment level is $\lambda^* = 1$.

Second, consider $\sigma > X$, in which case $\Psi(1,\sigma) < 0$. Then, when the market maker conjectures $\widehat{\lambda} = 1$, the manager has an incentive to deviate to a lower λ, and so $\lambda = 1$ cannot be an equilibrium. Since $\Psi(0,\sigma) > 0$ and $\Psi(\lambda,\sigma)$ is continuous in λ, $\Psi(\lambda,\sigma) = 0$ has a solution $r \in [0,1]$. As argued previously, we must have $\Psi'(r,\sigma) < 0$.

We now prove that $r(\sigma)$ is strictly decreasing and strictly concave. Recall that

$$\Psi(\lambda, \sigma) = \left(\frac{1}{\Omega} - \sigma\right)\lambda^2 - \sigma\frac{\Delta}{gK}\lambda + \frac{1}{\Omega},$$

and so we can calculate

$$\begin{aligned}
\left.\frac{\partial \Psi}{\partial \lambda}\right|_r &= 2\left(\frac{1}{\Omega} - \sigma\right) r - \sigma\frac{\Delta}{gK} < 0 \\
\left.\frac{\partial \Psi}{\partial \sigma}\right|_r &= -\left(r^2 + \frac{\Delta}{gK} r\right) < 0.
\end{aligned}$$

Thus, the Implicit Function Theorem yields

$$\frac{dr}{d\sigma} = -\frac{\partial \Psi / \partial \sigma}{\partial \Psi / \partial \lambda} < 0,$$

i.e., $r(\sigma)$ is strictly decreasing. To prove strict convexity, note that

$$\frac{\partial^2 r}{\partial \sigma^2} = \frac{1}{(\partial \Psi / \partial \lambda)^2}\left\{-\left[\frac{\partial^2 \Psi}{\partial \sigma \partial \lambda}\frac{\partial \lambda}{\partial \sigma} + \frac{\partial^2 \Psi}{\partial \sigma^2}\right]\frac{\partial \Psi}{\partial \lambda} + \frac{\partial \Psi}{\partial \sigma}\left[\frac{\partial^2 \Psi}{\partial \lambda^2}\frac{\partial \lambda}{\partial \sigma} + \frac{\partial^2 \Psi}{\partial \lambda \partial \sigma}\right]\right\}.$$

Since $\partial^2 \Psi / \partial \sigma^2 = 0$, plugging in $\frac{dr}{d\sigma} = -\frac{\partial \Psi / \partial \sigma}{\partial \Psi / \partial \lambda}$ yields

$$\begin{aligned}
&\frac{d^2 r}{d\sigma^2} > 0 \\
&\Leftrightarrow \frac{\partial^2 \Psi}{\partial \lambda^2}\left(\frac{\partial \Psi / \partial \sigma}{\partial \Psi / \partial \lambda}\right) - 2\frac{\partial^2 \Psi}{\partial \lambda \partial \sigma} > 0 \\
&\Leftrightarrow \left(\frac{1}{\Omega} - \sigma\right)\frac{-\left(r^2 + \frac{\Delta}{gK} r\right)}{2\left(\frac{1}{\Omega} - \sigma\right) r - \sigma\frac{\Delta}{gK}} + \left(2r + \frac{\Delta}{gK}\right) > 0.
\end{aligned}$$

There are two cases to consider. First, if $\frac{1}{\Omega} - \sigma \geq 0$, the above inequality automatically

holds. Second, if $\frac{1}{\Omega} - \sigma < 0$, we have

$$\begin{aligned}
&\left(\frac{1}{\Omega} - \sigma\right) \frac{-\left(r^2 + \frac{\Delta}{gK} r\right)}{2\left(\frac{1}{\Omega} - \sigma\right) r - \sigma \frac{\Delta}{gK}} + \left(2r + \frac{\Delta}{gK}\right) > 0 \\
&\Leftrightarrow -\left(\frac{1}{\Omega} - \sigma\right)\left(r^2 + \frac{\Delta}{gK} r\right) + \left[2\left(\frac{1}{\Omega} - \sigma\right) r - \sigma \frac{\Delta}{gK}\right]\left(2r + \frac{\Delta}{gK}\right) < 0 \\
&\Leftrightarrow 3\left(\frac{1}{\Omega} - \sigma\right) r^2 + \left(\frac{1}{\Omega} - \sigma\right) \frac{\Delta}{gK} r - 2\sigma \frac{\Delta}{gK} r - \sigma \left(\frac{\Delta}{gK}\right)^2 < 0.
\end{aligned}$$

The last equation holds because all terms on the left-hand side are negative. Therefore, $r(\sigma)$ is strictly convex.

Now assume $X < 1$, and fix $\sigma > X$. We wish to show that $r(\sigma)$ is increasing in g and K, and decreasing in ω and Δ. Since $\sigma > X$ implies $\Psi'(r, \sigma) < 0$, the Implicit Function Theorem gives us that the signs of partial derivatives $\partial r / \partial g$, $\partial r / \partial K$, $\partial r / \partial \omega$, and $\partial r / \partial \Delta$ are the same as those of $\partial \Psi / \partial g$, $\partial \Psi / \partial K$, $\partial \Psi / \partial \omega$, and $\partial \Psi / \partial \Delta$, respectively. By taking partial derivatives of Ψ (evaluated at $r(\sigma)$), we have

$$\begin{aligned}
\frac{\partial \Psi}{\partial g} &= \sigma \frac{\Delta}{g^2 K} r > 0, \\
\frac{\partial \Psi}{\partial K} &= \sigma \frac{\Delta}{g K^2} r > 0, \\
\frac{\partial \Psi}{\partial \omega} &= -\frac{r^2 + 1}{\omega^2} < 0.
\end{aligned}$$

Therefore,

$$\frac{\partial r}{\partial g} > 0, \ \frac{\partial r}{\partial K} > 0, \text{ and } \frac{\partial r}{\partial \omega} < 0.$$

Finally, analyzing equation (4) easily shows that X is increasing in g and K, and decreasing in ω and Δ.

Proof of Lemma 3

The investor contributes K and his expected return is $\alpha\left(\frac{V_H + V_L}{2}\right)$. In addition, w.p. $\frac{1}{2}$,she suffers a liquidity shock and is forced to sell β shares. The expected value of these shares is $\frac{1}{2}\beta\frac{V_H + V_L}{2}$ and the expected price that he receives is

$$\beta\left(\frac{1}{2}\left(\sigma\left(1 - \lambda^2\right) V_H + \sigma\lambda^2 \frac{\lambda^2 V_H + V_L}{1 + \lambda^2} + (1 - \sigma)\frac{1}{2}\left(V_H + V_L\right)\right) + \frac{1}{2} V_L\right).$$

Since the investor must break even, we have

$$\begin{aligned}K &= \frac{1}{2}\alpha\frac{V_H+V_L}{2}+\frac{1}{2}(\alpha-\beta)\frac{V_H+V_L}{2}\\ &+\frac{1}{2}\beta\left(\frac{1}{2}\left(\sigma\left(1-\lambda^2\right)V_H+\sigma\lambda^2\frac{\lambda^2V_H+V_L}{1+\lambda^2}+(1-\sigma)\frac{1}{2}(V_H+V_L)\right)+\frac{1}{2}V_L\right)\\ &=\alpha\frac{V_H+V_L}{2}-\frac{1}{4}\beta(V_H-V_L)\left(\frac{1}{2}(1-\sigma)+\frac{\lambda^2}{1+\lambda^2}\sigma\right)\end{aligned}$$

Solving for α and substituting $E[\Lambda(P)]$ proves the lemma.

Proof of Lemma 4

Using (11) to substitute for σ in the objective function (9) yields the manager's payoff as a function of investment alone:

$$\Pi(\lambda)=D+E\lambda+\frac{F}{\lambda}, \tag{19}$$

where

$$D\equiv R_H-\left(1+\frac{1}{4}\beta\right)\frac{\Delta}{2} \tag{20}$$

$$E\equiv Kg\left(1-\frac{1}{2}\left(1+\frac{1}{4}\beta\right)-\frac{\beta}{8\Omega}\right),\text{ and} \tag{21}$$

$$F\equiv\frac{\beta gK}{8\Omega}. \tag{22}$$

Since $\Pi(\lambda)$ is globally convex (due to the convexity of $\frac{F}{\lambda}$), the solution to $\Pi'(\lambda)=0$ is a minimum. $\Pi(\lambda)$ is maximized at a boundary: we have either $\lambda^*=r(X)=1$ or $\lambda^*=r(1)$.

Since $\lambda^*(\sigma)=1$ for all $\sigma\in[0,X]$, the manager's payoff becomes

$$\Pi(\sigma)=\frac{R_H+K+gK+V_L}{2}-\beta\frac{\Delta+gK}{8}-K,$$

which is independent of σ. Since the manager chooses the highest σ when he is indifferent, he selects $\sigma=X$.[21]

[21] This indifference arises because, when $\lambda=1$, both H and L always deliver $y=B$ regardless of disclosure policy σ and so this signal is uninformative. In a previous version of the paper, $\Pr(y=B|\theta=H)=\sigma\rho\lambda^2$ and $\Pr(y=G|\theta=H)=\sigma\left(1-\rho\lambda^2\right)$ where $\rho\in(0,1)$. Since $y=B$ is always informative, the manager strictly prefers higher disclosure $\sigma=X$. This version sets $\rho=1$ throughout to reduce the number of parameters in the model.

Proof of Proposition 3

When choosing the disclosure policy, the manager compares the payoffs from $\sigma = 1$ (in which case $\lambda = r(1)$) and $\sigma = X$ (in which case $\lambda = 1$). Thus, the equilibrium is $(\lambda^* = r(1), \sigma^* = 1)$ if $\Pi(r(1), 1) > \Pi(1, X)$, and $(\lambda^* = 1, \sigma^* = X)$ otherwise.

The manager chooses $(\lambda^* = 1, \sigma^* = X)$ if $\Pi(1, X) - \Pi(r, 1) > 0$, i.e.,

$$(1 - r) E + F - \frac{F}{r} > 0,$$

where we write r rather than $r(1)$ to save notation. Here, r can be solved from $\Psi(r, 1) = 0$, and $\Psi'(r, 1) < 0$. Since Ψ is not a function of β, the above inequality yields

$$1 - r > \beta \left[\frac{1}{4} \frac{\Delta + gK}{gK} - \frac{1}{2} \frac{r}{\Omega} \right].$$

The term in brackets on the right-hand side is

$$\begin{aligned} & \frac{1}{4} \frac{\Delta + gK}{gK} - \frac{1}{2} \frac{r}{\Omega} \\ > & \frac{1}{4} \frac{\Delta + gK}{gK} - r \frac{1}{4} \frac{\Delta + gK}{gK} \\ = & \frac{1}{4} \frac{\Delta + gK}{gK} [1 - r] > 0. \end{aligned}$$

The first inequality is due to the condition $X < 1$. As a result,

$$\widetilde{\beta} = \frac{1 - r}{\frac{1}{4} \frac{\Delta + gK}{gK} - \frac{1}{2} \frac{r}{\Omega}} > 0.$$

Since the denominator of $\widetilde{\beta}$ is strictly greater than $\frac{1-\omega}{\omega} \frac{1}{X} (1 - r)$, we have $\widetilde{\beta} < \frac{\omega}{1-\omega} X$. Thus, the manager strictly prefers $(\lambda^* = 1, \sigma^* = X)$ if and only if $\beta < \widetilde{\beta}$.

When $X < 1$, to derive the comparative statics of $\tilde{\beta}$, we first define

$$\chi(\beta) = (1 - r) - \beta \left\{ \frac{1}{4} \frac{\Delta + gK}{gK} - \frac{1}{2} \frac{r}{\Omega} \right\}.$$

It is clear that $\chi\left(\widetilde{\beta}\right) = 0$ and $\chi'\left(\widetilde{\beta}\right) < 0$. Thus, the signs of $\partial\widetilde{\beta}/\partial g$, $\partial\widetilde{\beta}/\partial K$, and $\partial\widetilde{\beta}/\partial\omega$ are the same as $\partial\chi/\partial g$, $\partial\chi/\partial K$, and $\partial\chi/\partial\omega$ (evaluated at $\widetilde{\beta}$).

First, we show that $\partial\chi/\partial g > 0$, so $\partial\widetilde{\beta}/\partial g > 0$.

$$\partial\chi/\partial g = \left(\widetilde{\beta}\frac{1}{\Omega} - 1\right)\frac{\partial r}{\partial g} + \frac{1}{4}\widetilde{\beta}\frac{\Delta}{g^2 K} > 0$$
$$\Leftrightarrow (r-1)^2 > 0.$$

The last inequality is automatic, because $r < 1$ when $X < 1$. The analysis for $\partial\chi/\partial K$ is very similar since g and K appear together as gK.

Finally, we show that $\partial\chi/\partial\omega$ depends on ω, so the sign of $\partial\widetilde{\beta}/\partial\omega$ depends on ω.

$$\partial\chi/\partial\omega = \left(\widetilde{\beta}\frac{1}{2}\frac{1-\omega}{\omega} - 1\right)\frac{\partial r}{\partial\omega} - \widetilde{\beta}\frac{1}{2}\frac{1}{\omega^2}r.$$

When ω is small, so that X is close to 1, we have $\widetilde{\beta}\frac{1-\omega}{\omega} - 1 \to 0$ and $r \to 1$. Thus, $\partial\chi/\partial\omega < 0$. When $\omega \to 1$, $r \to 0$ (from equation (5)). Then,

$$\partial\chi/\partial\omega > 0 \Leftrightarrow -\frac{\partial r}{\partial\omega} > 0,$$

the last inequality is true from Proposition 1.

Proof of Proposition 4

We first provide more precise details on the global comparative statics of Proposition 4.

(i) Comparative statics for g:

- ***(i-a)*** If $\beta > \lim_{g\to\infty}\tilde{\beta}$, $\sigma^* = 1$ and $\lambda^* = r(1)$, which increases as g increases.
- ***(i-b)*** If $0 < \beta < \Omega$ and $\frac{2}{\Omega} > 1$, $\sigma^* = 1$ and $\lambda^* = r(1)$ for low levels of g. Once g rises above a threshold, σ^* falls discontinuously to X, and λ^* jumps discontinuously to 1. As g increases further, σ^* keeps increasing to 1 (for g such that $X \geq 1$), while $\lambda^* = 1$.
- ***(i-c)*** If $0 < \beta < \lim_{g\to\infty}\tilde{\beta}$ and $\frac{2}{\Omega} \leq 1$, $\sigma^* = 1$ and $\lambda^* = r(1)$ for low levels of g. Once g rises above a threshold, σ^* falls discontinuously to X, and λ^* jumps discontinuously to 1. As g increases further, σ^* keeps increasing but remains below 1, while $\lambda^* = 1$.

(ii) Comparative statics for K:

(ii-a) If $\beta > \lim_{K\to\infty} \tilde{\beta}$, $\sigma^* = 1$ and $\lambda^* = r(1)$, which increases as K increases.

(ii-b) If $0 < \beta < \Omega$ and $\frac{2}{\Omega} > 1$, $\sigma^* = 1$ and $\lambda^* = r(1)$ for low levels of K. Once K rises above a threshold, σ^* falls discontinuously to X, and λ^* jumps discontinuously to 1. As K increases further, σ^* keeps increasing to 1 (for K such that $X \geq 1$), while $\lambda^* = 1$.

(ii-c) If $0 < \beta < \lim_{K\to\infty} \tilde{\beta}$ and $\frac{2}{\Omega} \leq 1$, $\sigma^* = 1$ and $\lambda^* = r(1)$ for low levels of K. Once K rises above a threshold, σ^* falls discontinuously to X, and λ^* jumps discontinuously to 1. As K increases further, σ^* keeps increasing but remains below 1, while $\lambda^* = 1$.

(iii) Comparative statics for Δ:

(iii-a) If $\beta > \lim_{\Delta\to 0} \tilde{\beta}$, $\sigma^* = 1$ and $\lambda^* = r(1)$, which increases as Δ decreases.

(iii-b) If $0 < \beta < \Omega$ and $\frac{2}{\Omega} \leq 1$, $\sigma^* = 1$ and $\lambda^* = r(1)$ for high levels of Δ. Once Δ drops below a threshold, σ^* falls discontinuously to X, and λ^* jumps discontinuously to 1. As R decreases further, σ^* keeps increasing but remains below 1, while $\lambda^* = 1$.

(iii-c) If $0 < \beta < \lim_{\Delta\to 0} \tilde{\beta}$ and $\frac{2}{\Omega} > 1$, $\sigma^* = 1$ and $\lambda^* = r(1)$ for high levels of Δ. Once Δ drops below a threshold, σ^* falls discontinuously to X, and λ^* jumps discontinuously to 1. As Δ decreases further, σ^* keeps increasing to 1 (for Δ such that $X \geq 1$), while $\lambda^* = 1$.

(iv) When $\beta < \tilde{\beta}$, the equilibrium is ($\sigma^* = X$, $\lambda^* = 1$); when $\beta > \tilde{\beta}$, it is ($\sigma^* = 1$, $\lambda^* = r(1)$). Both X and $r(1)$ are independent of β, and so λ^* is weakly decreasing in β and σ^* is weakly increasing in β.

(v) Comparative statics for ω. Let $\underline{\beta}$ denote the minimum $\tilde{\beta}$ over all ω such that $X \leq 1$:

(v-a) If $\beta < \underline{\beta}$, then for low ω, the equilibrium is $(\lambda^* = 1, \sigma^* = 1)$; once ω rises above a threshold, the equilibrium is ($\lambda^* = 1$, $\sigma^* = X$). Disclosure falls continuously; further increases in ω lower σ^* but have no effect on λ^*.

(v-b) If $\beta > \max\left\{\tilde{\beta}(X = 1), \tilde{\beta}(X = 0)\right\}$, then for low ω, the equilibrium is $(\lambda^* = 1, \sigma^* = 1)$. Once ω rises above a threshold, the equilibrium is $(\lambda^* = r(1), \sigma^* = 1)$. Investment falls continuously; further increases in ω lower λ^*, but σ^* is unaffected.

(v-c) If $\tilde{\beta}(X=1) > \beta > \tilde{\beta}(X=0)$, then, in addition to the effects in part (b), once ω rises above a second threshold, the equilibrium switches to $(\lambda^* = 1,\ \sigma^* = X)$. Investment rises discontinuously and disclosure falls discontinuously; further increases in ω lower σ^* but have no effect on λ^*.

(v-d) If $\beta \in \left(\underline{\beta}, \min\{\tilde{\beta}(X=1), \tilde{\beta}(X=0)\}\right)$, then for low ω, the equilibrium is $(\lambda^* = 1, \sigma^* = 1)$. Once ω rises above a threshold, the equilibrium is $(\lambda^* = 1,\ \sigma^* = X)$. Disclosure falls continuously; further increases in ω lower σ^*, but λ^* is unaffected. Once ω rises above a second threshold, the equilibrium switches to $(\lambda^* = r(1), \sigma^* = 1)$. Disclosure rises discontinuously and investment falls discontinuously; further increases in ω lower λ^* but have no effect on σ^*. Once ω rises above a third threshold, the equilibrium switches to $(\lambda^* = 1,\ \sigma^* = X)$. Investment rises discontinuously and disclosure falls discontinuously; further increases in ω lower σ^* but have no effect on λ^*.

We now prove the proposition. We start with part (i), the global comparative statics with respect to g; the effect of Δ in part (iii) is exactly the opposite since Δ and g appear together in $\frac{\Delta+gK}{gK}$ in both X and $\tilde{\beta}$. From Proposition 3, $\widetilde{\beta}$ is strictly increasing in g for $X < 1$. For part (i-a), if $\beta > \lim_{g\to\infty} \tilde{\beta}$, $\beta > \tilde{\beta}$ for all g. Then by Proposition 3, $\sigma^* = 1$ for all g, and $\lambda^* = r(1)$, which is strictly increasing in g.

For Part (i-b), since $\tilde{\beta} = 0$ when $g = 0$, when g is small, $\beta > \tilde{\beta}$, and so the equilibrium is $(\lambda^* = r(1), \sigma^* = 1)$. As g increases, the equilibrium remains $(\lambda^* = r(1), \sigma^* = 1)$ but the investment level $r(1)$ is increasing. When g hits the point at which $\tilde{\beta} = \beta$, the equilibrium jumps to $(\lambda^* = 1, \sigma^* = X)$, so investment rises and disclosure falls. As g continues to increase, λ^* is constant at 1, while σ^* increases but remains strictly below 1: since $X < 1$, we can never have full disclosure alongside full investment.

Part (i-c) is similar to Part (i-b), except that $\frac{2}{\Omega} > 1$. In this case, there exists a threshold g' such that, when $g \geq g'$, (10) is satisfied and we have $X \geq 1$. Note that $X = 1 \Leftrightarrow \tilde{\beta} = \Omega$. If $\beta \geq \Omega$, then we always have $\beta > \tilde{\beta}$ and full disclosure. When $g < g'$, the equilibrium is $(\lambda^* = r(1), \sigma^* = 1)$. As g rises, $\lambda^* = r(1)$ rises. When g crosses above g', we now have full investment as well as full disclosure: the equilibrium becomes $(\lambda^* = 1, \sigma^* = 1)$. If $\beta \in (0, \Omega)$, then for low g, we have the partial investment equilibrium $(\lambda^* = r(1), \sigma^* = 1)$. As g rises, σ^* remains constant at 1 and the partial investment level $r(1)$ rises, until $\tilde{\beta}$ crosses above β and we move to the full partial disclosure equilibrium $(\lambda^* = 1, \sigma^* = X)$. Note this crossing point for g is below g', because $\beta < \Omega$. As g continues to increase, λ^* is constant at 1 and σ^* rises. When g crosses above g', we have $X \geq 1$ so σ^* rises to 1. Unlike in the $\frac{2}{\Omega} \leq 1$ case, we can have

full disclosure alongside full investment.

The proofs of Part (ii) and Part (iii) are exactly the same as that of Part (i).

For Part (iv), Proposition 1 shows that $r(1)$ and X are independent of β. Furthermore, Proposition 3 shows that the equilibrium is $(\lambda^* = 1,\ \sigma^* = X)$ for $\beta < \widetilde{\beta}$ and $(\lambda^* = r(1),\ \sigma^* = 1)$ for $\beta > \widetilde{\beta}$, and that either equilibrium is feasible for $\beta = \widetilde{\beta}$.

Finally, we prove part (v). When ω is sufficiently small that $X \geq 1$, the equilibrium is $(\lambda^* = 1, \sigma^* = 1)$. When ω is sufficiently large, $X < 1$. The remainder of this proof will focus on which equilibrium is chosen when $X < 1$. Proposition 3 shows that when ω is small so that X is close to 1 (while remaining below 1), $\tilde{\beta}$ is decreasing in ω. When ω is large, $\tilde{\beta}$ is increasing in ω. If $\underline{\beta}$ denotes the minimum $\tilde{\beta}$ over all ω such that $X \leq 1$, then $\underline{\beta} < \min\left\{\tilde{\beta}(X=1), \tilde{\beta}(X=0)\right\}$.

For part (v-a), when $\beta < \underline{\beta}$, then $\beta < \tilde{\beta}$. Thus, when $X < 1$, we always have the partial disclosure equilibrium of $(\lambda^* = 1, \sigma^* = X)$. For part (v-b), when $\beta > \max\left\{\tilde{\beta}(X=1), \tilde{\beta}(X=0)\right\}$, $\beta > \tilde{\beta}$. Thus, when $X < 1$, we always have the partial investment equilibrium of $(\lambda^* = r(1), \sigma^* = 1)$. For part (v-c), when $\beta > \min\left\{\tilde{\beta}(X=1), \tilde{\beta}(X=0)\right\}$, then when ω rises sufficiently for X to cross below 1, $\beta > \tilde{\beta}$ and so we have the partial investment equilibrium of $(\lambda^* = r(1), \sigma^* = 1)$. If we also have $\tilde{\beta}(X=1) > \beta > \tilde{\beta}(X=0)$, then once ω crosses a second threshold, then $\tilde{\beta}$ crosses below β and so we move to the partial disclosure equilibrium of $(\lambda^* = 1,\ \sigma^* = X)$. For part (v-d), when $\beta \in \left(\underline{\beta}, \min\{\tilde{\beta}(X=1), \tilde{\beta}(X=0)\}\right)$, then when ω rises sufficiently for X to cross below 1, then $\beta < \tilde{\beta}$ and so we have the partial disclosure equilibrium of $(\lambda^* = 1,\ \sigma^* = X)$. Since $\tilde{\beta}$ is decreasing in ω for low ω, When ω crosses a second threshold, then $\tilde{\beta}$ crosses below β and so we move to partial disclosure. Since $\tilde{\beta}$ is increasing in ω for high ω, when ω crosses a third threshold, then $\tilde{\beta}$ crosses back above β and so we move to partial investment.

We end by illustrating the global comparative statics for ω in Figure 3:

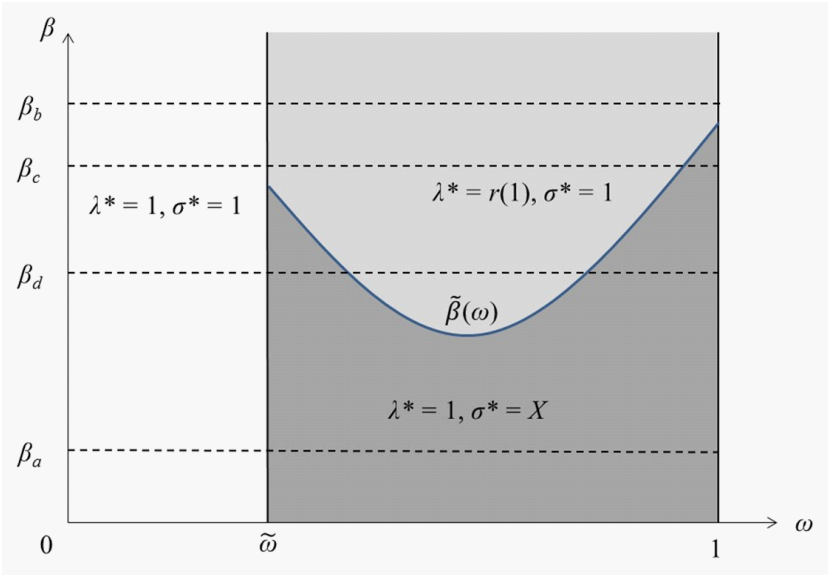

Figure 3: Global comparative statics for ω

The intuition is as follows. When ω is low, the manager invests efficiently even with full disclosure. When ω rises above a threshold $\widetilde{\omega}$, $(\lambda^* = 1,\ \sigma^* = 1)$ is no longer sustainable and there is a trade-off. When β is very low (e.g., at β_a in Figure 5), the manager always chooses partial disclosure, and additional increases in ω reduce the partial disclosure level further. When β is very high (e.g., at β_b), the manager always chooses partial investment, and additional increases in ω reduce the partial investment level further. For intermediate values of β (β_c and β_d), the manager switches from partial disclosure to partial investment when β falls below a threshold (the upward-sloping part of the solid curve). Moreover, if β is sufficiently low (e.g. at β_d), there is another threshold (the downward-sloping part of the solid curve) below which the manager switches back to partial investment. Considering all cases together, as with the other parameters, ω has a monotonic effect on investment, but a non-monotonic effect on disclosure.