Optimal Reporting Systems
with Investor Information Acquisition

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Abstract

This paper analyzes a manager’s optimal ex-ante reporting system using a Bayesian persuasion approach (Kamenica and Gentzkow (2011)) in a setting where investors affect cash flows through their decision to finance the firm’s investment opportunities, possibly assisted by the costly acquisition of additional information (inspection). I examine how the informativeness and the bias of the optimal system are determined by investors’ inspection cost, the degree of incentive alignment between the manager and the investor, and the prior belief that the project is profitable. I find that a mis-aligned manager’s system is informative only when the market prior is pessimistic and is always liberal (positively biased); this bias decreases as investors’ inspection cost decreases. In contrast, a well-aligned manager’s system is fully revealing when investors’ inspection cost is high, and is counter-cyclical to the market belief when the inspection cost is low: It is liberal (conservative) when the market belief is pessimistic (optimistic). Furthermore, I explore the extent to which the results generalize to a case with managerial manipulation and discuss the implications for investment efficiency. Overall, the analysis describes the complex interactions among determinants of firm disclosures and governance, and offers explanations for the mixed empirical results in this area.

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1 Introduction

This paper analyzes firms’ ex-ante optimal reporting strategies in a stylized setting in which reported information can affect investors’ subsequent decisions to acquire additional information and to approve (finance) firms’ future investments, which ultimately alters firms’ cash flows. The primary purpose is to understand the implications of three implicit assumptions commonly made in prior theoretical literature. The first assumption is that investors (shareholders) use the disclosed information either for stewardship purposes, i.e., to assess managers’ past performance and determine their compensation (e.g., Gigler and Hemmer (2001)), or for passive valuation purposes, i.e., to estimate the firm’s exogenously given cash flows (e.g., Dye (1985), Bertomeu et al. (2011)). In both cases, the investors’ decision after receiving the disclosure does not affect firms’ future investment decisions and cash flows. Second, investors rely solely on firm information for their decision-making without actively seeking additional private information. Third, managers’ disclosure strategy is executed ex post, contingent on the private information they receive exogenously. The managers’ disclosure strategy is to choose whether to disclose (e.g., Jung and Kwon (1988)) or whether to take real actions to signal their private information (e.g., Kanodia and Lee (1998), Beyer and Guttman (2012)).

I show that relaxing these assumptions can generate predictions that speak to a large body of empirical findings, and gain new insights on how several commonly discussed factors, such as managerial incentive misalignment and investors’ prior belief, jointly shape firms’ reporting behaviors. Specifically, I relax the first assumption to highlight that firm disclosures often contain forward-looking elements useful for investors to make decisions on firms’ future operations, and that such decisions affect managers’ future payoffs. Most disclosures fit this description, including both vol-

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1 Throughout the paper, I use reporting strategy and disclosure strategy interchangeably. Both refer to firms’ discretionary choices that affect the amount and nature of information released to investors. In the context of mandatory periodic reporting, managers are often permitted discretion in choosing accounting methods and estimates which can affect investors’ assessment of the profitability of firms’ future investments. In the context of voluntary disclosure, firms exercise significant discretion in whether to disclose certain information and how informative the disclosure is.

2 Dye and Sridhar (2002) and Gao and Liang (2013) explicitly consider investors’ information acquisitions, but investors do not directly affect firms’ investment decision in their models.

3 This decision-making view is broadly consistent with the perspective of standard setters as expressed in the Statement of Financial Accounting Concepts No. 1: “Financial accounting is not designed to measure directly the value of a business enterprise, but the information it provides may be helpful to those who wish to estimate its value” (FASB (1978)). While the conceptual framework does not specify how investors estimate firm values, in practice, investors often do so by relying on financial statements to evaluate the profitability of firms’ future investment plans and take corresponding actions.
untary disclosures of forward-looking information and mandatory reports of past performance that investors use to assess firms’ future profitability.\(^4\) I relax the second assumption to describe more realistically how investors collect information prior to decision-making. It also enables me to address the important and increasingly pertinent question of how firms’ reporting properties are affected by investors’ costs to acquire additional information, which have arguably been significantly reduced by the fast-growing computational and communication technology (see Magee (2001), Healy and Palepu (2001)).\(^5\) I relax the third assumption of ex-post disclosure (i.e., managers’ disclosure behavior is contingent on his exogenously endowed private information) by examining firms’ disclosure strategy from an ex-ante perspective. This perspective is suitable to study the disclosure of forward-looking information, for which information asymmetry between managers and investors is less likely. In addition, examining the ex-ante strategy also allows me to endogenize both the informativeness and the bias of disclosed information.\(^6\)

My model describes a firm with a potential investment project that requires a representative investor’s approval to proceed. The project’s payoff is uncertain and depends on the underlying state of the world. The state can be either good or bad, and the project has a positive net present value (NPV) only when the state is good. Neither the firm nor the investor observes the true state, and their uncertainty is captured by a common prior belief. In addition, the firm has an information system that maps each possible state (good or bad) into a binary signal (high or low) to be released to the investor. Importantly, after observing the firm’s reported signal, but prior to making her approval decision, the investor has the option to acquire additional information, at her own expense, that would reveal the true state.

I model the firm’s reporting strategy as the firm manager designing the mapping rule governing

\(^4\)In fact, when viewing firms as going concerns whose values largely depend on firms’ future decisions, a significant amount of disclosures are potentially useful for assessing firms’ future. Potentially useful does not necessarily mean observed disclosures actually move price or change investors’ prior. In fact, in my model, whether observed disclosure changes investors’ prior is the outcome of the endogenous choice by managers on how informative they want the disclosure to be.

\(^5\)The Financial Accounting Standards Board acknowledges this possibility in the Conceptual Framework for Financial Reporting: “If needed information is not provided, users incur additional costs to obtain that information elsewhere or to estimate it” (FASB (2010)). Magee (2001) called for more research on this issue: “... a common denominator in these questions (is) uncertainty about the role of accounting measurement when the economics of information delivery are changing rapidly.”

\(^6\)Prior literature has also studied ex-ante disclosure strategies (e.g., Diamond and Verrecchia (1991) and Gao and Liang (2013)). However, they restrict the information structure (e.g., to choosing the precision of an additive, normally-distributed noise term, or to choosing the probability of disclosure), and thus cannot endogenize both informativeness and bias.
how the reporting system maps the underlying state of the world into signals reported to the investor.\footnote{Viewing disclosure as a signal generated by a reporting system designed ex ante applies naturally to mandatory disclosures, where the existence of the signal, as well as its disclosure to investors, is dictated by the regulatory framework. One can also view firms’ voluntary disclosure as generated by a reporting system designed ex ante, where the system follows a set of pre-specified rules to decide whether and how to disclose certain information, as a function of exogenously given and possibly time-varying variables (such as the existing market condition and investors’ common prior). This view admits no disclosure as a special case where the ex-ante disclosure rule specifies the release of an uninformative signal when certain conditions are met.} The mapping rule determines the informational properties of the reported signal, including the likelihood of reporting good versus bad news (i.e., the bias in the disclosure), as well as the investor’s residual uncertainty about the project’s profitability upon receiving the disclosure (i.e., the informativeness of the disclosure). The manager decides the mapping rule ex ante, that is, prior to receiving any private information about the project’s profitability.\footnote{The investor can infer the mapping rule perfectly because she has all the information the manager has when designing the rule.} For my main analysis, I follow prior literature in assuming that the manager has to truthfully report the signal generated by the system, due to, for example, external auditor verification or legal penalties. I relax this assumption in the extended model of Section 4.

To capture the effect of managerial incentives, I assume the manager has partial ownership of the firm, and, if the project is approved, stands to receive a fraction of the project’s payoff as well as a private benefit that does not depend on the project’s success. To abstract from the stewardship use of reported information (e.g., Chen et al. (2007), Hemmer and Labro (2008)), I take the manager’s ownership share and private benefit as given, and separately analyze the strategies of two types of managers: a mis-aligned manager whose private benefit is so large that he always prefers to invest regardless of the underlying state, and a well-aligned manager who prefers to invest only when the underlying state is good.\footnote{I am agnostic about the extent to which firms successfully implement optimal contracts that completely neutralize the effect of private benefits. To the extent that managers’ incentive to over-invest is not a prevalent empirical phenomenon, my analysis regarding the reporting strategies of well-aligned managers apply.} Because the investor’s approval decision depends on the information available to her, the manager will choose the mapping rule to influence the investor’s information environment, and set the rule as a function of three determinants: his incentive alignment with the investor, the investor’s cost of acquiring additional information, as well as the common prior belief about the underlying state.

I apply the concavification technique developed by Kamenica and Gentzkow (2011) to solve the manager’s optimal reporting system. I find that the mis-aligned manager will choose an uninfor-
mative reporting system, or equivalently, no disclosure, when the investor’s prior is optimistic, and will choose an informative, but liberal system when the investor’s prior is pessimistic. Furthermore, the optimal system becomes more informative and less liberal when the investor’s inspection cost decreases.

The intuition for no disclosure when the investor’s prior is optimistic is as follows: Without additional information, the investor’s default action is to approve, which is the manager’s preferred action. Providing additional information can only lead the investor to choose an action less preferred by the manager. In contrast, when the investor’s prior is sufficiently pessimistic so that her default action is to disapprove the project, the mis-aligned manager has nothing to lose by providing informative disclosures to the investor. Specifically, the optimal system entails a liberal bias in that it is more likely to report good news than bad news.\(^{10}\) While this system reduces the investor’s posterior (that the true state is good) to zero upon receiving bad news disclosures, it also increases her posterior upon good news disclosures,\(^{11}\) which increases the likelihood of approval. In other words, an informative system gives the manager an “option” to benefit from disclosure when it changes the investor’s mind in his favor.\(^{12}\) Furthermore, when the investor can inspect, any positive posterior induced by the good news disclosure needs to be sufficiently informative to reduce the investor’s residual uncertainty, so that she would approve without inspection. Since the mis-aligned manager prefers over-investment, he would prefer outright approval (i.e., without inspection) over approval after inspection, because the latter eliminates over-investment. To improve the informativeness of good news disclosures, the system needs to reduce the likelihood of reporting a bad state as good news, i.e., it becomes less liberal and more informative.

For a well-aligned manager, the optimal system is fully revealing (the most informative) when the investor faces prohibitively high inspection cost, such that firm disclosures are effectively her sole source of information. This is because the well-aligned manager prefers the investor to make the right decision. Therefore, it is in his best interest to disclose all relevant information. However, when the investor’s inspection cost is low, the optimal reporting system is no longer fully revealing; instead, it becomes counter-cyclical: It is liberal when the investor’s prior is pessimistic and conservative.

\(^{10}\)I introduce the formal definition and measurement of liberal bias versus conservatism in Section 2.

\(^{11}\)This is because the information system must obey the law of iterated expectations.

\(^{12}\)While a conservative system also buys the manager this “option”, it is, compared to the liberal system, less likely to be “in the money” and is therefore not his optimal choice.
when the prior is optimistic. The intuition is that, unlike the mis-aligned manager who designs the system to discourage investor inspection, the well-aligned manager designs the system to motivate investor inspection, since inspection reveals the true state and ensures the right decision will be made. Investor inspection is particularly valuable when the opportunity cost of the investor’s default action (in the absence of inspection) is high. Thus, when the investor’s prior is high, the default action is to approve without inspection, which is costly when the true state is bad. A conservative system is more likely to provide “warnings” (in that it is more likely to report low signals), casting doubt on the default action, and therefore, motivating the investor to inspect. On the other hand, when the investor’s prior is low, the investor’s default action is to disapprove, which is costly when the true state is good. A liberal system is more likely to disclose a high signal, also casting doubt on the default action and inducing inspection.

The basic model assumes that the manager must truthfully disclose the signal generated by the system. This corresponds to the case where no information asymmetry exists between the manager and the investor at the time of the disclosure. In the extended model, I relax this assumption and allow the manager to alter the disclosure after privately observing the original signal generated by the system, albeit at a cost. This corresponds to the case where the manager has more, but incomplete information about the firm’s future profitability than an outside investor. I find that the qualitative results from the no-manipulation case carry through. In fact, the mis-aligned manager is strictly better off if he can credibly commit not to manipulate ex post. The reason is that the manager can replicate every distribution of post-manipulation posteriors under the no-manipulation case, and hence receives the same expected gross payoff, but without the cost of manipulation. As such, allowing manipulation does not change the well-aligned manager’s optimal system ex ante as he will never manipulate ex post. However, it may increase the informativeness of a mis-aligned manager’s ex-ante optimal system (compared to cases when manipulation is not possible). This is because investors are less responsive to reported signals if they suspect manipulation, forcing the manager to counteract the suspicion by increasing the informativeness of the system in the first place.\footnote{The informativeness and bias of the post-manipulation system remain unchanged.} In addition, I find that a larger scope of manipulation can actually improve investment efficiency in firms with mis-aligned managers and low investor inspection costs, because it makes investors more cautious and more likely to acquire additional information.

\footnote{The informativeness and bias of the post-manipulation system remain unchanged.}
Empirical implications

By relaxing critical implicit assumptions, my model generates predictions consistent with empirical findings unavailable from prior theoretical literature. At the same time, by incorporating several key determinants of disclosures identified in empirical literature (e.g., managerial incentive misalignment and investors’ prior), my model examines their effects on disclosure for all possible combinations of determinants. Combined, the analysis generates alternative interpretations for several empirical findings as well as new empirical implications. First, it shows that both mis-aligned and well-aligned managers would voluntarily disclose bad news, as part of the optimally designed information system. This prediction is not available from the large class of disclosure models that view disclosure as an ex-post choice by managers (e.g., Verrecchia (1983), Jung and Kwon (1988)). It suggests that bad news disclosures do not necessarily need to be situation- or event-driven (Skinner (1994)), and are not necessarily indicative of managerial incentive mis-alignment (Aboody and Kasznik (2000)) or alignment (Kumar et al. (2012)). Further, my model also predicts that good and bad news disclosures can have different degrees of informativeness, a prediction that is consistent with empirical findings (e.g., Kasznik and Lev (1995), Kothari et al. (2009)), but unavailable from models that view ex-ante disclosure strategy as choosing only the precision of an additive, normally-distributed noise term (e.g., Diamond and Verrecchia (1991)).

Second, while prior studies have considered the impact of investors’ private information on firms’ disclosure (Dye and Sridhar (2002), Gao and Liang (2013), Zuo (2013)), they are silent on how the effect depends on managerial incentives. My model shows that only well-aligned managers have incentives to design the reporting system in order to motivate investor’s information acquisition. Furthermore, the resulting system differs depending on investors’ information acquisition cost. Specifically, my analysis predicts that firms with well-aligned managers are more likely to offer informative disclosures when investors’ inspection cost is high, consistent with findings in Balakrishnan et al. (2014) and Chen and Vashishtha (2015) that firms increase disclosures after experiencing loss of analyst coverage or loss of bank monitoring, to the extent that these events make it more difficult for investors to obtain additional information.

My analysis also predicts that when investors’ information acquisition cost is low, well-aligned

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14 An exception is Armstrong et al. (2015), in which good and bad news are allowed to have different levels of precision.
manager’s reporting exhibits counter-cyclicality, consistent with empirical evidence that managers use discretions to smooth earnings (e.g., Liu and Ryan (2006)). Under this interpretation, my analysis offers an alternative explanation for the finding in Tucker and Zarowin (2006) that there is a positive association between earnings smoothness and the ability of stock price to predict future earnings. Tucker and Zarowin (2006) interpret this finding as consistent with managers smoothing earnings to improve earnings informativeness about firms’ future performance. My model suggests that well-aligned managers smooth earnings to reduce earnings’ informativeness, which motivates investors to acquire additional information. Nonetheless, since the acquired information affects firms’ investment decisions and thus future cash flows, and at the same time, is likely to be impounded in stock price, stock prices in firms with smoother earnings are expected to be more positively associated with future earnings.\footnote{This particular result is similar to Gao and Liang (2013), who find that a value-maximizing managers may reduce public disclosure to motivate information acquisition by traders. My model differs from theirs in two dimensions: First, investors in my model decide whether to acquire additional information after observing firm’s disclosure; second, I allow managers to use both informativeness and bias to induce investor information acquisition.}

More importantly, the finding that counter-cyclical reporting is chosen by well-aligned managers suggests caution in interpreting earnings smoothing as evidence of manipulation by mis-aligned managers (e.g., Leuz et al. (2003), Jayaraman (2008)). Specifically, my analysis identifies that an implicit assumption for such an interpretation is that investors are unable to acquire additional information, or unable to intervene in firms’ decisions, or both. When this assumption is violated,\footnote{It is an empirical question whether and to what extent reported earnings affect investors’ decisions and in turn affect firms’ future decisions and cash flows. Dechow et al. (2010) note that, outside the U.S., earnings smoothing is associated with low earnings quality and poor shareholder rights (Leuz et al. (2003)); within the U.S., earnings smoothing is associated with more informative stock prices (Tucker and Zarowin (2006)). My analysis reconciles these findings by tracing them to U.S. investors having lower information acquisition costs and U.S. managers’ incentives being better-aligned with those of shareholders.} earnings smoothness is actually indicative of better incentive alignment between managers and investors. More generally, my analysis shows that under certain conditions, (e.g., when investors’ inspection costs are low and the market prior is intermediate or low), mis-aligned managers issue more informative disclosures than well-aligned managers.

Third, my analysis also suggests an alternative explanation for the positive association between informational properties of disclosures and investment efficiency (e.g., Biddle et al. (2009), Francis and Martin (2010)). While some interpret such an association as consistent with certain reporting properties (such as conservatism) disciplining managers’ over-investment, my analysis shows that...
such a positive relation can also exist as a result of cross-sectional differences in investors’ inspection costs. Specifically, I show that investment efficiency tends to be high among firms whose investors’ inspection costs are low, and at the same time, mis-aligned managers reduce the liberal bias in their reporting (i.e., accounting appears more conservative) when investors’ inspection costs are low. While some researchers hypothesize that the relation between reporting properties and investment efficiency may not be causal (see Dechow et al. (2010), Roychowdhury (2010)), my analysis specifically identifies investor’s inspection cost as a correlated omitted variable.

Fourth, I analyze how investors’ cost of acquiring additional information affects the properties of firms’ disclosure. This issue is of concern to both standard setters and academic researchers, but has received little attention in analytical research so far. As a result, consensus is lacking on whether and how the properties of public disclosures are affected by the changing landscape for investor information acquisition. While some scholars deplore the diminishing relevance of financial accounting information due to competition with other information sources (Lev and Zarowin (1999)), others note that the informativeness of accounting information is not eroded by at least one form of competing information (Francis et al. (2002a)), or that accounting information has become more conservative (Givoly and Hayn (2000)). My analysis identifies managerial incentive alignment as a key determinant for the relation between disclosure properties and investor’s information acquisition cost. As investors’ information acquisition costs decrease, the observed disclosure will become more (less) informative if the observed disclosures are mostly driven by mis-aligned (well-aligned) managers. Furthermore, to the extent that mis-aligned managers exist in the sample, reported earnings will exhibit less liberal bias (that is, appear more conservative) over time.

Lastly, my analysis of the extended model that expressly allows ex-post manipulation by the manager provides additional insights. It demonstrates the value of commitment to ex-ante optimal disclosure strategies (e.g., Chen et al. (2015)), and further suggests that mis-aligned managers have stronger incentives to seek out costly external mechanisms (auditors, credit rating agency) to establish “reporting reputation” in that they benefit more from credibly committing not to engage in costly ex-post manipulation. At the same time, my analysis reveals that the equilibrium informativeness of disclosure is not changed, possibly explaining the difficulty in detecting the effect of auditor reputation on reporting quality (see Lawrence et al. (2011), DeFond et al. (2015), and DeFond and Zhang (2014) for a survey). In addition, my analysis adds to the literature that discovers
benefits of managerial manipulation in certain settings (e.g., Dutta and Gigler (2002), Jiang and Xin (2015)). I show that a larger scope of ex-post manipulation can actually improve investment efficiency in firms with mis-aligned managers and low investor inspection costs, because investors will be more cautious and more likely to acquire additional information.

In summary, my analysis highlights that both the nature of the disclosed information and investors’ response to it matter for understanding firms’ strategic disclosure behavior. A key condition for my results is that the disclosed information is forward-looking in nature and relevant to the firms’ investment opportunities, which affects investors’ assessment of firms’ prospects, and ultimately changes their decisions and alters firms’ future cash flows.

Related literature

This paper contributes to the literature on Bayesian persuasion (Kamenica and Gentzkow (2011), Gentzkow and Kamenica (2014), Michaeli (2014), Friedman et al. (2015)). Kamenica and Gentzkow (2011) provide a solution algorithm for a set of communication games in which the sender influences a rational Bayesian receiver’s information environment, with the goal of inducing the receiver to change her action. This resembles my setting in which a manager (the sender) designs a reporting system in order to induce the investor (the receiver) to take the action desired by the manager. While the sender can perfectly control the receiver’s information environment in Kamenica and Gentzkow (2011), my model allows the investor to acquire additional information. Furthermore, I relax the commitment assumption and show that the results generalize to a setting where the manager has private information and can manipulate the system ex post. This result also contributes to the literature on managerial manipulation (e.g., Arya et al. (1998), Laux (2014), Beyer et al. (2014)).

This paper extends the literature on public information disclosures and investor’s private information acquisition (e.g., Demski and Feltham (1994), Diamond (1985), McNichols and Trueman (1994), Kim and Verrecchia (1997), Gao and Liang (2013)) to a setting in which disclosures affect real investment efficiency. This paper also contributes to the literature on the interaction between firm investment and disclosure decisions, which highlights the real effects of accounting disclosures (Kanodia et al. (2004, 2005), Sapra (2002), Kumar et al. (2012), Beyer and Guttman (2012)). Beyer and Guttman (2012) study a setting in which a manager chooses jointly an investment, whether to disclose it and whether to raise capital. My paper differs in that I study the disclosure of forward-
looking information about the firm’s investment opportunities, and I model the manager’s disclosure strategy as designing a reporting system ex ante.

There is a large literature on the properties of the optimal reporting system in specific settings, such as debt contracting (e.g., Göx and Wagenhofer (2009), Gigler et al. (2009), Jiang (2012), Caskey and Hughes (2011)) and performance measurement (e.g., Gigler and Hemmer (2001), Chen et al. (2007)). For example, Göx and Wagenhofer (2009) study a setting in which the firm reports the value of collateral to a lender to obtain financing for a risky project, and the manager is subject to moral hazard. They find that optimal accounting reports impairments only when the asset value falls below a threshold level. Gigler et al. (2009) find that the optimal accounting system is conditionally liberal in a debt contracting setting, because the cost of falsely liquidating a good project is larger than the cost of wrongly continuing a bad project. Chen et al. (2007) find that the optimal accounting system is conservative when accounting serves both a valuation and a performance measurement role. My paper contributes to this stream of literature by analyzing a firm’s optimal reporting system when disclosures affect the investor’s information acquisition and intervention decisions.

The paper is organized as follows. Section 2 introduces the basic model without manipulation. Section 3 derives the optimal reporting systems for four cases: mis-aligned versus well-aligned managers, and high versus low investor inspection costs. Within each case, the common prior belief is allowed to vary. Section 4 studies the extended model with private information to the manager and possible ex-post manipulation. Section 5 concludes. Appendix 1 lists the definitions of variables, Appendix 2 presents the summary of results in tabular form, and Appendix 3 contains detailed proofs.

2 The basic model

The model spans five dates $t \in \{0, 1, 2, 3, 4\}$ and involves two risk-neutral players, the manager and the investor.
The firm and the manager

At $t = 0$, the firm is endowed with an investment opportunity that requires an initial fixed investment $I$ and needs the investor’s approval to proceed. The project produces a random cash flow, which is $R > 0$ if the project succeeds and $0$ if it fails. The project succeeds with probability $\theta_\omega$ and fails with probability $1 - \theta_\omega$, where $\omega \in \{g, b\}$ refers to the underlying state of the project (or firm), which can be either good ($g$) or bad ($b$). Both the manager and the investor hold the common prior that the firm is in the good state with probability $\mu_0 \in (0, 1)$. Without loss of generality, I assume the NPV of a firm in the good (bad) state is positive (negative):

$$N_g = \theta_g R - I > 0$$
$$N_b = \theta_b R - I < 0$$

The manager owns $s$ percent of the firm’s equity and the representative investor holds the remaining $1 - s$ percent. If the project is approved, the resulting cash flow is shared between the manager and the investor according to their equity shares, and the manager also receives a non-contractible, fixed private benefit $B$ from the project. The manager aims to maximize his expected payoff, including the private benefit. I assume the manager’s private benefit is too small to compensate for the total loss from investing in bad projects, i.e., $B + N_b < 0$.

Clearly, investing in a good project ($\omega = g$) benefits both the manager and the investor. However, investing in a bad project hurts the investor, but may benefit the manager if his private benefit $B$ is sufficiently large. Specifically, if $B + sN_b > 0$, the manager’s private benefit exceeds his share of the loss from the bad project, and his incentive is mis-aligned with the investor’s. If $B + sN_b < 0$, the manager’s private benefit does not compensate his share of the loss, and his incentive is well-aligned with the investor’s. I show that incentive-alignment is critical in shaping the firm’s reporting system, and discuss the mis-aligned and well-aligned manager’s cases separately.

Disclosure strategy as the design of a reporting system

The manager chooses a reporting system ex ante, i.e., before he learns any private information. More specifically, at $t = 1$, the manager determines the disclosure strategy by designing a reporting system which produces a high or low signal $\pi \in \{h, l\}$ about the firm’s true state $\omega \in \{g, b\}$ at
Figure 1 illustrates how the reporting system maps each underlying state into a signal. Given that the investor has two choices, approve or reject the project, the reporting system is, without loss of generality, limited to produce a binary signal. The properties of the reporting system, $\lambda_g$ and $\lambda_b$, become common knowledge after they have been determined by the manager. An important feature of this binary structure is that the manager chooses not only the informativeness, but also the bias of the reporting system. I define these two properties as follows:

**Definition 1. Neutrality and bias.** The reporting system is neutral if the probability of a good project generating a high signal is equal to the probability of a bad project generating a low signal, i.e., $\lambda_g = 1 - \lambda_b$. A liberal (positively biased) reporting system has a comparatively higher probability of a good project generating a high signal, relative to the probability of a bad project generating a low signal, i.e., $\lambda_g > 1 - \lambda_b$. A conservative (negatively biased) reporting system generates a high signal with a comparatively lower probability, i.e., $\lambda_g < 1 - \lambda_b$.

To compare the relative levels of bias between two reporting systems, I follow Gigler et al. (2009). A reporting system with $\pi(\lambda_g, \lambda_b)$ is more conservative (i.e., less liberal) than an alternative system $\pi'(\lambda'_g, \lambda'_b)$, if $\Pr(g|\pi = h) \geq \Pr(g|\pi' = h)$ and $\Pr(g|\pi = l) \geq \Pr(g|\pi' = l)$, with at least one inequality holding strictly. As conservatism increases, the reporting system requires a higher

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Pr(h|g) = \lambda_g \geq \lambda_b = Pr(h|b)
\]
threshold for recognizing good news relative to bad news. As such, it is less likely the system will produce a high signal $h$. To the investor, a high signal is therefore more convincing evidence of a good project, while a low signal becomes less indicative of a bad project, since more good projects are pooled to receive low signals.

**Definition 2. Informativeness.** The informativeness of a system is measured as the expected reduction in uncertainty relative to a fixed reference belief $\mu_r$. I use the entropy measure for uncertainty. If the investor’s belief that the state is good is $\mu$, the entropy is $H(\mu) = -\mu \ln \mu - (1 - \mu) \ln (1 - \mu)$. The informativeness of the system is measured as $L(\pi) = E_{(\pi|\mu_r)} (H(\mu_r) - H(\mu_\pi))$, where $\mu_\pi$ is the investor’s posterior belief upon receiving the disclosure. In the limit, the system is defined as uninformative if the prior remains unchanged after the disclosure.

In practice, a reporting system is costly, and more so when it is more informative (Sims (2006) and Gentzkow and Kamenica (2014)). To capture this observation, I model the cost of the reporting system as proportional to its informativeness:

$$c(\pi) = kL(\pi) = E_{(\pi|\mu_r)} (H(\mu_r) - H(\mu_\pi))$$

where $k$ is the cost for a one-unit reduction in entropy.$^{19}$

I derive the optimal reporting system for the general case with $k > 0$, and characterize its bias and informativeness. However, there is generally no closed-form solution to the $k > 0$ case; to keep tractability and to highlight the intuition, in the basic model, I assume that the per-unit cost of the system is positive but approaches zero ($k \to 0^+$). The optimal system is obtained by taking limit of the optimal system in the $k > 0$ case, and it is unique. The qualitative results in the $k \to 0^+$ case generalize to the case where $k > 0$.

**The investor**

The investor is Bayesian and interprets the firm’s disclosure rationally. After receiving the disclosure at $t = 3$, the investor derives her posterior belief that the firm is in the good state ($\mu$), and chooses whether to inspect, i.e., to collect additional information about the firm. If she chooses to inspect,

$^{19}$Following Gentzkow and Kamenica (2014), I measure uncertainty reduction against a fixed reference belief $\mu_r$, rather than the prior $\mu_0$, to ensure that the cost of reporting system does not vary with prior.
The manager chooses a reporting system. Disclosure is made by the reporting system. The investor first decides whether to inspect, and then whether to invest. Payoffs are realized.

Figure 2 summarizes the sequence of events in the model.

The project proceeds only if the investor approves, in which case the manager obtains the private benefit $B$. Since my main focus is to examine how investors’ information acquisition affects firms’ disclosures, I model investors as a single representative investor, and abstract from the approval process itself. In practice, the approval can be explicit, for example, in the form of shareholder voting on major strategic initiatives such as acquisitions. It can also be implicit in the form of investors pricing firms’ securities, or providing capital to firms seeking external financing. The key feature in these approval mechanisms is that disclosures affect investors’ decisions, and in turn, affect managers. In my model, investors have the option to acquire costly, private information, in addition to firms’ disclosures, and their information acquisition is not contractible. To avoid trivializing the problem, I also assume that the manager cannot internalize the investor’s inspection cost, which creates a friction insofar as the manager may free-ride on the investor’s information acquisition.

3 Optimal reporting systems

In this section, I derive the optimal reporting system using backward induction. Specifically, I first derive the investor’s optimal response to the disclosure at $t = 2$. I then analyze the manager’s problem at $t = 1$, when his anticipation of the (subsequent) investor reaction will shape the ex-ante optimal reporting system.
3.1 Investor’s reaction to disclosure

At $t = 3$, i.e., after receiving the firm’s disclosure, the investor updates her belief about the firm’s state, and makes two decisions: whether to inspect the firm, and whether to invest in the firm.\footnote{This subgame, in this basic characterization, is similar to Povel et al. (2007).}

The investor’s set of possible actions ($A$) includes three choices: to reject the investment outright ($N$), to approve the investment outright ($A$), or to inspect and invest only if inspection reveals that the project is good ($I$). Let the investor’s expected payoff be denoted by $u(\mu, a)$, where $\mu$ is the investor’s posterior belief about the state being good, and $a \in A = \{A, I, R\}$ is the investor’s action. The expected payoffs from each of the three choices are listed below:

$$ u(\mu, a) = \begin{cases} 
  u(\mu, a = A) = (1 - s)(\mu N_g + (1 - \mu) N_b) \\
  u(\mu, a = I) = (1 - s)\mu N_g - m \\
  u(\mu, a = R) = 0
\end{cases} \tag{3} $$

where the payoff from outright rejection is standardized to be zero, i.e., $u(\mu, a = R) = 0$. For completeness, and without loss of generality, I assume that when indifferent between two actions, the investor will take the action the manager prefers.

Obviously, the investor’s optimal action depends on her posterior belief about the state being good ($\mu$), as summarized by the following Lemma.

**Lemma 1.** Define $\bar{m} = \frac{(1-s)N_b}{N_b + N_g}$, $\bar{\mu} = \frac{|N_b|}{|N_b| + |N_g|}$, $\bar{\mu}_1 = \frac{m}{(1-s)N_g}$ and $\bar{\mu}_2 = 1 - \frac{m}{(1-s)N_g}$.

1. When $m > \bar{m}$, the investor will approve outright if $\mu \geq \bar{\mu}$ and will reject outright if $\mu < \bar{\mu}$.

2. When $m < \bar{m}$, the investor will inspect and invest only in good projects if $\bar{\mu}_1 < \mu < \bar{\mu}_2$; the investor will reject outright if $\mu < \bar{\mu}_1$, and invest without inspection if $\mu > \bar{\mu}_2$.

Lemma 1 can be proved by noting that $\{\bar{\mu}, \bar{\mu}_1, \bar{\mu}_2\}$ are the three threshold levels of the investor’s posterior belief at which the investor is indifferent between two of her potential choices. Specifically, at $\bar{\mu}$ the investor is indifferent between directly approving and rejecting the investment, i.e., $u(\bar{\mu}, a = A) = 0$. Since $u(\mu, a = A)$ is increasing in $\mu$, the investor strictly prefers investing without inspection to rejecting when $\mu \geq \bar{\mu}$. Likewise, at $\bar{\mu}_1$ the investor is indifferent between inspecting
and rejecting; and at $\bar{\mu}_2$ the investor is indifferent between investing outright and inspecting. When $\mu > \bar{\mu}_1$, the investor strictly prefers inspecting over rejecting; when $\mu < \bar{\mu}_2$, the investor strictly prefers inspecting over investing outright.

Overall, inspecting before investing is optimal only when $\bar{\mu}_1 < \mu < \bar{\mu}_2$, which is the case only when $m < \bar{m}$, where $\bar{m}$ is the threshold inspection cost that equates $\bar{\mu}_1 = \bar{\mu}_2$. That is, $\bar{m}$ represents the threshold inspection cost above which the investor will never inspect, in which case the investor either approves the investment outright if her posterior is sufficiently high (i.e., $\mu \geq \bar{\mu}$), or rejects outright. With $m < \bar{m}$, the investor optimally inspects if her posterior is in the intermediate range ($\bar{\mu}_1 < \mu < \bar{\mu}_2$), rejects outright if her posterior falls below ($\mu < \bar{\mu}_1$), and approves outright if her posterior is sufficiently high ($\mu > \bar{\mu}_2$). This result is graphically represented in Figure 3.

The intuition is as follows. Inspection benefits the investor by allowing her to avoid wrong decisions. When $\mu$ is small, the investor’s default action is to reject the project. Inspection therefore creates value by saving good projects from rejection, and this benefit is higher when the true underlying state is more likely to be good (i.e., when $\mu$ lies closer to the upper end of the rejection region). When $\mu$ is close to 1, the investor’s default action is to invest. Inspection therefore creates value by rejecting bad projects, and this benefit is larger when the true state is more likely to be bad (i.e., when $\mu$ lies closer to the lower end of the approval zone). Combined, the benefit of inspection is largest with $\mu$ in the intermediate range, where the residual uncertainty is largest. Further, a decrease in the inspection cost $m$ leads to an expansion of the intermediate range, corresponding to
an increase in the likelihood of inspection.

3.2 The manager’s problem of designing a reporting system

At \( t = 3 \), the manager’s expected payoff \( v(\mu, a) \) is determined by the investor’s posterior \( \mu \) and action \( (a \in \{A, I, R\}) \). His expected payoffs under the investor’s actions are as follows:

\[
v(\mu, a) = \begin{cases} 
  v(\mu, a = A) = B + s(\mu N_g + (1 - \mu) N_b) \\
  v(\mu, a = I) = \mu (B + sN_g) \\
  v(\mu, a = R) = 0 
\end{cases}
\] (4)

For a given \( m \), the investor’s action \( a \) is determined solely by her posterior \( \mu \), and the manager’s payoff is determined by \( v(\mu, a(\mu)) \), which I summarily denote as \( \hat{v}(\mu) \).

At \( t = 1 \), the commonly known prior that the state is good is \( \mu_0 \), and there is no information asymmetry between the manager and the investor. The manager designs the reporting system by choosing the mapping probabilities \( \lambda_g \) and \( \lambda_b \). He knows the investor is Bayesian and will update her posterior based on the disclosure. Denote the investor’s posterior about state being good upon seeing a high \( (h) \) or a low \( (l) \) signal as \( \mu_h \) and \( \mu_l \), respectively, with

\[
\begin{align*}
\mu_h &= \Pr(g|\pi = h) = \frac{\mu_0 \lambda_g}{\mu_0 \lambda_g + (1 - \mu_0) \lambda_b} \\
\mu_l &= \Pr(g|\pi = l) = \frac{\mu_0 (1 - \lambda_g)}{\mu_0 (1 - \lambda_g) + (1 - \mu_0)(1 - \lambda_b)}
\end{align*}
\] (5a, 5b)

Conditional on the prior \( \mu_0 \), the manager’s choice of \( \lambda_g \) and \( \lambda_b \) fully determines \( \mu_h \) and \( \mu_l \). Without loss of generality, the manager’s problem is to design a reporting system that generates a distribution of posteriors \((\mu_h, \mu_l)\), which, in turn, maximizes his gross expected payoff \( \mathbb{E}(\hat{v}(\mu)) \) less the cost of the reporting system \( c(\pi) \). The problem can be rewritten as to maximize \( \mathbb{E}(\hat{v}_c(\mu)) \), whereby \( \hat{v}_c(\mu) \)
is a function of the investor’s posterior belief:

\[ V(\mu_0) = \max_{\mu_h, \mu_l} \mathbb{E}(\hat{v}_c(\mu)) \]

\[ \text{s.t. } \mu_0 = \Pr(\mu_h) \mu_h + (1 - \Pr(\mu_h)) \mu_l \quad (6a) \]

\[ a(\mu) \in \arg \max_{a \in \{N, I, M\}} u(\mu, a) \quad (6b) \]

\[ \hat{v}_c(\mu) = \hat{v}(\mu) - k(H(\mu_r) - H(\mu_{\pi}(\mu, \mu_r))) \quad (6c) \]

Constraint (6a) states that Bayesian updating requires the expectation of posteriors to equal the prior. Constraint (6b) states that the investor will choose the action that maximizes her payoff, conditional on her posterior. Finally, Constraint (6c) writes the manager’s conditional expected payoff as of \( t = 3 \) as a function of the investor’s posterior. This enables me to rearrange the manager’s problem as choosing the distribution of posteriors and facilitate graphic representation. When the cost of the reporting system approaches zero \( (k \to 0^+) \), Constraint (6c)\(^{21}\) approaches the gross payoff:

\[ \hat{v}_c(\mu) \to \hat{v}(\mu) = v(\mu, a(\mu)) \quad (7) \]

In the following discussion of the optimal reporting systems, I distinguish four cases along the two dichotomous dimensions of incentive alignment and investor inspection cost. Section 3.3 (3.4) contains the analysis of a mis-aligned (well-aligned) manager; Section 3.3.1 and 3.4.1 (3.3.2 and 3.4.2) assume a high (low) cost of investor inspection.

### 3.3 Mis-aligned manager’s optimal reporting system

In the basic model, I present the results assuming the reporting system’s cost is positive and approaches 0 to highlight the intuition. These results can be viewed as represent the (realistic) situation where the cost of the reporting system is low compared to the collective inspection costs by all investors. The results hold qualitatively in the more general case of \( k > 0 \).

I first discuss the optimal reporting system of a mis-aligned manager, whose private benefits are sufficiently large that he always prefers investment. Proposition 1 characterizes his optimal reporting system, which is dependent on whether the investor inspection cost \( m \) is above or below

\(^{21}\)Under the reporting system \( \pi \), if the investor with prior \( \mu_0 \) has posterior \( \mu \), then the posterior of the investor with the prior \( \mu_r \) (the fixed reference belief) can be determined as a function of \( \mu \) and \( \mu_r \), denoted as \( \mu_{\pi}(\mu, \mu_r) \).
the threshold level $\bar{m}$.

**Proposition 1.** The mis-aligned manager’s optimal reporting system is as follows:

1. If $m \geq \bar{m}$:
   
   (a) If $\mu_0 \geq \bar{\mu}$: The optimal system has $\lambda_g = \lambda_b$, and is therefore uninformative, yielding the posteriors $\mu_h = \mu_l = \mu_0$.

   (b) If $\mu_0 < \bar{\mu}$: The optimal system has $\lambda_g = 1$ and $\lambda_b = \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\bar{\mu}}$, and is therefore liberal, yielding the posteriors $\mu_l = 0$ and $\mu_h = \bar{\mu}$.

2. If $m < \bar{m}$:

   (a) If $\mu_0 \geq \bar{\mu}_2$: The optimal system has $\lambda_g = \lambda_b$, and is therefore uninformative, yielding the posteriors $\mu_h = \mu_l = \mu_0$.

   (b) If $\mu_0 < \bar{\mu}_2$: The optimal system has $\lambda_g = 1$ and $\lambda_b = \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_2}{\bar{\mu}_2}$, and is therefore liberal, yielding the posteriors $\mu_l = 0$ and $\mu_h = \bar{\mu}_2$.

**Proof.** All proofs are in Appendix 3.

3.3.1 Mis-aligned manager and high investor inspection costs

Proposition 1, Part 1 characterizes the mis-aligned manager’s optimal reporting system when $m \geq \bar{m}$. In this case, the investor’s inspection cost is so high that she never inspects, and instead relies solely on the disclosed signal for her investment decision. I start by contrasting the manager’s payoff under two extreme reporting systems (an uninformative system and a fully revealing system), and plot them in Panel (a) of Figure 4. Specifically, the solid lines plot the manager’s expected payoff $\hat{v}(\mu_0)$ under an uninformative system. $\hat{v}(\mu_0)$ is not continuous in $\mu_0$: It equals zero when the market prior is low ($\mu_0 < \bar{\mu}$) because the investor will reject the project with a low prior. However, when the market prior is high ($\mu_0 > \bar{\mu}$), the investor will approve the project, and the manager’s expected payoff is $\hat{v}(\mu_0) = \mu_0 (B + sN_g) + (1 - \mu_0) (B + sN_b)$.

For direct comparison, the dash-dot line depicts the manager’s expected payoff under a fully revealing reporting system. When the reporting system truthfully reveals the underlying state
Figure 4: Mis-aligned Manager’s Expected Payoff

(a) High Investor Inspection Costs

(b) Low Investor Inspection Costs

Manager’s Expected Payoff

0 0

Liberal System

Uninformative System

Market Prior ($\mu_0$)

0 $\bar{\mu}$

Manager’s Expected Payoff

0

Liberal System

Uninformative System

Market Prior ($\mu_0$)

0 $\bar{\mu}_1$ $\bar{\mu}$ $\bar{\mu}_2$

(the full information case, FI), the investor invests only if the state is good, and the manager’s expected payoff is linear in the market prior: $v_{FI}(\mu_0) = \mu_0 (B + sN_\theta)$. For a mis-aligned manager, $v_{FI}(\mu_0) \leq \hat{v}(\mu_0)$ for $\mu_0 > \bar{\mu}$, and $v_{FI}(\mu_0) \geq \hat{v}(\mu_0)$ for $\mu_0 < \bar{\mu}$. Thus, providing full information hurts (benefits) the mis-aligned manager when the market prior is high (low) and the investor’s default action is to approve (reject).

The next question is whether a partially revealing and possibly biased system can improve the manager’s expected payoff relative to the two benchmark cases, and under which conditions. I use the concavification technique (Kamenica and Gentzkow (2011)) to derive the optimal system.\footnote{The concavification technique constructs $V(\mu_0)$ as the smallest concave function that is everywhere weakly greater than $\hat{v}(\mu_0)$.} In Panel (a), the dashed line depicts $V(\mu_0)$, the manager’s maximum expected payoff from the optimal reporting system.

The optimal reporting system varies with the market prior. When the market prior is high ($\mu_0 \geq \bar{\mu}$), a mis-aligned manager’s optimal system is uninformative. The investor cannot update her prior, and will default to approve without inspection. The reason why any informative system is not optimal (for the manager) is as follows. The manager will be strictly worse off if an informative system yields a posterior of $\mu_l$ too low to secure investor approval ($\mu_l < \bar{\mu}$). If the reporting system yields $\bar{\mu} \leq \mu_l < \bar{\mu}_h$, all projects will be approved and the manager receives the same expected payoff
as in the uninformative case. However, given the cost of the reporting system $k$, the manager will prefer the least informative system among a class of systems with the same expected payoff.

When the market prior is low ($\mu_0 < \bar{\mu}$), on the other hand, a mis-aligned manager benefits from an informative system, since the investor’s default action is not to invest. Since the investor is rational, the disclosure must be able to change her posterior, convincing her either more or less that the project is good. The manager’s payoff is strictly higher if the investor is sufficiently convinced to invest; however, his payoff is not reduced below zero if the investor is less convinced, since the investor’s default action is not to invest anyway.

The optimal system has two interesting properties. First, a high signal realization (hereafter, $h$-signal) should be sufficiently convincing, but not revealing the good state with certainty. The optimal system must induce a posterior of $\mu_h \geq \bar{\mu}$, because if $\mu_h < \bar{\mu}$, the investor will not invest even when she sees a $h$-signal, and the manager gets a payoff of zero. A $h$-signal is not a sure indicator of the good state ($\mu_h < 1$), because the mis-aligned manager privately benefits from investing even in a bad project, and if a $h$-signal is a sure indicator of the good state, no bad project will be invested. On the margin, the manager can increase his expected payoff by slightly increasing $\lambda_b$ from zero. In that case, a $h$-signal still warrants investment, but more (bad) projects are approved. In fact, the optimal system yields the posterior of $\mu_h = \bar{\mu}$, whereby the high signal is just sufficiently convincing to ensure approval. This is because, if $\mu_h > \bar{\mu}$, the manager can increase his expected payoff by decreasing $\mu_h$ while keeping $\mu_l$ constant, which increases the probability of obtaining a $h$-signal.

Second, a low signal realization ($l$-signal) will reveal a bad project with certainty ($\mu_l = 0$). This means that good projects never get a $l$-signal ($\lambda_g = 1$) and are never rejected. The reason is that, if $\mu_l > 0$, the manager can always increase his expected payoff by decreasing $\mu_l$ and keeping $\mu_h$ ($\geq \bar{\mu}$) constant. This implies both higher $\lambda_g$ and $\lambda_h$: More good projects receive a $h$-signal and are approved, while more bad projects are pooled with good projects in receiving a $h$-signal and are approved as well. For a mis-aligned manager, this strictly increases his expected payoff.

To summarize, a mis-aligned manager’s optimal reporting system is liberally biased, with more bad projects receiving $h$-signals than good projects receiving $l$-signals. Further, a bad news disclosure ($l$-signal) is more informative than a good news disclosure ($h$-signal). Prior empirical research suggests that bad news disclosures are less frequent than good news disclosures, and also more informative insofar as they are followed by larger market reactions (Kothari et al. (2009)). Both the
lower frequency and the higher informativeness are consistent with predictions of my model, under the condition of managers’ incentives being mis-aligned.

### 3.3.2 Mis-aligned manager and low investor inspection costs

Proposition 1, Part 2 presents the mis-aligned manager’s optimal system when the investor’s inspection cost is low \( (m < \bar{m}) \). The investor may realistically acquire additional information if her posterior falls into the intermediate range, between posteriors that lead to outright investment and posteriors that lead to rejection. In Panel (b) of Figure 4, the dashed line gives \( V(\mu_0) \), the manager’s maximum expected payoff from the optimal reporting system. The solid line segments depict the mis-aligned manager’s expected payoff \( \hat{v}(\mu_0) \) when the system is uninformative and the investor’s posterior equals her prior. \( \hat{v}(\mu_0) \) differs from the case of high inspection costs in that the investor’s set of possible actions now includes inspection in an intermediate range of priors. Graphically, the function \( \hat{v}(\mu_0) \) now has two discontinuities, at \( \bar{\mu}_1 \) and \( \bar{\mu}_2 \). When the prior is low \( (\mu_0 < \bar{\mu}_1) \), the investor neither inspects nor invests, and the manager’s payoff is zero. When the prior is in the intermediate range \( (\bar{\mu}_1 \leq \mu < \bar{\mu}_2) \), without additional disclosure, the investor inspects and only invests in good projects; as a result the manager’s payoff is \( \mu_0 (B + sN_g) \), which is linear in the market belief. When the belief is sufficiently high \( (\mu_0 > \bar{\mu}_2) \), the investor invests without inspection and the manager’s payoff is \( \mu_0 (B + sN_g) + (1 - \mu_0) (B + sN_b) \). The second discontinuity, at \( \bar{\mu}_2 \), is due to a mis-aligned manager’s private benefits from investing in bad projects exceeding his share of the loss. To summarize, a fully revealing system will result in a higher (lower) [the same] expected payoff for the mis-aligned manager compared to an uninformative system when market prior is low (high) [intermediate].

Again, a partially revealing system can achieve a higher expected payoff than either a fully revealing or an uninformative system, depending on the market prior. When \( \mu_0 \geq \bar{\mu}_2 \), the investor’s default action is to invest directly without inspection, which is the mis-aligned manager’s favored action. Thus, the manager’s optimal system is uninformative, since an informative system can never improve his expected payoff, but causes additional costs.

When \( \mu_0 < \bar{\mu}_1 \), the investor’s default action is not to invest, which is the least preferred action from the manager’s point of view. Hence, the manager benefits from an informative system if the system convinces the investor to take other actions with a higher probability. This requires the
optimal system to have $\mu_h \geq \bar{\mu}_1$; otherwise, the investor never invests. Furthermore, the optimal system has $\mu_l = 0$. If not, the manager can always improve his expected payoff by setting $\mu_l = 0$ while keeping $\mu_h \geq \bar{\mu}_1$ constant, which ensures all good projects get approved ($\lambda_g = 1$), increasing his expected payoff. Finally, the mis-aligned manager achieves the maximum expected payoff by setting $\mu_h = \bar{\mu}_2$ and keeping $\mu_l = 0$, since this system enables bad projects to get approved with the highest probability ($\lambda_b = \frac{\mu_0}{1 - \mu_0} \frac{1 - \bar{\mu}_2}{\bar{\mu}_2}$).

When $\bar{\mu}_1 \leq \mu_0 < \bar{\mu}_2$, the investor’s default action is to inspect and invest only in good projects, yielding a positive expected payoff for the manager. However, the manager can improve on this payoff by designing a system that induces approval for all good projects and some bad projects, setting $\mu_l = 0$ and $\bar{\mu}_2 \leq \mu_h < 1$. It turns out that the optimal system has $\mu_h = \bar{\mu}_2$ and $\mu_l = 0$, which retains the investor’s willingness to invest directly in $h$-signal firms, and maximizes the probability of obtaining $h$-signals for both good and bad projects.

Figure 5 summarizes how the mis-aligned manager’s optimal system changes with the market prior. For $\mu_0 \in (0, \bar{\mu}_2)$, the manager strictly benefits from the optimal system, while for $\mu_0 \in [\bar{\mu}_2, 1]$, he prefers an uninformative system. Furthermore, the optimal system is less liberal and more informative as the market prior decreases.

Also, $\bar{\mu}_2$ is larger than $\bar{\mu}$ when $m < \bar{m}$, i.e., the range of market priors in which the manager prefers an uninformative system, $[\bar{\mu}_2, 1]$, is smaller compared to the high investor inspection costs case. Corollary 1 presents the impact of investor inspection cost on firm disclosures. Denote $\bar{\mu} =$
max(\(\bar{\mu}, \bar{\mu}_2\)), as the threshold posterior belief above which the investor invests without inspection. \(\bar{\mu}\) weakly decreases in \(m\).

**Corollary 1.** For a mis-aligned manager, as \(m\) decreases:

1. The range of market priors in which an uninformative system is optimal, \([\bar{\mu}, 1]\), shrinks; the range over which an informative system is optimal, \((0, \bar{\mu})\), expands.

2. When the optimal system is informative, it has \(\lambda_g = 1\) and \(\lambda_b\) weakly decreases as \(m\) decreases; the system becomes more informative and less liberal.

A mis-aligned manager’s disclosure convinces the investor to approve the investment without inspection. The optimal system will ensure that good projects generate an \(h\)-signal and are approved (\(\lambda_g = 1\)), and also maximizes the probability that bad projects are approved. Lower investor inspection costs make inspection more likely and require more convincing evidence of a good project. Thus, the manager has to design a more informative and less liberal system.

In the last several decades, communication and computation technologies have substantially reduced investor inspection costs. At the same time, empirical studies find that firms expanded their financial disclosures (Francis et al. (2002b)), and accounting has become more conservative (Givoly and Hayn (2000)). My model traces both findings to the decrease in inspection costs as a potential explanation. Relatedly, to the extent that investors’ inspection costs vary across countries, my model predicts the degree of reporting conservatism will also vary across countries. Ball et al. (2003) find that despite having high quality accounting standards, the four East Asian countries in their sample exhibit low timeliness in loss recognition. My model suggests an alternative explanation: Investors in those countries face prohibitively high costs to acquire additional information, which renders them unable to monitor managers effectively. Rational managers will, in turn, report more liberally.

In addition, investor inspection costs have a direct impact on a mis-aligned manager’s investment efficiency, as summarized in Corollary 2.

**Corollary 2.** A mis-aligned manager over-invests with probability \(\min\left\{\frac{\mu_0}{\mu}, 1\right\} - \mu_0\). As the investor inspection cost \(m\) decreases, over-investment weakly decreases.

Prior empirical research finds that accounting conservatism is positively associated with investment efficiency. For example, Francis and Martin (2010) find that firms with more timely
incorporation of economic losses into earnings make more profitable acquisitions, and infer that accounting conservatism complements other governance mechanisms to achieve better investment outcomes. My results suggest an alternative explanation: Lower investor inspection costs lead to both more accounting conservatism and better investment efficiency, and conservatism per se does not directly affect investment efficiency.

3.4 Well-aligned manager’s optimal reporting system

A well-aligned manager differs from a mis-aligned one in that he prefers not to take a bad project because his private benefit is too small to compensate for his share of the project loss. This difference in incentives leads to a large difference in the optimal reporting systems. Proposition 2 characterizes a well-aligned manager’s optimal system when the cost of the reporting system is negligible ($k \to 0^+$).

Proposition 2. The well-aligned manager’s optimal reporting system is as follows:

1. If $m > \bar{m}$: The optimal system has $\lambda_g = 1$ and $\lambda_b = 0$, and therefore is fully revealing and neutral, yielding the posteriors $\mu_l = 0$ and $\mu_h = 1$.

2. If $m < \bar{m}$:

   (a) If $\mu_0 \geq \bar{\mu}_2$: The optimal system has $\lambda_g = \frac{\mu_0 - \bar{\mu}_2}{\mu_0 (1 - \bar{\mu}_2)}$ and $\lambda_b = 0$, and is therefore conservative, yielding the posteriors $\mu_l = \bar{\mu}_2$ and $\mu_h = 1$.

   (b) If $\bar{\mu}_1 \leq \mu_0 < \bar{\mu}_2$: The optimal system has $\lambda_g = \lambda_b$, and is therefore uninformative, yielding the posteriors $\mu_h = \mu_l = \mu_0$.

   (c) If $\mu_0 < \bar{\mu}_1$: The optimal system has $\lambda_g = 1$ and $\lambda_b = \frac{\mu_0 - \bar{\mu}_1}{1 - \mu_0 - \bar{\mu}_1}$, and is therefore liberal, yielding the posteriors $\mu_l = 0$ and $\mu_h = \bar{\mu}_1$.

Figure 6 plots the well-aligned manager’s expected payoff under different information system with different investor inspection costs. The solid lines plot his expected payoff $\hat{v}(\mu_0)$ under an uninformative system, the dash-dot lines plot his expected payoff $v_{FI}(\mu_0)$ under a fully-revealing system, and the dashed lines plot his expected payoff $V(\mu_0)$ from the optimal reporting system.
3.4.1 Well-aligned manager and high investor inspection costs

Proposition 2, Part 1 characterizes the well-aligned manager’s optimal system when the investor’s inspection cost is high. In this case, the investor makes decisions relying on the public disclosure only, and the well-aligned manager prefers the investor to invest only if the state is good. As a result, the optimal system is fully revealing.

This result is in sharp contrast with the choice by the mis-aligned manager: The mis-aligned manager prefers an uninformative system when the prior is sufficiently high ($\mu_0 \geq \bar{\mu}$), and a partially-revealing and liberal system when the prior is low ($\mu_0 < \bar{\mu}$). The reason is that while a mis-aligned manager always prefers the investor to invest, a well-aligned manager prefers the investor to make the right decision, and better information facilitates better decision-making. When the investor inspection costs are prohibitively high, it is optimal for a well-aligned manager to provide the best possible information. If the cost of the system approaches zero, he will choose a fully-revealing system. This is graphically represented in Figure 6a, where $V(\mu_0)$ coincides with $v_{FI}(\mu_0)$, the expected payoff in the full-information benchmark.
3.4.2 Well-aligned manager and low investor inspection costs

Proposition 2, Part 2 characterizes the well-aligned manager’s optimal system when the investor’s inspection cost is low, in which case the investor acquires additional information when the disclosure does not sufficiently resolve her residual uncertainty. The possibility of investor information acquisition changes the well-aligned manager’s optimal system from fully revealing to counter-cyclical: It is liberal when the market prior is low and is conservative when it is high, and is uninformative when the market prior is intermediate and the investor defaults to inspecting. The intuition is as follows.

When the market prior is high ($\mu_0 > \bar{\mu}_2$), the investor approves outright upon receiving a $h$-signal and inspects upon receiving a $l$-signal. Thus, Type-I error by the information system (i.e., reporting a good project as a $l$-signal) is costless, since a good project with a $l$-signal will be revealed by inspection and approved. In contrast, a Type-II error (reporting the bad project with a $h$-signal) is costly, because a $h$-signal leads to approval without inspection, which reduces the payoff of a well-aligned manager because the project is actually bad. Thus it is optimal for the manager to avoid Type-II errors as much as possible, which translates into all bad projects receiving a $l$-signal, even if some good projects also receive a $l$-signal as well. This renders the optimal system conservative when the market prior is high.

On the other hand, when the market prior is low ($\mu_0 < \bar{\mu}_1$), the investor inspects upon receiving a $h$-signal and disapproves without inspection upon receiving a $l$-signal. In this case, Type-I errors lead to opportunity losses due to foregone investments with positive NPV. However, a Type-II error is costless, since bad projects with a $h$-signal will be revealed by inspection and rejected. Thus, it is optimal for the manager to avoid Type-I errors as much as possible, which means that all good projects should receive a $h$-signal, even if some bad projects also receive a $h$-signal as well. This makes the optimal system liberal when market prior is low.

When the market prior is in the intermediate range ($\bar{\mu}_1 \leq \mu_0 \leq \bar{\mu}_2$), the investor will inspect and invest only in good projects, which is the well-aligned manager’s favored action. Since the reporting system is costly, the manager prefers an uninformative system. Figure 7 presents how the well-aligned manager’s optimal system changes with the market prior. The system is less biased and more informative when the market prior is less uncertain, i.e., when $\mu_0$ approaches 0 or 1.
Figure 7: The Well-aligned Manager’s Optimal System when $m < \bar{m}$

The counter-cyclical reporting system resembles earnings smoothing behaviors documented in prior literature (e.g., Liu and Ryan (2006)). When the market prior is high and the investor’s default action is to invest directly, a conservative system, which requires more income-decreasing accruals, maximizes the probability that bad projects will get inspected and stopped. When the market prior is low and the default action is not to invest, a liberal system, which requires more income-increasing accruals, maximizes the probability that good projects will get inspected and funded.

The counter-cyclical system is also consistent with the finding in Tucker and Zarowin (2006) that there is a positive association between earnings smoothness and the ability of stock price to predict firms’ future earnings. While Tucker and Zarowin (2006) interpret the finding as managers smooth earnings to improve its informativeness in predicting firms’ future performance, my model suggests that well-aligned managers smooth earnings to reduce its informativeness, and to motivate investors’ information acquisition. Nonetheless, since the acquired information affects firms’ investment decisions and thus future cash flows, and at the same time is also impounded in stock price by investors, stock prices in firms with actively smoothed earnings are expected to be more positively associated with future earnings.

**Corollary 3.** As $m$ decreases, within $0 < m < \bar{m}$, the following results obtain for a well-aligned manager:
1. The range of market priors over which the manager prefers uninformative disclosures, \( U = [\bar{\mu}_1, \bar{\mu}_2] \), expands. The range of market prior beliefs over which the manager prefers informative disclosures, \( I = (0, \bar{\mu}_1) \cup (\bar{\mu}_2, 1) \), shrinks.

2. If \( \mu_0 \in (0, \bar{\mu}_1) \): \( \lambda_g = 1 \) and \( \lambda_b \) increases as \( m \) decreases. The optimal system becomes less informative and more liberal.

3. If \( \mu_0 \in (\bar{\mu}_2, 1) \), \( \lambda_b = 0 \) and \( \lambda_g \) decreases as \( m \) decreases. The optimal system becomes less informative and more conservative.

One empirical implication of this corollary is that counter-cyclicality is more pronounced in industries where investors face relatively lower inspection costs. Hutton et al. (2012) find that a manager’s information advantage resides at the firm level, and an analyst’s information advantage resides at the macro-economic level. Analysts provide more accurate earnings forecasts than management when earnings correlate more strongly with macro-economic factors such as GDP and energy costs. My model predicts that such industries should benefit more from external information acquisition. As a consequence, these firms will make fewer disclosures, and these disclosures will be more counter-cyclical to the market prior to induce the collection of macro-level information by market participants.

Prior empirical work also provides evidence of income smoothing in industries that are more exposed to macroeconomic uncertainty. For example, Liu and Ryan (2006) document that commercial banks engage in earnings smoothing over business cycles using loan loss provisions, which they interpret as opportunistic behavior. In my model, however, such earnings smoothing may be optimal even if managers and investors are rational. Income-increasing (income-decreasing) accruals in recessions (boom periods) induce external information acquisition, which, in turn, improves investment efficiency.

Perhaps surprisingly, better incentive alignment between the manager and the investor does not necessarily lead to more informative disclosures. Figure 8 compares the optimal reporting systems for the mis-aligned and well-aligned managers. For inspection costs \( m < \bar{m} \) and market priors \( \mu_0 < \bar{\mu}_2 \), the disclosure is more informative when the manager is mis-aligned. When \( \bar{\mu}_1 < \mu_0 < \bar{\mu}_2 \), the well-aligned manager’s optimal system is uninformative, while the mis-aligned manager’s is
informative. When $\mu_0 < \bar{\mu}_1$, both employ informative systems, but the mis-aligned manager’s is more informative and less liberal.

The reason is that a mis-aligned manager uses disclosures to convince the investor to approve the investment, while a well-aligned manager does not prefer unconditional investing, but rather, he aims to induce the right investment decision. By disclosing less, he induces information acquisition by the investor, from which, in turn, he benefits. In its basic form, this result resembles the conclusion in Gao and Liang (2013). The “feedback effect” entails that the firm learns the information collected by investors as aggregated in price. My result highlights that incentive alignment is a key premise. Furthermore, in this basic model with $k \to 0^+$, lower investor inspection cost leads to less informative disclosure, but without reducing investment efficiency. In the costly reporting system case ($k > 0$), lower investor inspection costs will improve investment efficiency.

4 Allowing ex-post manipulation of the reporting system

In the basic model of Section 3, the manager commits to disclosing the unaltered signal from the reporting system. This section relaxes this assumption and presents an extended model in which the manager privately observes the output of the system, and may manipulate the reporting system before it generates the signal to the investor. While this model is less tractable mathematically, it better captures the empirical finding that managers possess private information relative to their
public disclosures, and may manipulate these disclosures to achieve a higher expected payoff.\footnote{Empirical evidence on earnings management suggests that managers manipulate the output of the reporting system (e.g., Burgstahler and Dichev (1997)). However, the scope of manipulation is constrained due to regulation and other institutional features (e.g., Barton and Simko (2002)).}

The purpose of the extended model is to answer three questions. First, from an ex ante perspective, will a manager benefit from being able to manipulate the system ex post (i.e., after the signals are revealed by the system)? Second, how will ex-post manipulation affect the characteristics of the ex-ante optimal reporting system, and how will these characteristics change as the investor’s information acquisition costs decrease? Third, how does allowing manipulation affect investment efficiency?

The setup of the extended model is as follows. After the reporting system is in place, the manager privately observes the reporting system’s original output $y \in \{h, l\}$, and chooses the probability of manipulation ($\phi_y$). Specifically, a manipulation can alter the output of the reporting system with probability $\delta$ at a fixed cost $F$. To differentiate, I denote the final output as $y' \in \{h', l'\}$. Both $\delta$ and $F$ are common knowledge. I allow managers with both high and low signals to manipulate, and assume $\delta (B + sN_b) \geq F$, so that the cost is sufficiently low for manipulation to occur. Figure 9 illustrates how manipulation affects the disclosed signal ($y'$), and Figure 10 presents the time-line of the extended model.

\subsection*{4.1 The equilibrium}

I study the Perfect Bayesian Equilibrium (PBE) of the extended model.

\textbf{Definition.} The equilibrium in the extended model is comprised of the manager’s choice of the reporting system ($\lambda_g, \lambda_b$), the manager’s manipulation strategy $\phi_y$, and the investor’s response
The manager chooses a reporting system \((\lambda_g, \lambda_b)\). The manager observes the output of the system \(y\), and chooses whether to manipulate the system. Signal \(y'\) is disclosed. The manager and the investor learn \((\mu_y')\), such that:

1. At \(t = 1\), the manager chooses \(\lambda_g, \lambda_b\) to maximize expected payoff:

\[
(\lambda_g, \lambda_b) \in \arg \max_{\lambda_g, \lambda_b} \mathbb{E}_{\pi(\lambda_g, \lambda_b)} \left( \mathbb{E} \left( \hat{v} \left( \mu_{y'}(\phi_h, \phi_l) \right) \mid y \right) \right)
\]

2. At \(t = 2\), the manager observes privately the original output \(y\), and chooses his manipulation strategy \(\{\phi_h, \phi_l\}\). Specifically,

- (a) Upon receiving a \(h\)-signal, the manager chooses \(\phi_h \in [0, 1]\) to maximize expected payoff:
  \[
  \phi_h \in \arg \max_{\phi_h} \mathbb{E} \left( \hat{v} \left( \mu_{y'}(\phi_h, \phi_l) \right) \mid y = h \right).
  
- (b) Upon receiving a \(l\)-signal, the manager chooses \(\phi_l \in [0, 1]\) to maximize expected payoff:
  \[
  \phi_l \in \arg \max_{\phi_l} \mathbb{E} \left( \hat{v} \left( \mu_{y'}(\phi_h, \phi_l) \right) \mid y = l \right).
  
3. At \(t = 4\), signal \(y'\) is disclosed. The investor chooses action \((a)\) to maximize her expected payoff:

\[
a \left( \mu_{y'} \right) \in \arg \max_{a} u \left( \mu_{y'}(\phi_h, \phi_l), a \right), y' \in \{h', l'\}
\]

**4.2 Comparison with the no-manipulation case**

I first study whether allowing ex-post manipulation \((\delta > 0)\) improves the manager’s ex-ante expected payoff. Denote \(V_{\delta} (\mu_0)\) the manager’s maximum expected payoff from any reporting system when the scope of manipulation is \(\delta\).

**Lemma 2.** \(V_{\delta=0} (\mu_0) \geq V_{\delta>0} (\mu_0)\), regardless of the manager’s type.

The manager (both the mis-aligned and the well-aligned) achieves the maximum expected payoff when ex-post manipulation is outright forbidden. The proof is similar to that of the Revelation
Principle (e.g., Arya et al. (1998)). Consider the optimal reporting system when $\delta > 0$. In equilibrium, the manager may or may not manipulate the signal, but the investor will always interpret the signal rationally. The manager's expected payoff is determined by this distribution of the investor's posterior. There always exists a system under the no-manipulation case that generates the same distribution of posteriors, thus yielding the same gross expected payoff, but without incurring manipulation cost. As a result, a manager achieves the highest expected payoff when he designs and commits to the ex-ante optimal system.

4.3 Well-aligned manager with ex-post manipulation

**Lemma 3.** For a well-aligned manager, $V^w_0(\mu_0) = V^w_\delta(\mu_0), \forall \delta > 0$. His optimal reporting system remains unaffected by whether allowing manipulation.

Lemma 2 has established that a well-aligned manager’s maximum payoff in the manipulation case will not exceed his payoff in the no-manipulation case. If a well-aligned manager’s optimal system in the no-manipulation case yields the same expected payoff as in the manipulation case, this system must be optimal in the manipulation case as well. This is indeed the case. Under the optimal system from the no-manipulation case, the well-aligned manager has no incentive to manipulate, since the investor will always take the manager’s favored action. Manipulation is then not only costly, but may also lead the investor to choose a less desirable action. Thus, allowing the well-aligned manager to manipulate the disclosed signal will not change his reporting system.

4.4 Mis-aligned manager with ex-post manipulation

Clearly, when $\mu_0 \geq \tilde{\mu}$, the mis-aligned manager’s optimal system remains uninformative, since under such a system he has no incentive to manipulate and receives the same expected payoff as under the no-manipulation case. Thus, the following discussion focuses on the cases where the prior is pessimistic and the optimal system is informative. When $\mu_0 \leq \tilde{\mu}$, his optimal system under no-manipulation derives a lower expected payoff and may no longer be optimal, since the possibility of manipulation makes the investor less willing to invest outright upon seeing the $h'$-signal. The manager thus designs the optimal reporting system in anticipation of ex-post manipulation.

I derive the optimal system by solving first the subgame equilibrium after the reporting system
is in place, and then the manager’s choice of the optimal system. The intermediate lemmas and proofs are in Appendix 3. Section 4.4.1 (4.4.2) presents the mis-aligned manager’s optimal system, assuming high (low) investor inspection costs.

4.4.1 Mis-aligned manager and high inspection costs

The following proposition characterizes the optimal system in the manipulation case when the investor faces high inspection costs \((m \geq \bar{m})\).

**Proposition 3.** Suppose \(m > \bar{m}\) and \(\mu_0 < \bar{\mu}\). Denote
\[
\bar{f}_1 = \frac{1-\mu_0}{\mu_0} \left(1-\frac{1-\bar{\mu}}{\mu} \bar{\lambda}_b + \frac{1}{\delta(B+sN_b)} \left((B+sN_b) + \frac{1-\bar{\mu}}{\mu} (B+sN_b)\right) \right),
\]
where \(\bar{\lambda}_b = \frac{1}{1-\delta} \left(\frac{1-\bar{\mu}}{\mu} \frac{\mu_0}{1-\mu_0} + \delta\right)\). The mis-aligned manager’s optimal reporting system is as follows:

1. If \(\delta > \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\mu} \) or \(F > \bar{f}_1\): The optimal system \((\pi_1)\) has \(\lambda_g = 1\), \(\lambda_b = \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\mu}\). The manager does not manipulate \((\phi_h = 0, \phi_l = 0)\). The investor’s posteriors are \(\mu_h' = \bar{\mu}\) and \(\mu_l' = 0\). Upon seeing the \(h'\)-signal, the investor approves without inspection with probability \(\chi_{h'} = \frac{F}{\delta(B+sN_b)}\), and does nothing with probability \(1 - \chi_{h'}\).

2. If \(\delta \leq \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\mu} \) and \(F \leq \bar{f}_1\): The optimal system \((\pi_2)\) has \(\lambda_g = 1\), \(\lambda_b = \frac{1}{1-\delta} \left(\frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\mu} - \delta\right)\).
   The \(l\)-signal manager manipulates and the \(h\)-signal manager does not \((\phi_h = 0 \text{ and } \phi_l = 1)\).
   The investor’s posteriors are \(\mu_h' = \bar{\mu}\) and \(\mu_l' = 0\). Upon seeing the \(h'\)-signal, the investor approves without inspection with probability \(\chi_{h'} = 1\).

Proposition 3 shows that the optimal system under the no-manipulation case (System \(\pi_1\)) remains optimal when either the scope \((\delta)\) or the cost \((F)\) of manipulation is large. In that case, under System \(\pi_1\), the original output of the reporting system \(y\) gives posteriors \(\mu_h = \bar{\mu}\) and \(\mu_l = 0\). In equilibrium, the managers do not manipulate, and thus upon seeing the disclosed signals \(y'\), the investor’s posteriors remain \(\mu_{h'} = \bar{\mu}\) and \(\mu_{l'} = 0\), the same as in the no-manipulation case. However, her response differs: Upon seeing the \(h'\)-signal, she invests without inspection with probability \(\chi_{h'} = \frac{F}{\delta(B+sN_b)} < 1\), and rejects with probability \(1 - \chi_{h'}\). She chooses this mixed strategy to make the manager indifferent between manipulation or not. As a result, the manager does not manipulate, which consists an equilibrium. Comparing to the no-manipulation case where the investor invests with certainty upon seeing a \(h\)-signal, allowing manipulation hurts the manager’s expected payoff through the reduced investment.
When both the scope and cost of manipulation are small, the optimal system becomes $\pi_2$, which has lower $\lambda_b$ and is more informative than System $\pi_1$ ex ante. Under $\pi_2$, the manager with a $l$-signal always manipulates. However, despite that manipulation makes the $h'$-signal less indicative of good state, a $h'$-signal still convinces the investor to provide outright approval: The investor’s posteriors are $\mu_{h'}(\phi_l = 1) = \bar{\mu}$ and $\mu_{l'}(\phi_l = 1) = 0$. Thus, the posteriors remain again the same as in the no-manipulation case; what differs is that the pre-manipulation system needs to be more informative, and the manager incurs manipulation costs.

The intuition for the tradeoff between the two systems is as follows. System $\pi_2$ is optimal only if $\delta$ is small. Otherwise, if the scope of manipulation is large, regardless of $\lambda_b$, the investor will not trust $h'$-signal for outright approval. When $\delta$ is small, both systems are potentially optimal. System $\pi_1$ reduces the likelihood of investment, while $\pi_2$, a more informative system, increases the manipulation incentive for the $l$-signal manager and incurs higher manipulation cost. The optimal system thus depends on the relative costs of manipulation versus foregone investment. When manipulation cost $F$ is small, System $\pi_2$ accommodates manipulation at a low cost and is thus preferred; otherwise, System $\pi_1$ forgoes a small percentage of investment ($\chi_h$ increases in $F$), and is preferred. Figure 11 shows the optimal system under different $\delta$ and $F$ values.
4.4.2 Mis-aligned manager and low inspection costs

Relative to a setting in which high inspection costs preclude the investor from acquiring additional information, the low inspection cost setting offers the manager an advantage, in that he can choose a reporting system that encourages investor inspection, and thereby receive a positive expected payoff. The following proposition characterizes the optimal system when the market prior is pessimistic \((\mu_0 \leq \bar{\mu}_1)\), under which the optimal system is informative. The optimal system and the subgame equilibrium are as follows.

**Proposition 4.** Suppose \(m < \bar{m} \) and \(\mu_0 < \bar{\mu}_1\). Denote \(\bar{f}_2 = \frac{1-\bar{\mu}_2}{\bar{\mu}_2} \delta (B + sN_{\bar{b}})\), where \(\lambda_{b,2} = \frac{1}{1-\delta} \left( \frac{1-\bar{\mu}_2}{\bar{\mu}_2} - \frac{\mu_0}{1-\mu_0} \right)\). The mis-aligned manager’s optimal reporting system is as follows:

1. If \(\delta > \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_2}{\bar{\mu}_2}\) or \(F > \bar{f}_2\): The optimal system \((\pi_1)\) has \(\lambda_g = 1\), \(\lambda_b = \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_2}{\bar{\mu}_2}\). The manager does not manipulate \((\phi_b = \phi_l = 0)\). The investor’s posteriors are \(\mu_{h'} = \bar{\mu}_2\) and \(\mu_{l'} = 0\), and approves without inspection upon seeing a \(h'\)-signal with probability \(\chi_{h'} = \frac{F}{s(1-\mu_{l'})}\).

2. If \(\delta \leq \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_2}{\bar{\mu}_2}\) and \(F \leq \bar{f}_2\): The optimal system \((\pi_2)\) has \(\lambda_g = 1\), \(\lambda_b = \frac{1}{1-\delta} \left( \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_2}{\bar{\mu}_2} - \delta \right)\).

The \(l\)-signal manager manipulates and the \(h\)-signal manager does not \((\phi_b = 0\) and \(\phi_l = 1)\).

The investor’s posteriors are \(\mu_{h'} = \bar{\mu}_2\) and \(\mu_{l'} = 0\), and approves without inspection upon seeing a \(h'\)-signal with probability \(\chi_{h'} = 1\).

When investor inspection cost is low and the market prior is pessimistic \((\mu_0 < \bar{\mu}_1)\), the optimal system is the same as the one under the no-manipulation case \((\text{System } \pi_1)\) when the scope \((\delta)\) or the cost \((F)\) of manipulation is large. Otherwise, the optimal system is the more informative System \(\pi_2\). When the market prior is in the intermediate range \((\bar{\mu}_1 \leq \mu_0 < \bar{\mu}_2)\), the potential optimal systems are \(\pi_1\), \(\pi_2\), and another system \(\pi_3\) that yields \(\mu_{h'} = \bar{\mu}_2\) and \(\bar{\mu}_1 \leq \mu_{l'} < \mu_0\), under which the manager does not manipulate \((\phi_b = \phi_l = 0)\), the investor inspects upon receiving a \(l'\)-signal, and approves outright upon seeing a \(h'\)-signal with probability \(\chi_{h'} = \frac{F}{s(1-\mu_{l'})}\). I draw three conclusions from these results.

**Corollary 4.** The impact of \(\delta\) and \(F\) on the mis-aligned manager’s expected payoff is as follows:

1. \(V^m_\delta (\mu_0)\) weakly decreases in \(\delta\);
2. When \( \delta < \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\bar{\mu}} \), \( V_m^\delta (\mu_0) \) weakly decreases (increases) in \( F \) when \( F \) is sufficiently small (large).

Corollary 4 shows a mis-aligned manager’s expected payoff decreases monotonically in the scope of manipulation (\( \delta \)), but changes non-monotonically with the manipulation cost \( F \). When \( F \) is small, the cost of manipulation is low and the manager prefers the more informative System \( \pi_2 \), under which a manager with \( l \)-signal manipulate the system. As a result, the ex-ante expected payoff decreases in \( F \). However, when \( F \) is sufficiently big, the manager chooses System \( \pi_1 \), as under the no-manipulation case. Upon seeing a \( h' \)-signal, the investor invests outright with a probability \( \chi_{h'} \) that increases in \( F \). As a result, \( V_m^\delta (\mu_0) \) decreases in \( F \) when \( F \) is sufficiently large.

**Corollary 5.** Suppose \( \mu_0 < \bar{\mu}_1 \). As \( m \) decreases, the post-manipulation signal \( y' \in (h', l') \) becomes less liberal.

Similar to the no-manipulation case, the post-manipulation signal \( y' \) is less liberal as investor inspection costs decrease.

**Corollary 6.** Suppose \( m < \bar{m} \) and \( \mu_0 < \bar{\mu}_1 \). Firms with a mis-aligned manager over-invest in bad projects, and over-investment decreases in \( \delta \).

While a larger scope of manipulation reduces the mis-aligned manager’s expected payoff, it improves investment efficiency when investor inspection costs are low. A larger \( \delta \) leads to more ex-post manipulation, and makes the investor more suspicious towards the \( h' \)-signal. As a result, the investor approves outright less (\( \chi_{h'} = \frac{F}{\delta (B + aN_b)} \)) and inspects more, which results in less over-investment and higher efficiency. The intuition is that the commitment to disclose the unaltered signal benefits the manager because it convinces the investors to invest according to the liberal system. A larger \( \delta \) weakens this commitment and leads the investor to rely more on her inspection, which improves investment efficiency.

Corollary 6 speaks to an unintended benefit of managerial discretion over disclosures. When the reporting system is endogenous, a commitment not to manipulate enables the manager to adopt reporting systems that discourage investor information acquisition, leading to over-investment in bad projects. Thus, when investor inspection costs are low, regulations that aim to soften such commitment will improve investment efficiency.
To summarize, a well-aligned manager’s optimal reporting system under the no-manipulation case remains optimal when manipulation is allowed, while a mis-aligned manager’s may no longer be optimal. The mis-aligned manager chooses the more informative System $\pi_2$ when both the scope and the cost of manipulation are small. The investor’s posterior upon seeing the signals are the same as under the no-manipulation case, but her investment may be less responsive to the signals. As $m$ decreases, the post-manipulation signals become more informative. Appendix 2(a) presents the optimal system for each case when manipulation is forbidden (the basic model), and Appendix 2(b) presents the optimal system when manipulation is allowed.

5 Conclusion

This paper analyzes how managers design their reporting strategies for forward-looking information about firms’ investment opportunities, in anticipation of investors’ information acquisition and intervention decisions. In the basic model, I assume the manager must truthfully disclose the signal generated by the system. In the extended model, I allow the manager to decide whether to manipulate the signal prior to its disclosure.

My basic model highlights that investor information acquisition serves different roles for well-aligned managers and mis-aligned managers. For the former, investor’s information acquisition leads to more informed investment decisions. For the latter, on the other hand, the investor’s information acquisition deters inefficient investment in bad projects. Incentive alignment is a prerequisite for managers to benefit from investors’ information acquisition. Furthermore, the model predicts that, if incentives are mis-aligned, lower investor inspection costs lead to more informative and less liberal reporting systems; when incentives are well-aligned, lower investor inspection costs lead to less informative systems, but the change in bias depends on the market prior. In the past decades, investor information acquisition cost has decreased substantially, which explains the research findings of a concurrent trend in the expansion of corporate disclosures (to the extent that incentive mis-alignment is present in the sample), and more importantly, also speaks to the increase in accounting conservatism. The results highlight the complex interactions among three key determinants of the optimal system: the cost of investor information acquisition, incentive alignment between the managers and the investor, and the prior belief about the investment opportunity.
The paper provides alternative explanations for several extant empirical results. For example, it shows that both mis-aligned and well-aligned managers voluntarily disclose bad news, as part of the optimally designed information system. In addition, the observed positive associations between the properties of disclosure (informativeness and bias) and investment efficiency can be a result of cross-sectional differences in investors’ inspection costs, and the observed earnings smoothing behavior can be chosen by well-aligned managers to induce investors’ information acquisition. Mis-aligned managers have stronger incentives to manipulate ex post, but also have stronger incentives to seek out external mechanisms to credibly commit to not manipulating. My model also generates yet-untested predictions for how disclosures are optimally structured under various conditions. For example, it identifies conditions under which mis-aligned managers issue more informative disclosures than well-aligned managers, and predicts how the informativeness and bias in disclosures vary across the business cycle. Overall, a key insight from my analysis is that the nature of the disclosed information and what investors do with the information matter for understanding firms’ disclosure behavior.
### Appendix 1: Variables and Definitions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_g, N_b$</td>
<td>The net present value of the project in good and bad state, respectively.</td>
</tr>
<tr>
<td>$\mu_0$</td>
<td>The commonly known prior about the state of the project (firm) being good.</td>
</tr>
<tr>
<td>$\lambda_g, \lambda_b$</td>
<td>The probability that the reporting system maps the good or bad state $\omega \in {g, b}$ into a high signal $h$.</td>
</tr>
<tr>
<td>$s$</td>
<td>The manager’s share of equity.</td>
</tr>
<tr>
<td>$m$</td>
<td>The investor’s inspection cost.</td>
</tr>
<tr>
<td>$B$</td>
<td>The manager’s private benefit from an approved project.</td>
</tr>
<tr>
<td>$k$</td>
<td>The cost of the reporting system per unit of entropy reduction.</td>
</tr>
<tr>
<td>$u(\mu, a)$</td>
<td>The investor’s expected payoff when her belief of state being good is $\mu$ and her action is $a \in {A, I, R}$.</td>
</tr>
<tr>
<td>$\mu_h, \mu_l$</td>
<td>The investor’s posterior belief about state being good after observing the signal $h$ or $l$, respectively.</td>
</tr>
<tr>
<td>$\bar{m}$</td>
<td>The threshold of investor inspection cost above which investors never find inspection optimal.</td>
</tr>
<tr>
<td>$\bar{\mu}_1$</td>
<td>The threshold of investor belief above which the investor prefers to inspect first over not investing; $\bar{\mu}_1 = \frac{m}{(1-s)N_g}$.</td>
</tr>
<tr>
<td>$\bar{\mu}_2$</td>
<td>The threshold of investor belief above which the investor prefers to inspect without inspection over inspecting; $\bar{\mu}_2 = 1 - \frac{m}{(1-s)N_g}$.</td>
</tr>
<tr>
<td>$\hat{v}_c(\mu_0)$</td>
<td>The manager’s expected payoff conditional on belief $\mu_0$ when the reporting system is costly ($k &gt; 0$). $\hat{v}<em>c(\mu_0) = \hat{v}(\mu_0) - k (H(\mu) - H(\mu</em>{\pi}(\mu, \mu_0)))$.</td>
</tr>
<tr>
<td>$\hat{v}(\mu_0)$</td>
<td>The manager’s expected payoff at $\mu_0$ when the reporting system cost goes to 0 ($k \to 0^+$).</td>
</tr>
<tr>
<td>$v_{FI}(\mu_0)$</td>
<td>The manager’s expected payoff at $\mu_0$ under a fully revealing reporting system.</td>
</tr>
<tr>
<td>$V(\mu_0)$</td>
<td>The manager’s maximum expected payoff at $\mu_0$ when $k \to 0^+$.</td>
</tr>
<tr>
<td>$\delta$</td>
<td>If the manager manipulates, he alters the output of the reporting system with probability $\delta$.</td>
</tr>
<tr>
<td>$F$</td>
<td>The fixed cost of manipulating the reporting system.</td>
</tr>
<tr>
<td>$\chi_h, \chi_l$</td>
<td>In the case with manipulation, the probability that the investor invests upon observing an $h$ ($l$) signal.</td>
</tr>
<tr>
<td>$\phi_h, \phi_l$</td>
<td>The equilibrium probability that a manager manipulates the system upon observing an $h$ ($l$) output.</td>
</tr>
<tr>
<td>$\mu_h(\phi_h, \phi_l)$</td>
<td>The posterior after observing the signal $h$ or $l$, when the $h$-signal ($l$-signal) manager manipulates with probability $\phi_h(\phi_l)$.</td>
</tr>
<tr>
<td>$V_\delta(\mu_0)$</td>
<td>The manager’s maximum expected payoff at $\mu_0$, when the scope of manipulation is $\delta$.</td>
</tr>
</tbody>
</table>
### Appendix 2(a): Summary of Results from the basic model (Section 3)

<table>
<thead>
<tr>
<th>Mis-aligned Manager</th>
<th>Well-aligned Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High inspection cost</strong> ( (m &gt; \bar{m}) )</td>
<td><strong>High inspection cost</strong> ( (m &gt; \bar{m}) )</td>
</tr>
<tr>
<td>Optimistic ( (\mu_0 \geq \max (\bar{\mu}, \bar{\mu}_2)) )</td>
<td>Fully Revealing</td>
</tr>
<tr>
<td>( \mu_h = \mu_0, \mu_l = \mu_0 )</td>
<td>( \mu_h = 1, \mu_l = 0 )</td>
</tr>
<tr>
<td>( \lambda_g = \lambda_b )</td>
<td>( \lambda_g = 1, \lambda_b = 0 )</td>
</tr>
<tr>
<td>Intermediate ( (\bar{\mu}_1 &lt; \mu_0 &lt; \bar{\mu}_2) )</td>
<td>Partially Revealing, Liberal</td>
</tr>
<tr>
<td>( \bar{\mu}_1 &lt; \mu_0 &lt; \bar{\mu}_2 )</td>
<td>( \mu_h = \bar{\mu}_2, \mu_l = 0 )</td>
</tr>
<tr>
<td>( \lambda_g = 1, \lambda_b = \frac{\mu_0 - \bar{\mu}_2}{\mu_0} )</td>
<td>( \lambda_g = 1, \lambda_b = 0 )</td>
</tr>
<tr>
<td>Pessimistic ( (\mu_0 &lt; \min (\bar{\mu}, \bar{\mu}_1)) )</td>
<td>Partially Revealing, Liberal</td>
</tr>
<tr>
<td>( \mu_0 &lt; \min (\bar{\mu}, \bar{\mu}_1) )</td>
<td>( \mu_0 &lt; \min (\bar{\mu}, \bar{\mu}_1) )</td>
</tr>
<tr>
<td>( \mu_h = \bar{\mu}, \mu_l = 0 )</td>
<td>( \mu_h = \bar{\mu}_2, \mu_l = 0 )</td>
</tr>
<tr>
<td>( \lambda_g = 1, \lambda_b = \frac{\mu_0 - \bar{\mu}}{1 - \mu_0} )</td>
<td>( \lambda_g = 1, \lambda_b = 0 )</td>
</tr>
<tr>
<td>( \lambda_g = 1, \lambda_b = \frac{\mu_0 - \bar{\mu}_2}{\mu_2} )</td>
<td>( \lambda_g = 1, \lambda_b = 0 )</td>
</tr>
<tr>
<td>( \lambda_g = 1, \lambda_b = \frac{\mu_0 - \bar{\mu}_1}{1 - \mu_0} )</td>
<td>( \lambda_g = 1, \lambda_b = 0 )</td>
</tr>
</tbody>
</table>
Appendix 2(b): Summary of Results from the Extended Model with Potential Manipulation (Section 4)

<table>
<thead>
<tr>
<th></th>
<th>Mis-aligned Manager</th>
<th>Well-aligned Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>High inspection cost</td>
<td>Low inspection cost</td>
<td></td>
</tr>
<tr>
<td>$(m &gt; \bar{m})$</td>
<td>$(m &lt; \bar{m})$</td>
<td></td>
</tr>
<tr>
<td>Optimistic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(\mu_0 \geq \max(\bar{\mu}, \bar{\mu}_2))$</td>
<td>Same as in Appendix 2(a)</td>
<td>Same as in 2(a)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Partially Revealing, Liberal</td>
<td></td>
</tr>
<tr>
<td>$(\bar{\mu}_1 &lt; \mu_0 &lt; \bar{\mu}_2)$</td>
<td>N/A</td>
<td>$\mu_{h'} = \bar{\mu}<em>2$, $\mu</em>{l'} = 0$ or $\mu_{l'} \in (\bar{\mu}_1, \mu_0)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\chi_{h'} = 1$ or $\frac{F}{s(1-\mu_0)(B+sN_b)}$</td>
</tr>
<tr>
<td>Pessimistic</td>
<td>Partially Revealing, Liberal</td>
<td>Partially Revealing, Liberal</td>
</tr>
<tr>
<td>$(\mu_0 &lt; \min(\bar{\mu}, \bar{\mu}_1))$</td>
<td>$\mu_{h'} = \bar{\mu}$, $\mu_{l'} = 0$</td>
<td>$\mu_{h'} = \bar{\mu}<em>2$, $\mu</em>{l'} = 0$</td>
</tr>
<tr>
<td></td>
<td>$\chi_{h'} = 1$ or $\frac{F}{s(B+sN_b)}$</td>
<td>$\chi_{h'} = 1$ or $\frac{F}{s(B+sN_b)}$</td>
</tr>
<tr>
<td></td>
<td>Same as in 2(a)</td>
<td>Same as in 2(a)</td>
</tr>
</tbody>
</table>
Appendix 3: Proofs

Proof of Lemma 1:

Let \( \bar{\mu}_1 \) denote the posterior belief that the state is \( \omega = g \), such that the investor is indifferent between rejecting and inspecting before investing, i.e., \( (1 - s) \bar{\mu}_1 N_g - m = 0 \), which yields \( \bar{\mu}_1 = \frac{m}{(1 - s)N_g} \).

When \( \mu > \bar{\mu}_1 \), the investor strictly prefers inspecting over rejecting. Similarly, let \( \bar{\mu}_2 \) be the posterior belief about state \( \omega = g \) such that the investor is indifferent between investing directly and inspecting before investing, i.e., \( (1 - s) \bar{\mu}_2 N_g - m = (1 - s) (\mu N_g + (1 - \mu) N_b) \), which yields \( \bar{\mu}_2 = 1 - \frac{m}{(1 - s)N_b} \).

When \( \mu < \bar{\mu}_2 \), the investor strictly prefers inspecting over investing directly. Finally define \( \bar{\mu} \) as the posterior belief about state \( \omega = g \) such that the investor is indifferent between directly rejecting and directly investing, i.e., \( (1 - s) (\mu N_g + (1 - \mu) N_b) = 0 \), which yields \( \bar{\mu} = \frac{|N_b|}{|N_b| + N_g} \). The investor strictly prefers investing to rejecting when \( \mu > \bar{\mu} \).

Inspecting before investing is optimal only when \( \bar{\mu}_1 < \mu < \bar{\mu}_2 \), which implies that \( \bar{\mu}_1 < \bar{\mu}_2 \). Let \( \bar{m} \) be the threshold inspection cost that equates \( \bar{\mu}_1 = \bar{\mu}_2 \). Rearranging \( \frac{m}{(1 - s)N_g} < 1 - \frac{m}{(1 - s)N_b} \) yields \( \bar{m} = \frac{(1-s)N_g N_b}{|N_b| + N_g} \). Thus, when \( m \geq \bar{m} \), the investor will approve outright without inspection if \( \mu \geq \bar{\mu} \) and will reject outright if \( \mu < \bar{\mu} \). When \( m < \bar{m} \), the investor will inspect and invest only in good projects if \( \bar{\mu}_1 < \mu < \bar{\mu}_2 \); the investor will reject outright if \( \mu < \bar{\mu}_1 \), and approve outright if \( \mu > \bar{\mu}_2 \).

Proof of Proposition 1: The optimal system of a mis-aligned manager

1. When \( m \geq \bar{m} \), the investor does not inspect.

(a) The case where \( \mu_0 \geq \bar{\mu} \): Consider any Bayesian plausible posterior \( \mu_h \) and \( \mu_l \). Then manager’s expected payoff under this system is:

\[
\mathbb{E}(\hat{v}(\mu)) = \mathbb{E}(1(\mu \geq \bar{\mu}) (B + s (\mu N_g + (1 - \mu) N_b)))
\]
\[
= \mathbb{E}(1(\mu \geq \bar{\mu}) \mu (B + s N_g)) + \mathbb{E}(1(\mu \geq \bar{\mu}) (1 - \mu) (B + s N_b))
\]
\[
\leq \mathbb{E}(\mu (B + s N_g)) + \mathbb{E}((1 - \mu) (B + s N_b)) = \hat{v}(\mu_0)
\]

Thus, the uninformative system gives the highest expected payoff. Since any informative system incurs a positive cost, the uninformative system is optimal.

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(b) If $0 < \mu_0 < \bar{\mu}$: First, if the optimal system is informative, it must have $\mu_h \geq \bar{\mu}$.

Otherwise, $\mathbb{E}(\hat{v}(\mu)) = \Pr(\mu_h) \hat{v}(\mu_h) + \Pr(\mu_l) \hat{v}(\mu_l) = 0$, the same as the payoff under the uninformative system. Second, the optimal system must have $\mu_l = 0$. If not, assume the optimal system $\pi$ has $\mu_l > 0$ and $\mu_h \geq \bar{\mu}$. Then consider an alternative system $\pi'$ with $\mu_l = 0$ and $\mu_h \geq \bar{\mu}$. Since $\mu_0 = \Pr(\mu_h|\pi) \mu_h + \Pr(\mu_l|\pi) \mu_l = \Pr(\mu_h|\pi') \mu_h$, we have $\Pr(\mu_h|\pi') > \Pr(\mu_h|\pi)$, that is, the probability of generating a high signal $h$ is higher under $\pi'$.

$$
\mathbb{E}_{\pi(\mu_h,\mu_l)}(\hat{v}(\mu)) = \Pr(\mu_l|\pi) \hat{v}(\mu_l) < \Pr(\mu_h|\pi') \hat{v}(\mu_h) = \mathbb{E}_{\pi(\mu_h,\mu_l)}(\hat{v}(\mu))
$$

Finally, the optimal system must have $\mu_h = \bar{\mu}$. Suppose this is not the case, then assume $\mu_l = 0$ and $\mu_h > \bar{\mu}$. Consider an alternative system $\pi'$ with $\mu_l = 0$ and $\mu_h = \bar{\mu}$.

$$
\mathbb{E}_{\pi(\mu_h,\mu_l)}(\hat{v}(\mu)) = \Pr(\mu_h|\pi) \hat{v}(\mu_h) = \Pr(\mu_h|\pi') B + \Pr(\mu_l|\pi) (s\mu_h N_g + s (1 - \mu_h) N_b) < \Pr(\mu_h|\pi') B + (s\mu_0 N_g + s (1 - \mu_0) N_b) = \mathbb{E}_{\pi(\mu_h,\mu_l)}(\hat{v}(\mu))
$$

So, the optimal reporting system has posterior $\mu_l = 0$ and $\mu_h = \bar{\mu}$. Solving for $\lambda_g$ and $\lambda_b$ yields $\lambda_g = 1$ and $\lambda_b = \frac{\mu_0}{1 - \mu_0} \frac{1 - \bar{\mu}}{\bar{\mu}}$.

2. When $m < \bar{m}$:

(a) The case $\mu_0 \geq \bar{\mu}_2$: The manager’s achieves the highest expected payoff under an uninformative system:

$$
\mathbb{E}(\hat{v}(\mu)) = \mathbb{E}(1(\mu_2 > \mu \geq \bar{\mu}_1) \mu (B + s N_g)) + \mathbb{E}(1(\mu \geq \bar{\mu}_2) (B + s (\mu N_g + (1 - \mu) N_b)))
$$

$$
= \mathbb{E}(1(\mu \geq \bar{\mu}_1) \mu (B + s N_g)) + \mathbb{E}(1(\mu \geq \bar{\mu}_2) (B + s N_b))
$$

$$
\leq \mathbb{E}(\mu (B + s N_g)) + \mathbb{E}((1 - \mu) (B + s N_b))
$$

$$
= B + s (\mu_0 N_g + (1 - \mu_0) N_b) = \hat{v}(\mu_0)
$$

Since any informative system incurs a positive cost, the optimal system is uninformative,
with $\mu_h = \mu_l = \mu_0$.

(b) The case $\bar{\mu}_1 < \mu_0 < \bar{\mu}_2$: First, if the optimal system is informative, it must have $\mu_h \geq \bar{\mu}_2$. Otherwise, the manager’s expected payoff will be no higher than with the uninformative system, $\hat{v}(\mu_0)$:

$$\mathbb{E}(\hat{v}(\mu)) = \mathbb{E}(1(\mu > \mu_1) \mu (B + sN_g)) + \mathbb{E}(1(\mu \geq \bar{\mu}_2) (B + s(\mu N_g + (1 - \mu) N_b)))$$

$$\leq \mathbb{E}(\mu (B + sN_g)) = \mu_0 (B + sN_g) = \hat{v}(\mu_0)$$

Second, the optimal system must have $\mu_l = 0$. Otherwise, assume the optimal system $\pi$ has $\mu_l > 0$ and $\mu_h \geq \bar{\mu}_2$. An alternative system $\pi'$ with the same $\mu_h$ and $\mu_l = 0$ will give higher expected payoff for any $\mu_l \leq \mu_0 < \bar{\mu}_2$:

If $\mu_l < \bar{\mu}_1$:

$$\mathbb{E}_{\pi(\mu_h, \mu_l)}(\hat{v}(\mu)) = \mathbb{E}(\mu_h | \pi) \hat{v}(\mu_h) + \mathbb{E}(\mu_l | \pi) \hat{v}(\mu_l) = \mathbb{E}_{\pi(\mu_h, 0)}(\hat{v}(\mu))$$

If $\bar{\mu}_1 \leq \mu_l < \bar{\mu}_2$:

$$\mathbb{E}_{\pi(\mu_h, \mu_l)}(\hat{v}(\mu)) = \mathbb{E}(\mu_h | \pi) \hat{v}(\mu_h) + \mathbb{E}(\mu_l | \pi) \hat{v}(\mu_l) = \mu_0 (B + sN_g) + \mathbb{E}(\mu_h | \pi) (B + sN_b) < \mathbb{E}_{\pi(\mu_h, 0)}(\hat{v}(\mu))$$

Third, the optimal system must have $\mu_h = \bar{\mu}_2$. If this is not the case, assume $\mu_l = 0$ and $\mu_h > \bar{\mu}_2$. Then an alternative system $\pi'$ with $\mu_l = 0$ and $\mu_h = \bar{\mu}_2$ will give higher payoff:

$$\mathbb{E}_{\pi(\mu_h, 0)}(\hat{v}(\mu)) = \mathbb{E}(\mu_h | \pi) (B + s(\mu_h N_g + (1 - \mu_h) N_b))$$

$$< \mathbb{E}(\mu_h | \pi) (B + s(\mu_0 N_g + (1 - \mu_0) N_b)) = \mathbb{E}_{\pi(\mu_2, 0)}(\hat{v}(\mu))$$

Solving for $\lambda_g$ and $\lambda_b$ yields $\lambda_g = 1$ and $\lambda_b = \frac{\mu_0}{\bar{\mu}_2 - \mu_0} \frac{1 - \mu_2}{\bar{\mu}_2}$.

(c) The case $0 < \mu_0 < \bar{\mu}_1$: First, the optimal system is informative and has $\mu_h \geq \bar{\mu}_1$. When $\mu_h > \bar{\mu}_1$ and $Pr(h|\pi) > 0$, the manager’s expected payoff is positive. Otherwise, his expected payoff is 0. Second, $\mu_l = 0$. Otherwise, assume optimal system has $\mu_l > 0$ and
\( \mu_h \geq \bar{\mu}_1 \). Then consider an alternative system \( \pi' \) with \( \mu_l = 0 \) and \( \mu_h \):

\[
\mathbb{E}_{\pi(\mu_h,\mu_l)}(\hat{v}(\mu)) = \Pr(\mu_h|\pi) \hat{v}(\mu_h) < \Pr(\mu_h|\pi') \hat{v}(\mu_h) = \mathbb{E}_{\pi(\mu_h,0)}(\hat{v}(\mu))
\]

Third, the optimal system has \( \mu_h = \bar{\mu}_2 \). For a system with \( \mu_l = 0 \) and \( \bar{\mu}_1 < \mu_h < \bar{\mu}_2 \),

\[
\mathbb{E}(\hat{v}(\mu')) = \Pr(\mu_h|\pi) \hat{v}(\mu_h) = \Pr(\mu_h|\pi) \mu_h (B + sN_g) = \mu_0 (B + sN_g)
\]

But a system with \( \mu_h \geq \bar{\mu}_2 \) achieves a higher expected payoff:

\[
\mathbb{E}_{\pi(\mu_h,0)}(\hat{v}(\mu)) = \Pr(\mu_h|\pi) \hat{v}(\mu_h) = \Pr(\mu_h|\pi) B + s (\mu_0 N_g + (1 - \mu_0) N_b) \leq \mathbb{E}_{\pi(\bar{\mu}_2,0)}(\hat{v}(\mu))
\]

So the optimal system has \( \mu_h = \bar{\mu}_2 \) and \( \mu_l = 0 \), with \( \lambda_g = 1 \) and \( \lambda_b = \frac{\mu_0}{1 - \mu_0} \frac{1 - \bar{\mu}_2}{\bar{\mu}_2} \).

**Proof of Corollary 1:**

1. Note that \( \bar{\mu}_2 = 1 - \frac{m}{(1-s)[N_b]} \). For a mis-aligned manager, the range of market priors in which uninformative system is optimal is \([\bar{\mu}, 1]\), where \( \bar{\mu} = \min\{\bar{\mu}, \bar{\mu}_2\} \). As \( m \) decreases, \( \bar{\mu}_2 \) and \( \bar{\mu} \) increase. Thus the range of informative disclosure expands and the range of uninformative disclosure \([\bar{\mu}, 1]\) shrinks.

2. Note a mis-aligned manager chooses \( \lambda_g = 1 \) and \( \lambda_b = \frac{\mu_0}{1 - \mu_0} \frac{1 - \bar{\mu}_2}{\bar{\mu}_2} \). In the range of priors with informative systems, the disclosure is liberal since \( 1 - \lambda_g < \lambda_b \). As \( m \) decreases, \( \lambda_b \) decreases, and by the definition of bias and informativeness in Section 2, the system becomes less liberal and more informative.

**Proof of Corollary 2: Mis-aligned manager’s investment efficiency**

Under the optimal system, for a market prior belief \( \mu_0 \in (0, \bar{\mu}) \), the optimal system has \( \mu_l = 0 \) and \( \mu_h = \bar{\mu} \), and thus \( \Pr(h) = \frac{\mu_0}{\bar{\mu}} \). If \( \mu_0 \in (\bar{\mu}, 1) \), the system is uninformative and the investor approves the project with probability 1. Thus, the probability of investment is \( \min\{\frac{\mu_0}{\bar{\mu}}, 1\} \), while the efficient level of investment is \( \mu_0 \) (only good projects are invested, and the probability of a project being
good is $\mu_0$). The firm over-invests in some bad projects when $\mu_0 < \bar{\mu}$ (note $\lambda_g = 1$ and $\lambda_b > 0$), and also when $\bar{\mu} \leq \mu_0 < 1$ (the system is uninformative and the investor invests with probability 1).

Thus, the level of over-investment is $\min\left\{\frac{\mu_0}{\bar{\mu}}, 1\right\} - \mu_0$. As $m$ decreases, $\bar{\mu}_2$ weakly increases, and over-investment weakly decreases.

**Proof of Proposition 2: The optimal system of a well-aligned manager**

When two systems give the manager the same expected gross payoff, the manager prefers the least informative one since it is least costly.

1. If $m \geq \bar{m}$: consider any system $\pi$:

$$
\mathbb{E}(\hat{v}(\mu)) = \mathbb{E}(1(\mu \geq \bar{\mu}) (B + s (\mu N_g + (1 - \mu) N_b)) + \mathbb{E}(1(\mu > \bar{\mu}) (1 - \mu) (B + s N_b)) \\
\leq \mathbb{E}(1(\mu \geq \bar{\mu}) (B + s N_g)) \leq \mu_0 (B + s N_g) = v_{FI}(\mu_0)
$$

The optimal reporting system is fully revealing.

2. If $m < \bar{m}$: First note that for any $\mu_0$, the maximum expected payoff to the manager has an upper bound. For any system $\pi$,

$$
\mathbb{E}(\hat{v}(\mu)) = \mathbb{E}(1(\mu \geq \bar{\mu}_1) \mu (B + s N_g) + 1(\mu > \bar{\mu}_2) (1 - \mu) (B + s N_b)) \\
\leq \mathbb{E}(\mu (B + s N_g)) = \mu_0 (B + s N_g)
$$

(a) If $\mu_0 > \bar{\mu}_2$: Under the uninformative system, the manager’s payoff is:

$$
\hat{v}(\mu_0) = (B + s (\mu_0 N_g + (1 - \mu_0) N_b))
$$

Smaller than $\mu_0 (B + s N_g)$. But with $\mu_h = 1$ and $\mu_l = \bar{\mu}_2$, the manager’s expected payoff is:

$$
\mathbb{E}_{\pi(1,\bar{\mu}_2)}(\hat{v}(\mu)) = \mathbb{E}_{\pi(1,\bar{\mu}_2)}(1(\mu \geq \bar{\mu}_1) \mu (B + s N_g) + 1(\mu > \bar{\mu}_2) (1 - \mu) (B + s N_b)) \\
= \mu_0 (B + s N_g)
$$
When \( \mu = \bar{\mu}_2 \), the investor is indifferent between inspecting at cost \( m \) and investing without inspection, and I assume that she chooses the well-aligned manager’s favored action, i.e., to inspect the project. The optimal disclosure must have \( \mu_h = 1 \). Assume \( 1 > \mu_h \geq \mu_0 > \bar{\mu}_2 \),

\[
\mathbb{E}_{\pi(\mu_h, \mu_l)} (\hat{v}(\mu)) = \mathbb{E}_{\pi(\mu_h, \mu_l)} (1(\mu \geq \bar{\mu}_1) \mu (B + sN_g) + 1(\mu > \bar{\mu}_2) (1 - \mu) (B + sN_b)) < \mathbb{E}_{\pi(\mu_h, \mu_l)} (1(\mu \geq \bar{\mu}_1) \mu (B + sN_g)) \leq \mu_0 (B + sN_g)
\]

Only when \( \mu_h = 1 \) and \( \mu_l \leq \bar{\mu}_2 \), we have \( \mathbb{E}_{\pi(\mu_h, \mu_l)} (\hat{v}(\mu)) = \mu_0 (B + sN_g) \). Since the manager chooses the least informative one within a class of systems with the same expected payoff, the optimal system has \( \mu_h = 1 \) and \( \mu_l = \bar{\mu}_2 \). Thus \( \lambda_b = 0 \) and \( \lambda_g = 1 - \frac{1 - \mu_0}{\mu_0} \cdot \frac{\bar{\mu}_2}{1 - \bar{\mu}_2} \).

(b) If \( \bar{\mu}_1 \leq \mu_0 < \bar{\mu}_2 \): The optimal system is uninformative. In this case, under the uninformative system, the investor will inspect and the manager’s expected payoff is \( \hat{v}(\mu_0) = \mu_0 (B + sN_g) \), which is the highest achievable payoff. Other systems with \( \bar{\mu}_1 \leq \mu_l \leq \mu_h \leq \bar{\mu}_2 \) all give the same expected payoff. Since the manager picks the least informative one among the class of systems with the same expected payoff, his optimal system is uninformative with \( \mu_h = \mu_l = \mu_0 \).

(c) If \( \mu_0 < \bar{\mu}_1 \): First, the optimal system must have \( \mu_h \geq \bar{\mu}_1 \). Otherwise, since \( \mu_l \leq \mu_h < \bar{\mu}_1 \), no investment occurs and the manager’s payoff is 0. Second, the optimal system must have \( \mu_l = 0 \). Otherwise, if \( \mu_l > 0 \), an alternative system with the same \( \mu_h \) but \( \mu_l = 0 \) will yield a higher expected payoff:

\[
\mathbb{E}_{\pi(\mu_h, \mu_l)} (\hat{v}(\mu)) = \Pr (\mu_h | \pi) \hat{v}(\mu_h) < \Pr (\mu_h | \pi') \hat{v}(\mu_h) = \mathbb{E}_{\pi(\mu_h, 0)} (\hat{v}(\mu))
\]

Systems with \( \bar{\mu}_1 \leq \mu_h \leq \bar{\mu}_2 \) and \( \mu_l = 0 \) achieve the maximum expected payoff.

\[
\mathbb{E}_{\pi(\mu_h \geq \bar{\mu}_1, 0)} (\hat{v}(\mu)) = \mu_0 (B + sN_g)
\]

The optimal system has \( \mu_l = 0 \) and \( \mu_h = \bar{\mu}_1 \), since this is the least informative system among the class that obtains the highest payoff. The manager chooses \( \lambda_g = 1 \) and
\[ \lambda_b = \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_1}{\bar{\mu}_1}. \]

**Proof of Corollary 3:**

1. For a well-aligned manager, when \( m < \bar{m}, \) as \( m \) decreases, \( \bar{\mu}_1 = \frac{m}{(1-s)N_g} \) decreases, and \( \bar{\mu}_2 \) increases. Thus, the range of priors over which the manager prefers uninformative systems, \( U = [\bar{\mu}_1, \bar{\mu}_2] \), expands. The range of priors over which the manager prefers informative systems, \( I = (0, \bar{\mu}_1) \cup (\bar{\mu}_2, 1) \), shrinks.

2. When \( \mu_0 \in (0, \bar{\mu}_1) \), the optimal system has \( \lambda_g = 1 \) and \( \lambda_b = \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}_1}{\bar{\mu}_1} \). The system is liberal since \( 1 - \lambda_b < \lambda_g \). When \( m \) decreases, \( \lambda_b \) increases, thus \( \mu_h \) decreases and \( \mu_l \) remains 0, thus the system becomes more liberal and less informative.

3. When \( \mu_0 \in (\bar{\mu}_2, 1) \), the optimal system has \( \lambda_b = 0 \) and \( \lambda_g = 1 - \frac{1-\mu_0}{\mu_0} \frac{\bar{\mu}_2}{1-\bar{\mu}_2} \). The system is conservative since \( \lambda_g < 1 - \lambda_b \). When \( m \) decreases, \( \lambda_g \) decreases, thus \( \mu_l \) increases and \( \mu_h \) remains 1, and the system becomes less informative and more conservative.

**Proof of Lemma 2:**

The proof is similar to the proof of the Revelation Principle. Consider the optimal reporting system in the case where \( \delta > 0 \). In equilibrium, the manager may or may not manipulate. Suppose, in equilibrium, the investor’s posteriors upon receiving the disclosed signals are \( \mu_h' \) and \( \mu_l' \). Since the investor interprets the signals rationally, \( \mathbb{E}(\mu_y') = \mu_0 \), i.e., the post-manipulation posterior must satisfy the Bayes-plausibility constraint. The manager’s expected payoff \( \mathbb{E}(r_y) = \mathbb{E}(\hat{v}(\mu_y')) - \Phi \), in which \( \mathbb{E}(\hat{v}(\mu_y')) \) is determined by this distribution of the investor’s posterior, and \( \Phi \geq 0 \) is the expected cost from manipulation. For any distribution of \( \mu_h', \mu_l' \), the manager can always find a system \( \pi \) under the no-manipulation case that generates the same distribution of posteriors \( (\mu_h = \mu_h', \mu_l = \mu_l') \). In the no-manipulation case, this system yields the same expected gross payoff, but will not incur the cost of manipulation. Thus, the manager is ex ante better off in the no-manipulation case.
Proof of Lemma 3:

The manager's maximum payoff in the manipulation case will not exceed his payoff in the no-manipulation case. For a well-aligned manager, if his optimal system in no-manipulation case yields the same expected payoff in the manipulation case, this system must be optimal in the manipulation case as well. This is indeed the case. Under the optimal system from the no-manipulation case, the well-aligned manager has no incentive to manipulate, since the investor will always take the manager’s favored action. Manipulation is then not only costly, but may also lead the investor to choose a less desirable action. Thus, allowing the well-aligned manager to manipulate the disclosed signal will not change his reporting system.

Lemma 4. When manipulation is allowed, a mis-aligned manager never manipulates when he privately observes a h-signal, i.e., \( \phi_h = 0 \).

Lemma 4 shows that the manager with a h-signal never manipulates. In the following discussion, I simplify the notation \( \mu_y' (\phi_h, \phi_l) \) to \( \mu_y' (\phi_l) \).

Proof of Lemma 4:

Suppose the reporting system is in place and the original signals \( h \) (\( l \)) lead to posterior \( \mu_h \) (\( \mu_l \)). The requirement \( \lambda_y \geq \lambda_b \) ensures \( \mu_h \geq \mu_l \). The proof has two steps. First, I show that at most one type of managers will manipulate; second, I show that the manager with a h-signal never manipulates.

1. Suppose both managers with h-signal and l-signal manipulate. Then

\[
(1 - \delta) \hat{v} (\mu_h') + \delta \hat{v} (\mu_l') - F \geq \hat{v} (\mu_l')
\]

\[
(1 - \delta) \hat{v} (\mu_l') + \delta \hat{v} (\mu_h') - F \geq \hat{v} (\mu_l')
\]

This implies \( -F \geq \delta (\hat{v} (\mu_h') - \hat{v} (\mu_l')) \geq F \), which is a contradiction. Thus, at most one type manipulates.

2. Suppose the manager with a h-signal manipulates. Then \( \hat{v} (\mu_l') > \hat{v} (\mu_h') \). However, since \( \mu_h \geq \mu_l \), we have \( \mu_h' (\phi_h, 0) = \mu_h > \mu_l' (\phi_h, 0) \), and \( \hat{v} (\mu_h' (\phi_h, 0)) > \hat{v} (\mu_l' (\phi_h, 0)) \). Contradiction. Thus, a h-signal manager will not manipulate, and \( \phi_h = 0 \) in equilibrium. Only managers with a l-signal may manipulate (\( \phi_l \geq 0 \)).
Lemma 5. Assume $\lambda_g = 1$. Upon observing the original output $y$, the mis-aligned manager's manipulation decision and the investor's inspection decision, are as follows:

1. If $\lambda_b > \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0}$: The $l$-signal manager does not manipulate ($\phi_l = 0$). The investor inspects if $\mu_y (\phi_l = 0) \geq \hat{\mu}_1$, and invests only if inspection reveals a good firm.

2. If $1 - \delta \left( \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0} - \delta \right) < \lambda_b < \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0}$: The $l$-signal manager manipulates with probability $\phi_l = \frac{1}{\delta} \left( \frac{\mu_0 (1-\hat{\mu})}{(1-\mu_0)\mu} - \lambda_b \right)$. The investor invests without inspection upon seeing the $h'$-signal with probability $\chi_{h'} = \frac{F}{\delta(B+s\lambda_b)}$.

3. If $\lambda_b < 1 - \delta \left( \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0} - \delta \right)$: The $l$-signal manager manipulates with probability $\phi_l = 1$. The investor invests without inspection upon seeing the $h'$-signal with probability $\chi_{h'} = 1$.

Lemma 5 shows that the $l$-signal manager manipulates only if manipulation increases the probability of approval without inspection, since he knows that his project is bad for sure ($\mu_y (\phi_l = 0) = 0$), which will be revealed in an inspection. Furthermore, a more liberal system leads to less manipulation. That is, $\phi_l$ weakly decreases in $\lambda_b$. This is intuitive, as a higher $\lambda_b$ makes the $h'$-signal less indicative of a good state and the investor less willing to invest. The lower payoff to a $h'$-signal leads to less manipulation.

Proof of Lemma 5:

There are three cases.

1. If $\lambda_b > \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0}$: In this case, the original signal yields posteriors $\mu_h < \hat{\mu}$ and $\mu_l = 0$. The disclosed signal has $\mu_{h'} (\phi_l) < \hat{\mu}$, regardless of $\phi_l$, and a $h'$-signal leads to inspection if $\mu_{h'} (\phi_l) > \hat{\mu}_1$, or outright rejection if $\mu_{h'} (\phi_l) < \hat{\mu}_1$. In either case, the $l$-signal manager has no incentive to manipulate, since he knows for sure that his project is bad and will be revealed by the inspection. Thus, in equilibrium $\phi_l = 0$.

2. If $1 - \delta \left( \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0} - \delta \right) < \lambda_b < \frac{1-\hat{\mu}}{\mu} \frac{\mu_0}{1-\mu_0}$: In this case, the original signal gives posteriors $\mu_h > \hat{\mu}$ and $\mu_l = 0$, but the disclosed signal has $\mu_{h'} (1) < \mu_h < \mu_{h'} (0)$. It can not constitute an equilibrium if the $l$-signal manager employs a pure strategy, i.e., if he manipulates for sure or if he never manipulates. If he manipulates for sure, the investor’s posterior $\mu_{h'} (1) < \hat{\mu}$ is too low.
to justify outright approval, and hence manipulation does not pay off. On the other hand, if he never manipulates, then \( \mu_{h'} (0) > \bar{\mu} \), and the investor approves upon seeing the \( h' \)-signal with certainty, which leads the manager to strictly prefer manipulation. Thus, in equilibrium, the \( l \)-signal manager manipulates with a positive probability \( \phi_l \) to make the investor indifferent between approval and inspection, and the investor approves upon seeing the \( h' \)-signal with probability \( \chi_{h'} \) to make the \( l \)-signal manager indifferent between manipulation or not. This requires that \( \mu_{h'}(\phi_l) = \bar{\mu} \), and \( \chi_{h'}(B + sN_b) - F = 0 \), i.e., \( \phi_l = \frac{1}{\delta} \left( \frac{\mu_0(1 - \bar{\mu})\lambda_0}{(1 - \mu_0)\mu} - \lambda_b \right) \) and \( \chi_{h'} = \frac{F}{\delta (B + sN_b)} \).

3. If \( \lambda_b < \frac{1}{1 - \delta} \left( \frac{1 - \bar{\mu}}{\mu} \frac{\mu_0}{1 - \mu_0} - \delta \right) \): In this case, the original signal gives posteriors \( \mu_b > \bar{\mu} \) and \( \mu_l = 0 \). The disclosed signal has \( \mu_{h'} (1) > \bar{\mu} \). That is, even if the \( l \)-signal manager manipulates for sure, the investor is still willing to approve without inspection upon seeing the \( h' \)-signal. For a \( l \)-signal manager, the expected payoff from manipulation is \( \delta (B + sN_b) \), greater than the cost \( F \). Thus, he manipulates with certainty. \( \chi_{h'} = 1 \) and \( \phi_l = 1 \) constitutes an equilibrium.

**Lemma 6.** When \( m \geq \bar{m} \), depending on the investor’s response to a \( h' \)-signal, the systems that give the mis-aligned manager positive expected payoff can be classified into two exhaustive and mutually exclusive types. Denote \( r_y = \mathbb{E}(\hat{v}(\mu_{h'}(\phi_b, \phi_l)) | y) \), the manager’s expected payoff conditional on observing an original signal \( y \). The types and the optimal system within each type, are identified as follows.

1. **Systems that induce investors to approve without inspection with probability \( \chi_{h'} < 1 \) upon receiving the \( h' \)-signal.** Among this class, the optimal system is \( \pi_1 \) with \( \lambda_g = 1 \) and \( \lambda_b = \frac{1 - \bar{\mu}}{\mu} \frac{\mu_0}{1 - \mu_0} \). Under \( \pi_1 \), upon seeing a \( h' \)-signal, the investor approves outright with probability \( \chi_{h'} = \frac{F}{\delta (B + sN_g)} \), and rejects outright with probability \( 1 - \chi_{h'} \). The manager’s expected payoff is \( \mathbb{E}_{\pi_1} (r_y(\mu_0)) = \frac{F}{\delta (B + sN_g)} \left( \mu_0 (B + sN_g) + \mu_0 \frac{1 - \bar{\mu}}{\mu} (B + sN_b) \right) \).

2. **Systems that induce investor’s outright approval upon receiving the \( h' \)-signal.** Among this class, the optimal system is \( \pi_2 \) with \( \lambda_g = 1 \) and \( \lambda_b = \frac{1}{1 - \delta} \left( \frac{1 - \bar{\mu}}{\mu} \frac{\mu_0}{1 - \mu_0} - \delta \right) \). Under \( \pi_2 \), the investor approves outright upon seeing a \( h' \)-signal with probability \( \chi_{h'} = 1 \), and the \( l \)-signal manager manipulates with probability \( \phi_l = 1 \). The manager’s expected payoff is \( \mathbb{E}_{\pi_2} (r_y(\mu_0)) = \mu_0 (B + sN_g) + \mu_0 \frac{1 - \bar{\mu}}{\mu} (B + sN_b) - (1 - \mu_0) \left( 1 - \frac{1}{1 - \delta} \left( \frac{1 - \bar{\mu}}{\mu} \frac{\mu_0}{1 - \mu_0} - \delta \right) \right) F \).
Lemma 6 introduces the reporting systems that are each optimal within a given type of systems, and are thus potential candidates for the optimal system.

**Proof of Lemma 6:**

The idea in the proof of Lemma 6 is that, when \( m \geq \bar{m} \), for any reporting system \( \pi \) with \( \lambda_g < 1 \), there exists a reporting system with \( \lambda_g = 1 \) and gives the mis-aligned manager a weakly higher payoff in expectation. Suppose, in equilibrium, the \( l \)-signal manager manipulates with probability \( \phi_l \). First classify all reporting systems into two types and identify the optimal system within each type.

1. Systems that induce investor’s outright approval with probability \( 0 < \chi_{h'} < 1 \): Since in equilibrium the investor uses a mixed strategy, she must be indifferent between outright approval and outright rejection, which is only possible when \( \mu_{h'}(\phi_l) = \bar{\mu} \). In addition, in order to make the manager indifferent between manipulating or not, \( \hat{v}(\mu_{l'}) = 0 \) and \( \chi_{h'} = \frac{F}{\delta(B + sN_g + (1 - \mu_l)N_b)} \). Thus \( \chi_{h'} \) decreases in \( \mu_l \). Since the manager’s ex-ante expected payoff is \( \Pr(\mu_{h'}|\pi) \chi_{h'}(B + s(\bar{\mu}N_g + (1 - \bar{\mu})N_b)) \), System \( \pi_1 \) with \( \mu_{h'} = \bar{\mu} \) and \( \mu_l = 0 \) is optimal within this class, which maximizes \( \chi_{h'} \Pr(\mu_{h'}|\pi) \). Under System \( \pi_1 \), in equilibrium, both managers with \( h \)- or \( l \)-signal do not manipulate, and the investor’s posterior is either \( \mu_{h'} = \bar{\mu} \) or \( \mu_{l'} = 0 \). She approves outright upon seeing a \( h' \)-signal with probability \( \chi_{h'} = \frac{F}{\delta(B + sN_b)} \).

Under System \( \pi_1 \), the manager’s expected payoff is:

\[
\mathbb{E}_{\pi_1}(r_g|m \geq \bar{m}) = \mathbb{E}_{\pi_1}(\hat{v}(\mu_{l'})) - \Phi_{\pi_1} = \chi_{h',1} \Pr(h') v(\mu_{l'}, a = A) = \frac{F}{\delta(B + sN_b)} \left[ \mu_0 (B + sN_g) + \mu_0 \frac{1 - \bar{\mu}}{\bar{\mu}} (B + sN_b) \right]
\]

2. Systems that induce outright approval \((\chi_{h'} = 1)\): In this type of systems, in equilibrium, \( \mu_{h'}(\phi_h, \phi_l) \geq \bar{\mu} \) and \( \chi_{h'} = 1 \). The investor invests outright upon receiving a \( h' \)-signal. I show that System \( \pi_2(\lambda_g = 1, \lambda_b = \frac{1}{1 - \delta}\left(\frac{1 - \bar{\mu}}{\bar{\mu}} - \frac{\mu_0}{1 - \mu_0} - \delta\right)) \) achieves the highest payoff among this type of systems. Under System \( \pi_2 \), the original signal has \( \mu_h > \bar{\mu} \) and \( \mu_l = 0 \). A \( l \)-signal manager manipulates with certainty \((\phi_l = 1)\), and the investor’s posteriors are \( \mu_{h'} = \bar{\mu} \) and \( \mu_{l'} = 0 \). As
such, the $h'$-signal is sufficiently convincing that upon seeing a $h'$-signal the investor approves outright. For any system $\pi$ in this class, I show that $E_\pi (\hat{v} (\mu)) \leq E_{\pi_2} (\hat{v} (\mu))$ by similar proof of Proposition 1. Furthermore, note that the expected manipulation cost is

$$\Phi_\pi = F ((1 - \mu_0) (1 - \lambda_b) + \mu_0 (1 - \lambda_g))$$

Thus, System $\pi_2$ gives the lowest manipulation cost since it has largest $\lambda_g, \lambda_b$ within this type. Thus, $\pi_2$ achieves the highest expected payoff within this class:

$$E_\pi (r_y) = E_\pi (\hat{v}' (\mu')) - \Phi_\pi \leq E_{\pi_2} (\hat{v} (\mu)) - \Phi_{\pi_2}$$

And the mis-aligned manager’s payoff under System $\pi_2$ is:

$$\begin{align*}
E_{\pi_2} (r_y) &= E_{\pi_2} (\hat{v} (\mu')) - \Phi_{\pi_2} = \Pr (h') v (\mu_h', a = A) - (1 - \mu_0) (1 - \lambda_{b,2}) F \\
&= \mu_0 (B + sN_g) + \mu_0 \frac{1 - \overline{\mu}}{\mu} (B + sN_b) - (1 - \mu_0) \left(1 - \frac{1}{1 - \delta} \left(\frac{1 - \overline{\mu}}{\mu} \frac{\mu_0}{1 - \mu_0} \delta\right)\right) F
\end{align*}$$

To summarize, when $m \geq \bar{m}$, the optimal system is either System $\pi_1$ or $\pi_2$, and always has $\lambda_g = 1$.

**Proof of Proposition 3:**

To prove Proposition 3, I first prove Lemma 4, 5 and 6. With Lemmas 4, 5 and 6, I next prove Proposition 3. When $m > \bar{m}$ and $\mu_0 < \bar{\mu}$,

1. If $\delta > \frac{\mu_0 \overline{\mu} = \frac{1 - \mu}{\mu}}{1 - \mu_0}$: From Lemma 5, the optimal system is either System $\pi_1$ or System $\pi_2$. When $\delta > \frac{\mu_0 \overline{\mu}}{1 - \mu_0}$, System $\pi_2$ gives zero expected payoff since $\mu_{h'} (\phi_l) < \bar{\mu}$: The scope of manipulation $\delta$ is so large that a $h'$-signal can not convince the investor to provide outright approval. Thus, the optimal system must be $\pi_1$.

2. If $\delta < \frac{\mu_0 \overline{\mu} = \frac{1 - \mu}{\mu}}{1 - \mu_0}$: In this case, both $\pi_1$ and $\pi_2$ are potentially optimal. Since $E_{\pi_1} (r_y)$ increases in $F$ and $E_{\pi_2} (r_y)$ decreases in $F$, the optimality of the system depends on $F$. Denote $\tilde{f}_1$ the cutoff $F$ above which the mis-aligned manager prefers System $\pi_1$ to System $\pi_2$: $\tilde{f}_1 = \frac{(B + sN_g) \overline{\lambda}_b + (1 - \overline{\lambda}_b) (B + sN_b)}{1 - \mu_0 (1 - \lambda_g) + \frac{1}{\mu} (B + sN_g) + \frac{1}{\mu} (B + sN_b)}$, where $\overline{\lambda}_b = \frac{1}{1 - \delta} \left(\frac{1 - \overline{\mu}}{\mu} \frac{\mu_0}{1 - \mu_0} \delta\right)$ is the $\lambda_b$ in System $\pi_2$.  

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Lemma 7. When $m < \bar{m}$ and $\mu_0 < \bar{\mu}_1$, depending on the investor’s response to a $h'$-signal, the systems with a positive expected payoff to the mis-aligned manager can be classified into three exhaustive and mutually exclusive types. The types and the optimal system within each type, are identified as follows.

1. Systems that induce investors to approve without inspection with probability $\chi_{h'} < 1$ upon receiving the $h'$-signal. Among this class, the optimal system is $\pi_2$ with $\lambda_g = 1$ and $\lambda_b = \frac{1-\bar{\mu}_2}{\bar{\mu}_2} \frac{\mu_0}{1-\mu_0}$. Under $\pi_2$, upon seeing a $h'$-signal, the investor approves outright with probability $\chi_{h'} = \frac{F}{\delta (B + s N_g)}$, and inspects with probability $1 - \chi_{h'}$. The manager’s expected payoff is $E_{\pi_2}(r_y(\mu_0)) = \mu_0 (B + s N_g) + \mu_0 \frac{1-\bar{\mu}_2}{\bar{\mu}_2} F \frac{F}{\delta}.$

2. Systems that induce investor’s outright approval upon receiving the $h'$-signal. Among this class, the optimal system is $\pi_2$ with $\lambda_g = 1$ and $\lambda_b = \frac{1-\bar{\mu}_2}{\bar{\mu}_2} \frac{\mu_0}{1-\mu_0}$. Under $\pi_2$, the investor approves outright upon seeing a $h'$-signal with probability $\chi_{h'} = 1$, and the $l$-signal manager manipulates with probability $\phi_l = 1$. The manager’s expected payoff is $E_{\pi_2}(r_y(\mu)) = \mu_0 (B + s N_g) + \mu_0 \frac{1-\bar{\mu}_2}{\bar{\mu}_2} (B + s N_b) - (1 - \mu_0) \left( 1 - \frac{1}{1-\delta} \left( \frac{1-\bar{\mu}_2}{\bar{\mu}_2} \frac{\mu_0}{1-\mu_0} - \delta \right) \right) F.$

3. Systems that induce inspection upon receiving $h'$-signal, $\bar{\mu}_1 < \mu_{h'}(\phi_l) < \bar{\mu}_2$. Among this class, the optimal system is $\pi_4$ with $\lambda_g = 1$ and $\lambda_b = \frac{1-\bar{\mu}_1}{\bar{\mu}_1} \frac{\mu_0}{1-\mu_0}$. Under System $\pi_4$, the manager’s expected payoff is $E_{\pi_4}(r_y(\mu_0)) = \mu_0 (B + s N_g).$
Proof of Lemma 7:

The idea in the proof of Lemma 7 is that, when \( m < \bar{m} \) and \( \mu_0 < \bar{\mu}_1 \), for any reporting system \( \pi \) with \( \lambda_g < 1 \), there exists a reporting system with \( \lambda_g = 1 \) and yields the mis-aligned manager a weakly higher payoff in expectation. Suppose, in equilibrium, the \( l \)-signal manager manipulates with probability \( \phi_l \). I first classify all reporting systems into three types and identify the optimal system within each type.

1. Systems that induce investor’s outright approval with probability \( (0 < \chi_{h'} < 1) \): Since in equilibrium the investor uses a mixed strategy, she must be indifferent between outright approval and another action, which is only possible when \( \mu_{h'} (\phi_h, \phi_l) = \bar{\mu}_2 \). I show that the system \( \pi_1 \left( \lambda_g = 1, \lambda_b = \frac{1-\bar{\mu}_2}{\bar{\mu}_2}, \mu_0 \right) \) achieves the highest payoff among this class of systems. Under System \( \pi_1 \), \( \mu_h = \bar{\mu}_2 \) and \( \mu_l = 0 \). In equilibrium, both managers with a \( h \)- or \( l \)-signal do not manipulate, and the investor’s posterior is either \( \mu_{h'} = \bar{\mu}_2 \) or \( \mu_{l'} = 0 \). She approves outright upon seeing a \( h' \)-signal with probability \( \chi_{h'} = \frac{F}{\delta (B + sN_b)} \). The reduced approval rate ensures the managers have no incentive to manipulate.

\[
E_\pi (r_y) = E_\pi (\tilde{v}_{y'}) - \Phi_\pi \leq E_{\pi_1} (\hat{v} (\mu)) - \Phi_{\pi_1}
\]

where \( \Phi_\pi \) is the expected manipulation cost under system \( \pi \). Easy to see that \( \Phi_\pi \geq \Phi_{\pi_1} = 0 \); next I show \( E_{\pi_1} (\hat{v} (\mu)) \geq E_\pi (\hat{v} (\mu)). \) Note that

\[
\delta \hat{v} (\mu') = \delta (\chi_{h'} (B + s (\mu_l N_g + (1 - \mu_l) N_b)) + (1 - \chi_{h'}) \mu_l (B + sN_g)) - F
\]

\[
\chi_{h'} = \frac{\delta (\hat{v} (\mu') - \mu_l (B + sN_g)) + F}{\delta (1 - \mu_l) (B + sN_b)}
\]

Since \( \mu_l < \mu_0 < \bar{\mu}_1 \), the investor is indifferent between outright approval and rejection, thus \( \hat{v} (\mu') = 0 \) and \( \chi_{h'} = \frac{F - \mu_0 \delta (B + sN_g)}{\delta (1 - \mu_l) (B + sN_b)}. \) \( \chi_{h'} \) decreases in \( \mu_l \). As a result, System \( \pi_1 \) with \( \mu_h = \bar{\mu}_2 \) and \( \mu_l = 0 \) is optimal within this type, since it maximizes \( \chi_{h'} \) and \( \Pr (h') \). Its expected payoff is:

\[
E_{\pi_1} (r_y) = \chi_{h',1} \Pr (h') v (\mu_{h'}, a = A) + (1 - \chi_{h',1}) \Pr (h') v (\mu_{h'}, a = I)
= \mu_0 (B + sN_g) + \frac{F}{\delta} \frac{\mu_0}{\bar{\mu}_2} (1 - \bar{\mu}_2)
\]

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2. Systems that induce outright approval ($\chi_{h'} = 1$): Under this type of systems, in equilibrium, $\mu_{h'} (\phi_h, \phi_l) \geq \bar{\mu}_2$ and $\chi_{h'} = 1$. The investor invests outright upon receiving a $h'$-signal. I show that System $\pi_2 (\lambda_g = 1, \lambda_b = \frac{1}{1 - \delta} \left( \frac{1 - \bar{\mu}_2}{\bar{\mu}_2} \frac{\mu_0}{1 - \mu_0} - \delta \right))$ achieves the highest payoff among this class of systems. Under System $\pi_2$, the original signal has $\mu_h > \bar{\mu}_2$ and $\mu_l = 0$. In equilibrium, a $l$-signal manager manipulates with certainty ($\phi_l = 1$), and the investor’s posteriors are $\mu_{h'} = \bar{\mu}_2$ and $\mu_{l'} = 0$. As such, the $h'$-signal is sufficiently convincing that the investor approves outright upon seeing a $h'$-signal.

$$E_{\pi} (r_y) = E_{\pi} (\hat{v}_y) - \Phi_{\pi} \leq E_{\pi_2} (\hat{v} (\mu)) - \Phi_{\pi_2}$$

For any system in this class, with similar proof to that of Proposition 1, I show that $E_{\pi} (\hat{v} (\mu)) \leq E_{\pi_2} (\hat{v} (\mu))$, and $\Phi_{\pi} \leq \Phi_{\pi_2}$, since the expected manipulation cost is $F ((1 - \mu_0) (1 - \lambda_b) + \mu_0 (1 - \lambda_g))$, and System $\pi_2$ has $\lambda_g = 1, \lambda_b = \frac{1}{1 - \delta} \left( \frac{1 - \bar{\mu}_2}{\bar{\mu}_2} \frac{\mu_0}{1 - \mu_0} - \delta \right)$. Thus, $\pi_2$ achieves the highest expected payoff within this class:

$$E_{\pi_2} (r_y) = E_{\pi_2} (\hat{v} (\mu_{h'})) - \Phi_{\pi_2} = \Pr (h') v (\mu_{h'}, a = A) - (1 - \mu_0) (1 - \lambda_{b,2}) F$$

$$= \mu_0 (B + sN_g) + \mu_0 \frac{1 - \bar{\mu}_2}{\bar{\mu}_2} (B + sN_b) - (1 - \mu_0) \left( 1 - \frac{1 - \bar{\mu}_2}{\bar{\mu}_2} \frac{\mu_0}{1 - \mu_0} - \delta \right) F$$

3. Systems that induce inspection upon seeing a $h'$-signal ($\chi_{h'} = 0$ and $\bar{\mu}_1 \leq \mu_{h'} < \bar{\mu}_2$): In equilibrium, the investor inspects upon receiving a $h'$-signal, then the manager’s payoff:

$$V_{\delta}^m (\mu_0) \leq \Pr (h') \hat{v} (\mu_{h'}) + \Pr (l') \hat{v} (\mu_{l'}) \leq \mu_0 (B + sN_g)$$

Thus, under this type of systems, the mis-aligned manager’s expected payoff is always lower than under System $\pi_1$, and are thus never optimal. As a result, when $\mu_0 < \bar{\mu}_1$, the optimal system is either System $\pi_1$ or $\pi_2$, with $\lambda_g = 1$.

**Proof of Proposition 4**: The proof of Proposition 4 utilizes Lemma 4, 5 and 7. Lemma 7 shows that when $m < \bar{m}$ and $\mu_0 < \bar{\mu}_1$, the mis-aligned manager’s optimal system is either System $\pi_1$ or $\pi_2$.

1. If $\delta > \frac{\mu_0}{1 - \mu_0} \frac{1 - \bar{\mu}_2}{\bar{\mu}_2}$, the optimal system is $\pi_1$, since under $\pi_2$ the investor has $\mu_{h'} (\phi_l) < \bar{\mu}_2$ regardless of $\phi_l$, and will not approve outright.

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2. If \( \delta < \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\bar{\mu}} \), both \( \pi_1 \) and \( \pi_2 \) are potentially optimal. Since both \( E_{\pi_1}(r_y), E_{\pi_2}(r_y) \) are linear in \( F \), I obtain the cutoff \( \bar{f}_2 \), above which the manager is better off with System \( \pi_1 \):

\[
\bar{f}_2 = \frac{1-\bar{\mu} \delta (B+sN_b)}{\bar{\mu} + 1-\mu_0 (1-\lambda_{b,2})} \text{, where } \lambda_{b,2} = \frac{1}{1-\delta} \left( \frac{1-\bar{\mu}}{\bar{\mu}} \frac{\mu_0}{1-\mu_0} - \delta \right).
\]

(a) If \( F < \bar{f}_2 \), \( E_{\pi_2}(r_y) \geq E_{\pi_1}(r_y) \). The optimal system is \( \pi_2 \) with \( \lambda_y = 1 \), \( \lambda_{b,2} = \frac{1}{1-\delta} \left( \frac{1-\bar{\mu}}{\bar{\mu}} \frac{\mu_0}{1-\mu_0} - \delta \right) \). In equilibrium, the \( l \)-signal manager manipulates with probability \( \phi_l = 1 \). Despite the manipulation, the investor’s posterior \( \mu_{h'}(\phi_l = 1) = \bar{\mu} \), and she is willing to approve outright upon seeing a \( h' \)-signal.

(b) If \( F > \bar{f}_2 \), \( E_{\pi_1}(r_y) \geq E_{\pi_2}(r_y) \). In equilibrium, the \( l \)-signal manager manipulates with probability \( \phi_l = 0 \), the investor’s posterior has \( \mu_{h'}(\phi_l = 1) = \bar{\mu} \). However, the investor approves upon seeing a \( h' \)-signal with probability \( \chi_{h'} = \frac{F}{\delta(B+sN_b)} \).

This concludes the proof of Proposition 4.

**Proof of Corollary 4**

1. Note that \( E_{\pi_1}(r_y), E_{\pi_2}(r_y) \) decrease in \( \delta \):

\[
\frac{\partial E_{\pi_1}(r_y)}{\partial \delta} = -\frac{F}{\delta^2 (B+sN_b)} \left[ \mu_0 (B+sN_b) + \mu_0 \frac{1-\bar{\mu}}{\bar{\mu}} (B+sN_b) \right] < 0
\]

\[
\frac{\partial E_{\pi_2}(r_y)}{\partial \delta} = (1-\mu_0) \frac{1}{(1-\delta)^2} \left( \frac{1-\bar{\mu}}{\bar{\mu}} \frac{\mu_0}{1-\mu_0} - 1 \right) F < 0
\]

The second inequality uses \( \mu_0 < \bar{\mu} \). Thus, \( V^m_\delta(\mu_0) = \max \{ E_{\pi_1}(r_y), E_{\pi_2}(r_y) \} \) decreases in \( \delta \).

2. When \( \delta < \frac{\mu_0}{1-\mu_0} \frac{1-\bar{\mu}}{\bar{\mu}} \), System \( \pi_2 \) is potentially optimal. When \( F \) is sufficiently small (i.e., \( F < \bar{f}_2 \) in the \( m < \bar{m} \) case and \( F < \bar{f}_1 \) in the \( m \geq \bar{m} \) case), the optimal system is \( \pi_2 \). Since \( E_{\pi_2}(r_y(\mu_0)) \) decreases in \( F \), \( V^m_\delta(\mu_0) = \max \{ E_{\pi_1}(r_y), E_{\pi_2}(r_y) \} \) decreases in \( F \) when \( F \) is small. When \( F \) is sufficiently large (i.e., \( F > \bar{f}_2 \) in the \( m < \bar{m} \) case, and \( F > \bar{f}_1 \) in the \( m \geq \bar{m} \) case), the optimal system is \( \pi_1 \). Since \( E_{\pi_1}(r_y(\mu_0)) \) increases in \( F \), \( V^m_\delta(\mu_0) \) increases in \( F \) when \( F \) is sufficiently large.
Proof of Corollary 5

Note that the investor’s posterior in the manipulation case is $\mu_{h'} = \tilde{\mu}$ and $\mu_{l'} = 0$, the same as the posteriors in the no-manipulation case. Thus, as $m$ decreases, the post-manipulation signal $y'$ becomes less liberal and more informative.

Proof of Corollary 6

Under System $\pi_1$, over-investment exists since bad projects receive a $h'$-signal with probability $\lambda_b = \frac{1-\tilde{\mu}}{\tilde{\mu}} \frac{\mu_0}{1-\mu_0}$, and conditional on receiving a $h'$-signal, are approved outright with probability $\chi_{h'} = \frac{F}{\delta(B+sN_b)}$ and inspected with probability $1 - \chi_{h'}$. System $\pi_2$ leads to over-investment since bad projects receive a $h'$-signal with probability $\frac{1-\tilde{\mu}}{\tilde{\mu}} \frac{\mu_0}{1-\mu_0}$ and are approved with certainty. As $\delta$ increases, the optimal system changes from $\pi_2$ to $\pi_1$ and the probability of inspection $(1 - \chi_{h'})$ increases. As a result, over-investment decreases in $\delta$.

References


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