Investment and Financial Reporting with Two-Dimensional Information Asymmetry

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Abstract

This paper analyzes the real consequences of making a firm's executives more accountable for the fidelity of a firm's financial reports using a basic model of investment under asymmetric information with reporting. Greater accountability generally leads to less underinvestment but more overinvestment. The level of accountability that maximizes investment efficiency is low enough to allow some misreporting to occur in equilibrium. The results yield a sharp testable implication and have implications for reporting regulation.

Keywords: financial reporting; regulation; asymmetric information

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Abstract

This paper analyzes the real consequences of making a firm's executives more accountable for the fidelity of a firm's financial reports using a basic model of investment under asymmetric information with reporting. Greater accountability generally leads to less underinvestment but more overinvestment. The level of accountability that maximizes investment efficiency is low enough to allow some misreporting to occur in equilibrium. The results yield a sharp testable implication and have implications for reporting regulation.

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1 Introduction

The corporate accounting scandals of the early 2000s spurred regulation, including the Sarbanes-Oxley Act of 2002, aimed at holding executives more accountable for their firms' financial statements. This regulation was perceived by many as necessary to restore confidence in the U.S. financial accounting system. However, we still lack a complete understanding of how efforts to curb misreporting are likely to affect economic productivity and growth. Such efforts are likely to have especially important implications for the real investment decisions of external finance-dependent firms, since financial reporting alters the nature of information asymmetries between firm insiders and outside investors.

This paper studies the impact of greater reporting accountability on investment decisions by embedding a simple reporting game in a classic model of investment under asymmetric information a la Myers and Majluf (1984). I show that greater accountability - modeled as a higher cost borne by an insider from misreporting - has both positive and negative effects on the efficiency of investment decisions. It alleviates underinvestment by reducing information asymmetries about assets in place but also exacerbates overinvestment by limiting firms' ability to send informative signals about their investment opportunities through their financial reports. Whether greater accountability has a positive or negative net impact on investment efficiency depends on the parameters of the model. The level of accountability that maximizes investment efficiency is never large enough, though, to completely eliminate misreporting.

These results have important implications for regulators, since they show that increasing reporting accountability can have adverse economic consequences. This raises questions about whether the excessive investment in highly-risky assets that led to the financial crisis of the late 2000s might have been at least partly triggered by the tightening of reporting regulations in the early 2000s. The paper contributes to the theoretical financial reporting literature by modeling information asymmetries relating to both assets in place and investment opportunities in a single framework. As I show, the interaction of these two dimensions of asymmetric information has important implications for the consequences of reporting accountability. The paper also ties together two classical models of investment under asymmetric information. And the model generates a sharp testable prediction: The predicted relationship between overinvestment and accountability is unlikely to be generated by alternative models.

I describe the base model formally in Section 2. The firm in the model has assets already in place and access to a single, indivisible risky investment project (its "investment opportunity"). Assets in place can be of high or low quality, and the investment project can be positive or negative NPV. The firm is managed by an insider, who privately observes the "type" of both the firm's assets in place and its investment project. The firm lacks cash and must raise capital from outside investors who form rational expectations if it is to pursue its project. I focus on the case of debt financing - by far the primary source of external financing - and consider equity financing in an extension.

Before raising capital, the insider issues a report to to outside investors about the firm's assets in place. This can be thought of as an earnings report, since only assets in place (and not investment projects that it might undertake in the future) generate earnings. To keep things simple, I assume that the insider just directly reports the quality of the firm's assets in place. The insider can misreport (i.e., report a quality of assets in place that deviates from the true quality), but bears a cost if she does so. This cost captures in a simple manner the resources, including time, that the insider must expend to falsify a report, as well as the expected cost of any lawsuits or criminal sanctions that she might face later. In the main line of analysis, the insider's objective is to maximize current shareholder value less any cost that she bears from misreporting, though I also consider the case where the insider internalizes only part of the benefit of increasing shareholder value.

After issuing a report, the insider decides whether or not to raise capital from outside investors, and if the firm raises capital, whether or not to invest in the firm's risky project. The firm can opt to retain any capital it raises, earning a risk-free zero NPV return, but cannot pay it out to shareholders. This restriction is motivated by the common inclusion in debt contracts of covenants restricting distributions. Finally, the firm receives cash flow from its assets in place and, if it invested, from its investment project. If there is enough cash to repay outside investors in full, shareholders receive the residual cash flow. Otherwise, outside investors receive whatever cash the firm has. In either event, the game ends at that point.

Section 3 presents the paper's main results. When the cost of misreporting is very low, reports convey little credible information. A firm with high-quality assets in place then faces severe adverse selection when raising capital and therefore forgoes even a positive NPV investment project rather than issue undervalued securities. When the cost of misreporting is very high, the insider always reports accurately, completely eliminating information asymmetries about assets in place. However, information asymmetries about the investment project remain. A firm with a negative NPV project has an incentive to raise capital because pooling with firms possessing positive NPV projects in the capital market allows it to sell overpriced debt. Moreover, having raised capital, the firm has an incentive to invest in its risky negative NPV project rather than to simply retain the capital because creditors bear much of the downside risk. As a result, fully truthful reports result in overinvestment.

A cost of misreporting low enough that some amount of misreporting takes place in equilibrium results in less overinvestment than one high enough to deter misreporting completely. To see why, note that the benefit of exaggerating the firm's report about the quality of its assets in place is a lower face value of debt. Reducing the face value of debt leaves more cash flow for shareholders only in states where the firm can repay its debt in full. Since the firm's expected cash flow increases with the cash flow its project is expected to generate, this benefit of misreporting is greater for a firm with a high-quality project than one with a low-quality project.

This differential leads to a degree of separation by firms with good projects, who misreport the quality of their assets in place some of the time, when the cost of false reporting is moderate. Firms with negative NPV projects have less opportunity to pool with these firms in the capital market. Forced to internalize more of the cost of overinvesting, they do so less often. A reduction in the cost of misreporting in this moderate range results in more misreporting and hence less overinvestment. The level of accountability that maximizes investment efficiency is low enough to at least partly eliminate the overinvestment problem.[1]

Out of necessity, I derive the paper's results analytically in a model with discrete types, as the two-dimensional nature of the asymmetric information problem makes a model with continuous types difficult to solve. One drawback of this model is that the degree of underinvestment is discontinuous in the cost of misreporting. In Section 4, I consider a variant of the model in which project quality has continuous support. This model yields the same conclusions as the purely discrete type model, but results in a continuous relationship between underinvestment and the cost of misreporting. As a result, it implements the tradeoff between underinvestment and overinvestment in a more natural way.

Finally, Section 5 briefly considers three extensions of the base model. First, I consider the case of equity rather than debt financing. The results of the paper continue to hold in the case of equity financing, though a deadweight transaction cost of issuing equity - a realistic feature - is required to generate the same efficiency consequences. Second, I consider the possibility that the cost of misreporting decreases with future cash flow, motivated by the idea that a regulator and investors are more likely to suspect and investigate misreporting if realized cash flow is low in light of a firm's earlier reports. I show that this actually strengthens the paper's conclusions. Third, I consider the possibility of internal conflicts between the insider and other shareholders that are mitigated partially by a link between the insider's compensation and realized shareholder value. I show that the more pay-performance sensitivity is equivalent to a lower cost of misreporting in terms of its impact on the firm's

[1] While regulation is likely the most important determinant of the level of reporting accountability that executives face, firms' internal governance and audit policies may also impact accountability. The only other paper I am aware of that considers optimal internal policies determining the ease with which insiders in a firm can manipulate information they report is by Arya, Glover and Sunder (1998), who argue that allowing a manager to inflate reports enables a firm to overcome its inability to commit to not firing underperforming managers too often.

reporting practices. Thus other shareholders would prefer that the insider own a stake that is neither too large nor too small, even if there are no risk-sharing costs associated with a larger stake.[2]

My paper contributes primarily to the literature examining the effects of financial misreporting on equilibrium investment decisions. Kedia and Philippon (2003) show that firms may overinvest when they inflate their reports in order to further imitate the better types of firms whose reports they mimic. Bar-Gill and Bebchuk (2003) argue that firms may make inefficient investments that make it easier for them to inflate their reports in the future. They also argue that firms may overinvest when they can sell securities at inflated prices due to report inflation, though investment is synonymous with capital-raising by assumption in their model.[3] Wang (2011) argues that firms may invest in projects with higher cash flow variance in order to make report inflation more difficult to detect.

Beyer and Guttman (2012) show that, if firms can voluntarily disclose information and can manipulate the information they disclose, there are situations in which firms with intermediate (neither too favorable nor too unfavorable) information about their assets in place underinvest.[4] They also show that the benefit a firm gets from inflating its report decreases with the true value of the firm's assets in place. This complements my conclusion that the benefit of inflating reports about assets in place *increases* with the quality of a firm's *investment opportunities*. Each of these four papers focuses on information asymmetry on a single dimension. As my analysis demonstrates, additional insights can be gained by considering

[2]Goldman and Slezak (2006) argue that making a CEO's compensation highly-sensitive to the firm's stock price may be undesirable because doing so gives the CEO a strong incentive to inflate reports in order to increase the firm's stock price in the short run. Dye (1988) and Bolton, Sheinkman and Xiong (2006), on the other hand, argue that shareholders may actually prefer contracts that induce report inflation if they plan to sell their shares in the short-run. Kumar and Langberg (2009) find that a contract of this type may be the optimal renegotiation-proof contract, even if shareholders do not benefit directly from report inflation. A sample of empirical work relating conflicts between managers and shareholders to fraudulent reporting includes papers by Beneish and Vargus (2002), Li (2005), Burns and Kedia (2006), Erickson, Hanlon and Maydew (2006), Bergstresser and Philippon (2006), and Johnson, Ryan and Tian (2009), as well as the survey evidence of Graham, Harvey and Rajgopal (2005).

[3]See also Roychowdhury (2003).

[4]See Kumar, Langberg and Sivaramakrishnan (2012) and Wen (2012) for other recent examples of papers examining voluntary rather than mandatory disclosure in a setting with asymmetric information and investment.

the more realistic case in which managers possess separate private information about assets in place and the firm's investment opportunities.[5]

My paper also links together two important papers considering investment under asymmetric information by firms dependent on external finance. Myers and Majluf (1984) show that firms may underinvest in the face of asymmetric information about assets in place. De Meza and Webb (1987) show that firms may overinvest in the face of asymmetric information about investment opportunities if financing takes the form of debt. These two cases emerge endogenously as a function of the cost of misreporting in my model. When the cost of misreporting is low, information asymmetries about assets in place are severe, and firms underinvest. when the cost of misreporting is high, information asymmetries about investment opportunities are severe, and firms overinvest.

2 The Base Model

The model consists of a firm operated by an "insider" and outside investors who begin with no financial claim on the firm. Outside investors form rational expectations and operate in a perfectly competitive capital market. All actors are risk-neutral and there is no discounting. The firm begins with assets in place and access to a single, indivisible investment project it has the option to undertake. The firm's assets in place yield uncertain future cash flow of $\tilde{a}$. The firm's investment project requires a one-time upfront capital outlay of I and, if undertaken, generates uncertain future cash flow of $\tilde{b}$.

Neither the firm, its shareholders, nor the insider possesses the capital necessary to finance investment in the firm's project. In order to invest in its project, the firm must raise capital by issuing debt to outside investors. I assume debt financing for two reasons. First,

[5] Another set of papers focuses on the consequences of reporting precision rather than the scope for manipulation. Kanodia, Singh and Spero (2005) show that, when managers possess private information about returns to investment, greater imprecision in measuring investment level reduces incentives to overinvest in order to signal the quality of the firm's investment opportunities. Gao (2009) shows that more precise information can either increase or decrease a firm's cost of capital. While they do not consider investment, Povel, Singh and Winton (2007) argue that making disclosure more precise can lead to greater manipulation of reports, since investors give greater weight to reports when disclosure precision is high.

most large corporate investment that cannot be financed internally is, in reality, financed with debt. Second, the risk-shifting incentives created by financial leverage are useful for motivating the overinvestment that plays a significant role in my analysis (Jensen, 1976). I consider equity financing in an extension.

Firms differ only in the quality of their assets in place (denoted A) and the quality of their investment projects (denoted B). Assets in place can either be high-quality (A_H) or low quality (A_L). The density and distribution of cash flow from assets in place are $f_i(\tilde{a})$ and $F_i(\tilde{a})$, respectively, for $i = L, H$, with f_i continuously differentiable and defined on $[0, \infty)$. Assets in place of higher quality yield higher future cash flow in the sense of first order stochastic dominance. That is, $F_H(\tilde{a}) < F_L(\tilde{a})$ for all $\tilde{a} < \infty$.

Likewise, a firm's investment project can be either high-quality (B_H) or low quality (B_L). The density and distribution of cash flow from the investment project are $g_j(\tilde{b})$ and $G_j(\tilde{b})$, respectively, for $j = L, H$, with g_j continuously differentiable and defined on $[0, \infty)$. An investment project of higher quality also yields higher future cash flow in the sense of first order stochastic dominance. That is, $G_H(\tilde{b}) < G_L(\tilde{b})$ for all $\tilde{b} < \infty$. Define the expected cash flow from assets in place as $a_i = E[\tilde{a}|A = A_i]$ for $i = L, H$ and the expected cash flow from the project as $b_j = E[\tilde{b}|B = B_j]$ for $j = L, H$. A high quality project is positive NPV ($b_H > I$) while a low-quality project is negative NPV ($b_L < I$).

I refer to a firm with assets in place of quality A_i and investment project of quality B_j as a type ij firm. There are then four types of firms: LL, LH, HL and HH. The prior probability that a firm is of type ij is q_{ij}, with $\sum_{i\in\{L,H\},j\in\{L,H\}} q_{ij} = 1$. The firm's insider privately observes the firm's type, while outside investors only observe the prior distribution of types. Thus the insider possesses private information about both the quality of the firm's assets in place and its investment project.

Before choosing whether or not to raise capital, the insider (or the firm, at the insider's behest) issues a report $m \in \{A_L, A_H\}$ of the quality of the firm's assets in place A to outside investors. He can misreport - i.e., report $m \neq A$ - but bears a cost $c \geq 0$ if he does so. The report m can be thought of as an earnings report, since it captures information about assets that the firm already has in place. The cost c represents the time and resources that the insider devotes to falsifying her report, as well as any expected cost of sanctions due to the possibility of the misreporting being discovered in the future. The insider's incentive is to inflate his report to imitate better types. I therefore do not consider the possibility that the insider understates his type.

The timing of the model is as follows. At time 0, the insider observes the firm's type ij and issues her report m, bearing the cost of misreporting if he reports falsely. At time 1, the firm can raise capital I by issuing debt with a face value of d that must be repaid at time 3 to outside investors. The face value of the firm's debt must allow outside investors buying the debt to break even in expectation, conditional on the firm's report at time 0. At time 2, the firm chooses whether or not to invest in its project if it raised capital at time 1. Finally, at time 3, the firm receives its cash flow, pays creditors the lesser of this cash flow and d, and pays out any remaining cash to equityholders. At this point, the firm ceases to exist.

I consider perfect Bayesian equilibria of the game. Beliefs are constrained by the intuitive criterion of Cho and Kreps (1985) for off-equilibrium path moves. The insider makes three decisions in the model: (i) a report to issue, (ii) whether or not to raise capital, and (iii) conditional on raising capital, whether or not to invest. Since a firm does not take on debt if it does not invest and there is no discounting, the time 2 value of the equity of a firm that does not invest is a_i. Let $E_{ij}(d)$ and $D_{ij}(d)$, respectively, denote the time 2 value of the equity and debt of a firm of type ij when it raises capital and invests, and promises to repay d to outside investors. Then,

$$E_{ij}(d) = \int_0^d \int_{d-\tilde{a}}^{\infty} (\tilde{a} + \tilde{b} - d) f_i(\tilde{a}) g_j(\tilde{b})\, \mathrm{d}\tilde{b}\, \mathrm{d}\tilde{a} + \int_d^{\infty} \int_0^{\infty} (\tilde{a} + \tilde{b} - d) f_i(\tilde{a}) g_j(\tilde{b})\, \mathrm{d}\tilde{b}\, \mathrm{d}\tilde{a} \qquad (1)$$

and

$$D_{ij}(d) = a_i + b_j - E_{ij}(d). \qquad (2)$$

Let d_{ij} denote the face value of debt that allows outside investors to break even on average if they are financing a firm of type ij. That is, d_{ij} is the solution to $I = D_{ij}(d_{ij})$. Further, let $d_{i_1 j_1, i_2 j_2}$ denote the face value of debt that allows investors to break even if they are financing a firm of either type $i_1 j_1$ or $i_2 j_2$, with the probabilities that the firm is of type $i_1 j_1$ and type $i_2 j_2$ equal to $\frac{q_{i_1 j_1}}{q_{i_1 j_1}+q_{i_2 j_2}}$ and $\frac{q_{i_2 j_2}}{q_{i_1 j_1}+q_{i_2 j_2}}$, respectively. That is, $d_{i_1 j_1, i_2 j_2}$ is the solution to $I = \frac{q_{i_1 j_1}}{q_{i_1 j_1}+q_{i_2 j_2}} D_{i_1 j_1}(d_{i_1 j_1, i_2 j_2}) + \frac{q_{i_2 j_2}}{q_{i_1 j_1}+q_{i_2 j_2}} D_{i_2 j_2}(d_{i_1 j_1, i_2 j_2})$. I now make three assumptions that place restrictions on the model's parameters.

Assumption 1. *For* $i = L, H$, $a_i < E_{iL}(d_{iH})$.

Assumption 2. $a_H > E_{HH}(d_{LH,HH})$.

Assumption 3. *For* $i = L, H$, $E_{iL}(d_{iL,iH}) < a_i < E_{iH}(d_{iL,iH})$.

Under Assumption 1, a firm of type iL prefers to raise capital and invest rather than forgo investment if outside investors price the firm's debt as though it were a firm of type iH. This is due to simple cross-subsidization: A firm of type iL finds its debt overpriced and therefore has an incentive to raise capital, even though it can only deploy it in a negative NPV investment. Assumption 1 ensures that this overpricing is large enough when the market believes that its type is iH rather than iL that the firm will indeed raise capital. Thus, Assumption 1 gives rise to the possibility of overinvestment in the model.

Under Assumption 2, a firm of type HH prefers to forgo raising capital when outside investors price the firm's debt as though it could be either a type LH or type HH firm. This is the classic adverse selection problem studied by Myers and Majluf (1984). A firm of type HH finds its debt underpriced when it is pooled with firms of type LH in the capital market. Assumption 2 ensures that this underpricing is severe enough that the firm forgoes its positive NPV investment rather than selling underpriced debt. Thus, Assumption 2 gives rise to the possibility of underinvestment in the model.

Assumption 3 is a technical assumption that eliminates some corner solutions that arise in the model without altering the model's insights. I discus in detail the specific role this assumption plays at the points at which it impacts the analysis.

3 Analysis of the Model

This section presents the analysis of the model. I first present a useful preliminary result that simplifies the remainder of the analysis. I then solve for the equilibrium of the game. This is followed by a numerical example.

3.1 Investment and risk-shifting - a preliminary result

Before investigating the equilibrium of the model, I present a preliminary result that narrows down the set of equilibrium actions that I need to consider in the analysis. In principle, the insider makes three decisions: 1) a report to issue, 2) whether or not to raise capital, and 3) whether or not to invest, conditional on having raised capital. If he does not plan to raise capital, then the insider has no incentive to issue an inaccurate report. Since doing so would be costly, he will never issue an inaccurate report and then subsequently fail to raise capital.

Consider now the possibility that the firm raises capital but chooses to retain the capital rather than invest it. For outside investors to at least break even on average, the face value of the debt that the firm issues when raising capital must at a minimum satisfy $d \geq I$. If outside investors anticipate that the firm will invest in its risky project with positive probability, then they anticipate being repaid in full with probability less than one. In this case, d must be strictly greater than I for outside investors to break even in expectation.

Suppose that the firm has raised capital I at time 1 by promising to repay $d > I$ at time 3. If the firm simply retains this capital, then shareholders receive $\tilde{a} + I - d$ if this is positive and zero otherwise. Since $d > I$, $\tilde{a} + I - d$ is less than shareholders' payoff if the firm does not raise capital at all, which is just $\tilde{a}$. Thus, as Lemma 1 presents formally, raising capital and retaining it is a strictly dominated strategy if $d > I$.

Lemma 1. *If $d > I$, then raising capital and not investing is a strictly dominated strategy.*

If $d = I$, then shareholders would be indifferent between the firm not raising capital on the one hand, and raising capital and retaining it on the other. However, in reality, raising capital is likely to have associated costs that I do not model here. Even an infinitesimally small cost of raising capital would make raising capital and retaining it a strictly dominated strategy if $d = I$. I therefore only consider equilibria in which any firm that raises capital invests it.

3.2 Equilibrium

The first step in determining the equilibrium is calculating the face value of debt that outside investors require, conditional on the firm's report. Let $\sigma_{ij}^{A_k}$ denote the mixed strategy probability that a firm of type ij reports $m = A_k$ and raises capital, for $k = L, H$. Then $1-\sum_{k\in\{L,H\}} \sigma_{ij}^{A_k}$ is the probability that it does not raise capital. Thus $(\sigma_{ij}^{A_L}, \sigma_{ij}^{A_H})$ completely characterizes a firm's strategy. Since I only consider the case in which a firm might inflate its report, $\sigma_{Hj}^{A_L} = 0$ for $j = L, H$. Let $\hat{\sigma}_{ij}^{A_k}$ denote outsiders' belief about the probability that a firm of type ij reports $m = A_k$ and raises capital. Outside investors' breakeven condition requires that the face value of the firm's debt be the value of $d(A_k)$ that solves

$$I = \frac{\sum_{i\in\{L,H\};j\in\{L,H\}} q_{ij}\hat{\sigma}_{ij}^{A_k} D_{ij}(d(A_k))}{\sum_{i\in\{L,H\};j\in\{L,H\}} q_{ij}\hat{\sigma}_{ij}^{A_k}}. \tag{3}$$

if $\sum_{i\in\{L,H\};j\in\{L,H\}} \hat{\sigma}_{ij}^{A_k} > 0$. Since outside investors form rational expectations, $\hat{\sigma}_{ij}^{A_k} = \sigma_{ij}^{A_k}$ must hold in equilibrium. If, in equilibrium, $\sum_{i\in\{L,H\};j\in\{L,H\}} \sigma_{ij}^{A_k} = 0$ for a report A_k, then such a report is an out-of-equilibrium move, and beliefs are restricted by the intuitive criterion.

Suppose that the cost of misreporting is high enough that all type reports honestly. In this case, outside investors can perfectly distinguish firms with assets in place of different quality, but cannot distinguish firms with investment projects of different quality. This means that firms with investment projects of different quality are pooled when raising capital. As a result, firms with low-quality projects find their securities overpriced and have an incentive to raise capital.

Of course, outside investors anticipate such pooling and demand a face value of debt that reflects the average of the types. The higher the probability with which outside investors anticipate that a firm with a low-quality project raises capital, the greater the face value of debt required, and therefore the lower the benefit to such a firm of raising capital. In equilibrium, a firm with a low-quality project raises capital often enough that $d(A_i)$ makes it just indifferent between raising capital and not raising capital. This indifference requires that the face value of debt satisfy

$$a_i = E_{iL}(d(A_i)).$$

for $i = L, H$. Suppose that a firm of type iL raises capital with probability ϕ_i. Then investors' breakeven condition requires that

$$I = \frac{q_{iL}\phi_i D_{iL}(d(A_i)) + q_{iH} D_{iH}(d(A_i))}{q_{iL}\phi_i + q_{iH}}.$$

Solving for ϕ_i and substituting into the iL type's indifference condition yields

$$\phi_i = \frac{q_{iH}}{q_{iL}} \times \frac{D_{iH}(E_{iL}^{-1}(a_i)) - I}{I - D_{iL}(E_{iL}^{-1}(a_i))}. \tag{4}$$

Proposition 1 shows that, when all firms report truthfully, a firm with assets in place of quality A_i and a low-quality investment project will raise capital with probability ϕ_i.

Proposition 1. *If all firms report truthfully, then, for $i = L, H$, a firm of type iH invests with probability one, while a firm of type iL invests with probability $\phi_i \in (0, 1)$, where ϕ_i is given by (4).*

Assumption 1 ensures that $\phi_i > 0$. This is a necessary condition for overinvestment to arise and is therefore essential to the analysis. Assumption 3 restricts the parameters to ensure that $\phi_i < 1$. In the absence of this assumption, there would be parameter values such that an iL type would invest with probability one when pooled with an iH type. This would change none of the conclusions of the paper. Assumption 3 here simply reduces the number of cases that must be considered without loss of insight.

I refer to an equilibrium in which all types report the quality of their assets in place truthfully as a "truthful reporting equilibrium" ("TRE" for short). Since firms with positive NPV projects invest with probability one and firms with negative NPV projects invest with positive probability when all firms report truthfully (by Proposition 1), a truthful reporting equilibrium is characterized by overinvestment but not underinvestment. For a truthful reporting equilibrium to exist, the cost of reporting falsely must be high. I characterize the exact threshold cost of misreporting that ensures the existence of a truthful reporting equilibrium shortly.

Observe now that a firm with higher-quality assets in place has higher cash flow in the future on average than one with lower-quality assets in place. Thus, other things being equal, if outside investors place greater weight on a firm having high-quality assets in place, the face value of debt that they require to break even is lower. That is, one would expect that $d(A_H) < d(A_L)$. This creates an incentive for firms with low-quality assets in place to falsely report that they have high-quality assets in place.

Let $\Delta(B_j) = E_{Lj}(d(A_H)) - E_{Lj}(d(A_L)) > 0$ denote the increased equity value if a firm of type Lj falsely reports A_H instead of A_L, for $j = L, H$. For d less than realized cash flow, a small decrease in the face value of debt d increases the payoff to equityholders by that amount. Recall that the cash flow from a high-quality project first order stochastic dominates the cash flow from a low-quality project. This implies that, holding fixed the quality of the firm's assets in place, more of the firm's cash flow distribution will lie above d when the firm invests in a high-quality project than when it invests in a low-quality project. As a result, a small decrease in d benefits the shareholders of a firm with a high-quality project more than one with a low-quality project, again holding fixed the quality of the firm's assets in place. Therefore, $\Delta(B_H) > \Delta(B_L)$. This implies that a firm with better investment opportunities has a stronger incentive to exaggerate its reports. Proposition 2 states this result formally, as well as its implications for the nature of any equilibrium in which misreporting occurs.

Proposition 2. *Suppose that $d(A_H) < d(A_L)$. Then $\Delta(B_H) > \Delta(B_L)$. In any equilibrium in which the LH type reports $m = A_H$ with probability less than one, the LL type reports $m = A_H$ with probability zero. In any equilibrium in which the LL type reports $m = A_H$ with probability greater than zero, the LH type reports $m = A_H$ with probability one.*

Proposition 2 implies that, when the cost of misreporting becomes low enough that some firms with low-quality assets in place find it worthwhile to report high-quality assets in place, it is firms with high-quality *projects* that inflate their reports first. This is a key result. The fact that firms with high-quality investment projects have an advantage when it comes to inflating their reports suggests that such firms might be able to achieve separation in the capital market from those with lower-quality investment projects by inflating reports about their assets in place. This is important because it impacts the opportunity that firms with low-quality projects have to pool in the capital market.

Consider the case where an LH type firm reports $m = A_H$ with probability $\psi \in (0, 1)$. In principle, the firm might either report A_L and raise capital or simply not raise capital at all when it doesn't report A_H. However, Assumption 3 ensures that the LH firm prefers reporting A_L and raising capital over not raising capital, even if investors set the face value of debt under the assumption that a firm reporting a_L and raising capital is an LL type. Thus, if an LH type reports A_H and raises capital with probability ψ, it reports A_L and raises capital with probability $1 - \psi$. From Proposition 2, the LL type will never report $m = A_H$ when $\psi < 1$. But it will report $m = A_L$ and raise capital with positive probability since it can pool with the LH type. As ψ increases, the opportunity for the LL type to pool with the LH type diminishes since the LH type reports A_L less often. The LL type therefore raises capital less often. Lemma 2 shows that the probability the LL type raises capital is a decreasing linear function of the probability that the LH type reports A_H instead of A_L.

Lemma 2. *Suppose that the LH type reports $m = A_H$ and raises capital with probability $\psi \in (0, 1)$ in equilibrium. Then the LL type raises capital with probability $\phi_L[1 - \psi]$.*

I refer to an equilibrium in which the LH type mixes between reporting A_L and A_H as a "mixed reporting equilibrium" ("MRE" for short). The frequency with which the LH type falsely reports $m = A_H$ in an MRE naturally depends on the cost of misreporting c. To capture this dependence, I write $\psi(c)$. Not surprisingly, as I show shortly, $\psi'(c) < 0$. Now consider what happens when c is just low enough that the LH type reports $m = A_H$ with positive probability. The addition of LH type firms to the pool of firms reporting A_H and raising capital makes raising capital less attractive for the HL type. This results in a decline in the mixed strategy probability that the HL type raises capital. But the removal of HL types from the pool of firms reporting A_H and raising capital makes reporting A_H and raising capital more attractive for the LH type, who then reports A_H more often. Iterating this logic yields the following lemma:

Lemma 3. *The HL type does not raise capital in any equilibrium in which the LH type reports $m = A_H$.*

To better understand this result, consider the following. To have a solution in which the LH type mixes between reporting A_L and A_H and the HL type mixes between raising capital and not raising capital, three indifference conditions must hold. The first is $\Delta(B_H) = c$, which makes the LH type indifferent between reporting $m = A_H$ and A_L. The other two are $E_{iL}(d(A_i)) = a_i$ for $i = L, H$, which makes the LL and HL types indifferent between raising capital and not raising capital. But there are only two free variables to solve these three equalities: $d(A_L)$ and $d(A_H)$. Thus all three indifference conditions cannot be satisfied simultaneously. The LL type's indifference condition always holds as long as $\psi < 1$, so one of the other two must not. The LH type has a more profitable investment project, and the

HL type faces more adverse selection due to the information asymmetry about its assets in place. When the cost of misreporting is low enough that the LH type prefers to report $m = A_H$ with positive probability, the LH type's indifference condition will be the one that holds, and the HL type will strictly prefer not raising capital.

The next step is to compute $\psi(c)$. From the LL type's indifference condition, $d(A_L) = E_{LL}^{-1}(a_L)$. The promised repayment that outside investors require to break even on average when the firm reports $m = A_H$ depends on $\psi(c)$. Specifically, $d(A_H)$ solves

$$I = \frac{q_{LH}\psi(c)D_{LH}(d(A_H)) + q_{HH}D_{HH}(d(A_H))}{q_{LH}\psi(c) + q_{HH}}. \tag{5}$$

Substituting $d(A_L) = E_{LL}^{-1}(a_L)$ and the LH type's indifference condition $\Delta(B_H) = c$ into (5) and solving for $\psi(c)$ yields

$$\psi(c) = \frac{q_{HH}}{q_{LH}} \times \frac{D_{HH}(E_{LH}^{-1}(E_{LH}(E_{LL}^{-1}(a_L)) + c)) - I}{I - D_{LH}(E_{LH}^{-1}(E_{LH}(E_{LL}^{-1}(a_L)) + c))}. \tag{6}$$

Since debt is more valuable when the face value of debt is higher, $D'_{ij} > 0$. Observe also that $E'_{ij} < 0$, which implies that $(E_{ij}^{-1})' < 0$. Therefore, as one would expect, $\psi'(c) < 0$.

When c is low, the LH type reports $m = A_H$ with high probability if it can pool with the HH type by doing so. Indeed, if c is low enough, the underpricing that the HH type faces as a result of this pooling is so severe that it prefers not to raise capital. That is, when the cost of misreporting is sufficiently low, there can be underinvestment due to adverse selection (a la Myers and Majluf, 1984). I refer to any equilibrium in which the HH type does not invest as an "underinvestment equilibrium" ("UIE" for short). As I show shortly, there are three different types of UIE.

I formally describe the equilibrium in Proposition 3. In describing the equilibrium, I use the following threshold values of c:

$$c_T = E_{LH}(E_{HL}^{-1}(a_H)) - E_{LH}(E_{LL}^{-1}(a_L)),$$

$$c_M = E_{LH}(E_{HH}^{-1}(a_H)) - E_{LH}(E_{LL}^{-1}(a_L)),$$

$$c_U^{1+} = E_{LH}(d_{HH}) - E_{LH}(E_{LL}^{-1}(a_L)),$$

$$c_U^{2+} = a_L + b_H - I - E_{LH}(d_{LL}),$$

$$c_U^{3+} = E_{LL}(d_{HH}) - a_L,$$

$$c_U^{1-} = a_L + b_H - I - E_{LH}(E_{LL}^{-1}(a_L)),$$

$$c_U^{2-} = E_{LL}(d_{LH}) - a_L.$$

The large number of thresholds that are required to describe the equilibrium is driven by the variety of types of underinvestment equilibria that can hold. The key thresholds are c_T and c_M. The proof of Proposition 3 shows that $0 < c_M < c_T < \infty$, $0 < c_U^{1-} < c_U^{1+}$, $0 < c_U^{2-} < c_U^{2+}$, and $c_U^{3+} > 0$.

Proposition 3. *The equilibria are as follows:*

i) (TRE) If $c \geq c_T$, there exists an equilibrium in which all firms report truthfully, a firm of type iH invests with probability one, and a firm of type iL invests with probability $\phi_i \in (0,1)$ for $i = L, H$, where ϕ_i is given by (4).

ii) (MRE) If $c \in [c_M, c_T)$, there exists an equilibrium in which the HH type reports truthfully and invests with probability one, the HL type does not invest, and the LH type always invests. The LH type reports A_H with probability $\psi(c) \in (0,1)$ and A_L with probability $1-\psi(c)$, where $\psi(c)$ is given by (6). The LL type reports A_L and invests with probability $\phi_A^L[1-\psi(c)]$ and does not invest otherwise.

iii) (UIE) If $c < max\{c_U^{1+}, c_U^{2+}\}$, there exists at least one equilibrium in which the HH and HL types do not invest. In this case, *a) If $c \in [c_U^{1-}, c_U^{1+})$ or $c < c_U^{3+}$, there exists an equilibrium in which the LH type reports A_L and invests with probability one, and the LL type reports A_L and invests with probability ϕ_L and does not raise capital otherwise.*

b) If $c \in [c_U^{2-}, c_U^{2+})$, there exists an equilibrium in which the LH type reports A_H and invests with probability one, and the LL type does not invest.

c) If $c < c_U^{2-}$, there exists an equilibrium in which the LH type reports A_H and invests with probability one, and the LL type reports A_H and invests with probability $\eta(c) \in (0,1)$, where $\eta(c) = \frac{q_{LH}}{q_{LL}} \frac{D_{LH}(E_{LL}^{-1}(a_L+c))-I}{I-D_{LL}(E_{LL}^{-1}(a_L+c))}$, and does not invest otherwise.

Note that the mixed reporting and truthful reporting equilibria are mutually exclusive. That is, there are no values of c for which both exist. However, there can be values of c for which one of these types of equilibrium and an underinvestment equilibrium exist. There can also be values of c for which more than one type of underinvestment equilibrium exists.

Since the LL type raises capital and invests with probability $\phi_A^L[1-\psi(c)]$, and $\psi'(c) < 0$, the LL type invests more often as c increases in a mixed reporting equilibrium. In other words, in this equilibrium, the amount of overinvestment *increases* as the cost of misreporting increases. The LL type invests even more often (with probability ϕ_L) in the truthful reporting equilibrium. Moreover, the HL type also raises capital and invests (in a negative NPV project) with positive probability in a truthful reporting equilibrium but not in a mixed reporting equilibrium. Proposition 4 formalizes these results:

Proposition 4. *In a mixed reporting equilibrium, the probability that the LL type invests, and hence the amount of overinvestment, increases with c. There is more overinvestment in the truthful reporting equilibrium than in the mixed reporting equilibrium. Within the mixed reporting and truthful reporting equilibria, the value of c that maximizes investment efficiency is c_M.*

This represents the key takeaway from this analysis. Since there is no underinvestment in the mixed reporting and truthful reporting equilibria, Proposition 4 shows somewhat counter-intuitively that an increase in the cost of misreporting can actually have an adverse effect on the efficiency of investment decisions. While underinvestment equilibria are likely to be even less efficient, with firms forgoing positive NPV investments, this result shows at a minimum that the cost of misreporting that maximizes investment efficiency is not maximal. I next present a numerical example to further illustrate equilibrium behavior.

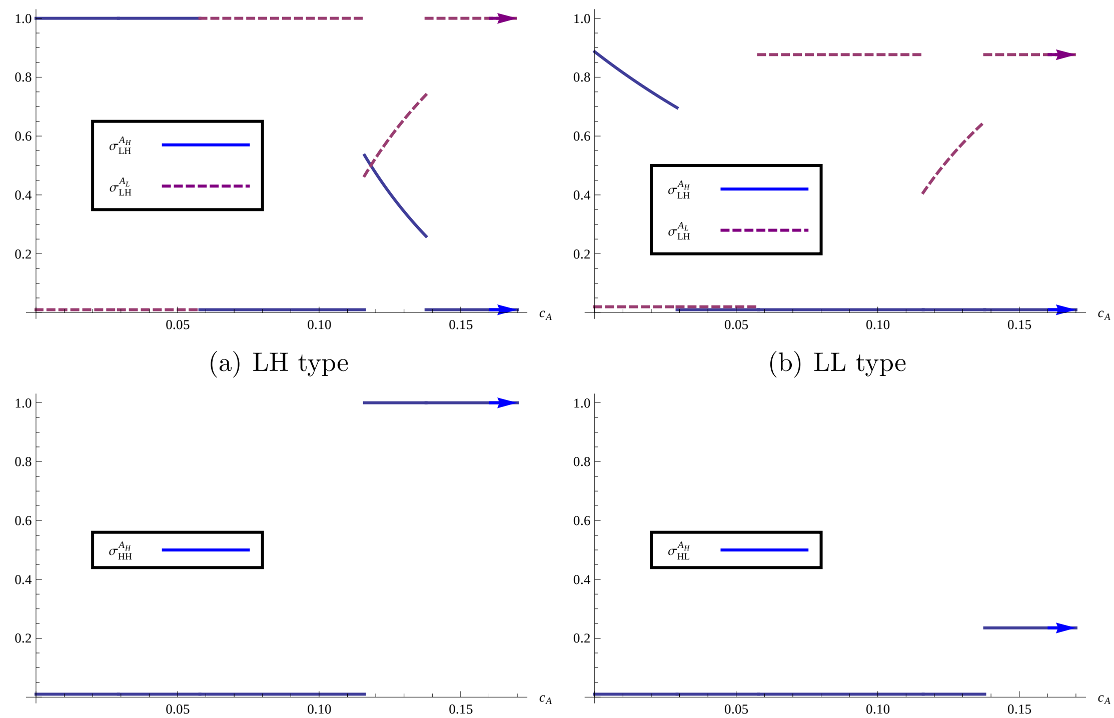
3.3 Numerical example

I assume in this numerical example that assets in place and the investment project each yield cash flow that is exponentially distributed. The rate parameter of the cash flow distribution for assets in place is λ_{A_L} if $A = A_L$ and $\lambda_{A_H} < \lambda_{A_L}$ if $A = A_H$, which implies that $a_L < a_H$. The rate parameter of the cash flow distribution for the investment project is λ_{B_L} if $\hat{B} = B_L$ and $\lambda_{B_H} < \lambda_{B_L}$ if $\hat{B} = B_H$, which implies that $b_L < b_H$. I choose the following for parameter values:

Parameter	Value
q_{LL}	0.4
q_{LH}	0.2
q_{HL}	0.2
q_{HH}	0.2
I	1
λ_{A_L}	7.5
λ_{A_H}	2.5
λ_{B_L}	1.02
λ_{B_H}	0.93

Given these parameters, $a_H = 0.4$, $a_L = 0.1333$, $b_H = 1.0753$, and $b_L = 0.9804$. Since a firm must invest 1 unit of capital to pursue its project, a high-quality project is positive NPV and a low-quality project is negative NPV. The parameters satisfy Assumptions 1, 2 and 3. The threshold values of c are $c_T = 0.1378$, $c_M = 0.1161$, $c_U^{1-} = 0.0344$, $c_U^{1+} = 0.1722$, $c_U^{2-} = 0.0291$, $c_U^{2+} = 0.0579$, and $c_U^{3+} = 0.1500$.

In mapping from c to strategies, I choose the equilibrium that provides the greatest investment efficiency whenever multiple equilibria exist. This proves to be either the mixed reporting or truthful reporting equilibrium when one of these coexists with an underinvestment equilibrium (recall that the mixed reporting and truthful reporting equilibria never coexist for any value of c). Figure 1 depicts equilibrium strategies as a function of the cost of misreporting.



(a) LH type (b) LL type (c) HH type (d) HL type

This figure depicts equilibrium reporting and investment decisions as a function of the cost of misreporting. In the example, $q_{LL} = 0.4$, $q_{LH} = q_{HL} = q_{HH} = 0.2$, and $I = 1$. Cash flow from assets in place $\tilde{a}$ is exponentially distributed with rate parameter 7.5 if $A = A_L$ and 2.5 if $A = A_H$. Cash flow from the investment project is also exponentially distributed, with rate parameter 1.02 if $B = B_L$ and 0.93 if $B = B_H$.

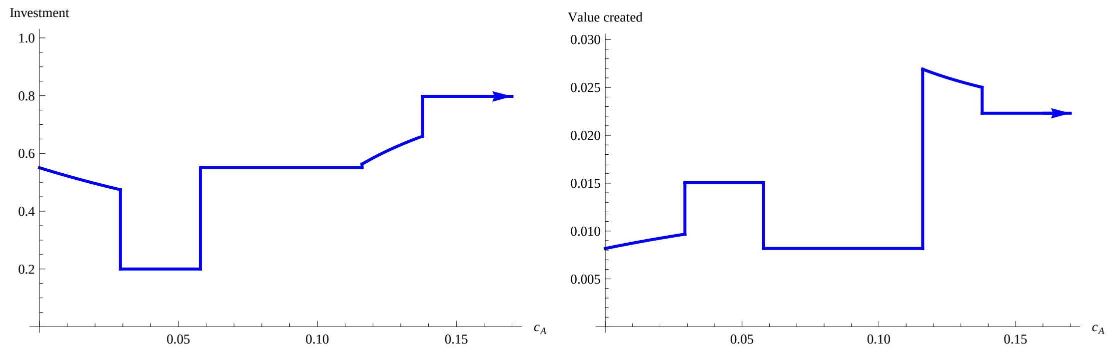
Figure 1: Equilibrium strategies as a function of cost of misreporting

For $c \geq 0.1378$, the truthful reporting equilibrium holds. Firms with high-quality projects invest with probability one, while firms with low-quality projects mix between investing and not investing. Specifically, the LL type firm invests with probability $\phi_L = 0.8765$, while the HL type firm invests with probability $\phi_H = 0.2353$. For $c \in [0.1161, 0.1378)$, a mixed reporting equilibrium holds. Firms with high-quality projects continue to invest with probability one, but the LH type firm now mixes between reporting A_L and A_H. As Figure 1 makes clear, a higher c in this range results in the LH type falsely reporting A_H less often, but also results in the LL type raising capital and investing more often. The HL type does not invest in the mixed reporting equilibrium.

Once c falls below 0.1161, there no longer exists an equilibrium in which the HH type invests. Thus the only equilibria below this point are underinvestment equilibria. For $c \in [0.0579, 0.1161)$, the only equilibrium is one in which the LH type reports A_L and invests with probability 1, and the LL type reports A_L and invests with probability 0.8765 and does not invest with probability 0.1235. Reporting A_H and raising capital is an out-of-equilibrium move. This equilibrium continues to exist once c falls below 0.0579, but there are more efficient underinvestment equilibria when $c < 0.0579$. In these equilibria, reporting A_L and raising capital is an out-of-equilibrium move. When $c \in (0.0291, 0.0579]$, the LH type reports A_H and invests with probability one and the LL type abstains from investing. When $c < 0.0291$, the LH type reports A_H and invests with probability one, and the LL type mixes between reporting A_H and investing and abstaining from investment. As c gets smaller in this range, the LL type reports A_H and invests more often.

Figure 2 depicts investment level and total value created by investment as a function of c. As the figure shows, investment generally increases with c, except when c is very low. As the cost of misreporting increases, reports become more credible, and firms are more willing to raise capital. However, the figure also shows that value created by investment is a non-monotonic function of c, and is maximized at $c_M = 0.1161$. Lower levels of c lead to underinvestment, while higher levels of c lead to more overinvestment.

Figures 3 and 2 show the weakness of the discrete type model analyzed in this section. The HH type either invests with probability one or doesn't invest at all, and never mixes between the two. Thus underinvestment is all-or-nothing. This makes it difficult to consider



(a) Investment level

(b) Value created by investment

This figure depicts equilibrium (a) investment level and (b) total value created by investment as a function of the cost of misreporting when firms report the quality of their assets in place. In the example, $q_{LL} = 0.4$, $q_{LH} = q_{HL} = q_{HH} = 0.2$, and $I = 1$. Cash flow from assets in place $\tilde{a}$ is exponentially distributed with rate parameter 7.5 if $A = A_L$ and 2.5 if $A = A_H$. Cash flow from the investment project is also exponentially distributed, with rate parameter 1.02 if $B = B_L$ and 0.93 if $B = B_H$.

Figure 2: Investment level and value created by investment when firms report quality of assets in place

the tradeoffs associated with a small increase in the cost of misreporting. In the next section, I allow the project type to be continuously-distributed rather than binary. While I can only solve this variant of the model numerically, it results in underinvestment and overinvestment that are both continuous in the cost of misreporting.

4 Continuous project quality

The timing and actions remain as before. Assets in place are high-quality ($A = A_H$) with probability p and low-quality ($A = A_L$) with probability $1 - p$. Project quality B is distributed uniformly on $[\underline{B}, \overline{B}]$.[6] To keep things as simple as possible, I assume that the payoffs on both assets in place and the investment project are binary. Assets in place generate a time T payoff of $x > 0$ with probability A and 0 with probability $1 - A$. A project of quality B yields a payoff of x with probability B and 0 with probability $1 - B$. The assumption that that payoff support for assets in place and the project are the same is not

[6]While allowing the quality of both assets in place and the investment project to be continuously distributed would be ideal, it is not clear how such a model could be solved even numerically.

necessary but minimizes the necessary notation. I assume that A and B are independently distributed. Some firms have positive NPV projects while others have negative NPV projects, so $\underline{B}x < I < \overline{B}x$.

There are three regions of c. When c is high, all firms report truthfully. There are threshold values of B above which firms with low-quality and high-quality assets in place invest and below which they do not. I label these thresholds B_{L0} and B_{H0}, respectively. The equilibrium is characterized by these thresholds, along with face values of debt d_L and d_H that allow outside investors to break even when they loan to a firm reporting $m = A_L$ and $m = A_H$, respectively. The equilibrium, then, is the set of values $\{B_{L0}, B_{H0}, d_L, d_H\}$, with $B_{L0}, B_{H0} \in [\underline{B}, \overline{B}]$, that solve the following system of equations:

$$E_{A_L,B_{L0}}(d_L) = A_L x$$
$$E_{A_H,B_{H0}}(d_H) = A_H x$$
$$\frac{1}{\overline{B} - B_{L0}} \int_{B_{L0}}^{\overline{B}} D_{A_L,B}(d_L)\, dB = I$$
$$\frac{1}{\overline{B} - B_{H0}} \int_{B_{H0}}^{\overline{B}} D_{A_H,B}(d_H)\, dB = I$$

The first two equalities represent the indifference conditions of the threshold firms and the last two outside investors' breakeven conditions.

When c is intermediate, firms with low-quality assets but project quality above some threshold report $m = A_H$ and invest. I label this threshold B_{L1}. Firms with low-quality assets and project quality below this threshold but above another threshold, which I label B_{L0}, report A_L and invest. Firms with low-quality assets and $B < B_{L0}$ do not raise capital. Again, there is a threshold value B_{H0} such that firms with high-quality assets in place invest if $B \geq B_{H0}$ and do not invest if $B < B_{H0}$. The equilibrium with intermediate c is the set of values $\{B_{L0}, B_{L1}, B_{H0}, d_L, d_H\}$, with $B_{L0}, B_{L1}, B_{H0} \in [\underline{B}, \overline{B}]$ and $B_{L0} < B_{L1}$, that solve the following system of equations:

$$E_{A_L,B_{L0}}(d_L) = A_L x$$

$$E_{A_L,B_{L1}}(d_L) = E_{A_L,B_{L1}}(d_H) - c$$

$$E_{A_H,B_{H0}}(d_H) = A_H x$$

$$\frac{1}{B_{L1} - B_{L0}} \int_{B_{L0}}^{B_{L1}} D_{A_L,B}(d_L)\, dB = I$$

$$\frac{p}{Z} \int_{B_{H0}}^{\overline{B}} D_{A_H,B}(d_H)\, dB + \frac{1-p}{Z} \int_{B_{L1}}^{\overline{B}} D_{A_L,B}(d_H)\, dB = I,$$

where $Z = p(\overline{B} - B_{H0}) + (1-p)(\overline{B} - B_{L1})$. The first and third equalities represent the indifference conditions of firms at the threshold between investing and not investing. The second equality is indifference condition of a firm with low-quality assets in place that is at the threshold of reporting $m = A_H$ and reporting $m = A_L$. The last two equalities are outside investors' breakeven conditions.

Finally, when c is low, no firm reports $m = A_L$. Firms with low-quality and high-quality assets in place report $m = A_H$ and invest if $B \geq B_{L1}$ and $B \geq B_{H0}$, respectively, and do not invest otherwise. The equilibrium with low c then is the set of values $\{B_{L1}, B_{H0}, d_H\}$, with $B_{L1}, B_{H0} \in [\underline{B}, \overline{B}]$ that solve the following system of equations:

$$E_{A_L,B_{L1}}(d_H) - c = A_L x$$

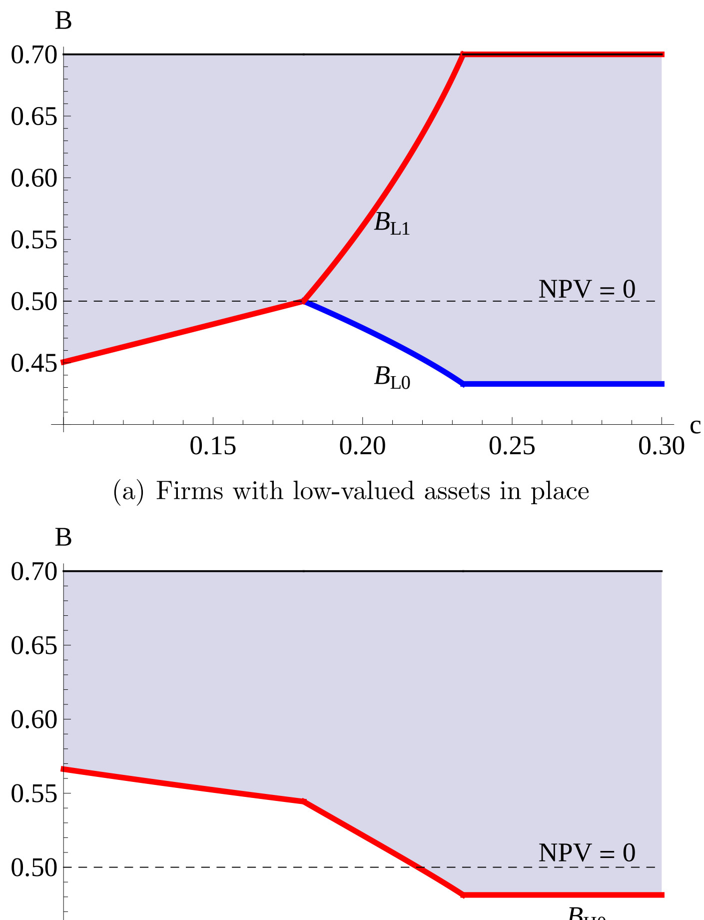
$$E_{A_H,B_{H0}}(d_H) = A_H x$$

$$\frac{p}{Z} \int_{B_{H0}}^{\overline{B}} D_{A_H,B}(d_H)\, dB + \frac{1-p}{Z} \int_{B_{L1}}^{\overline{B}} D_{A_L,B}(d_H)\, dB = I$$

The first two equalities represent the indifference conditions of the threshold firms and the last is outside investors' breakeven condition.

No closed form solution to these systems of equations is available, so I solve the problem numerically. I choose as parameter values $I = 1$, $x = 2$, $p = 0.5$, $A_L = 0.3$, $A_H = 0.7$,

$\underline{B} = 0.3$, and $\overline{B} = 0.7$. I have tried a number of different parameter values and the results are qualitatively the same. Figure 3 shows the equilibrium actions of firms in the model. The dashed line represents the zero NPV value of B, which is equal to I/x. In part (a) of the figure, which depicts the actions of firms with low-quality assets in place, firms with B above the red line report $m = A_H$ and invest, firms with B between the blue and red lines (if there are any) report $m = A_L$ and invest, and firms below both lines (in the non-shaded area) do not invest. In part (b) of the figure, which depicts the actions of firms with high-quality assets in place, firms with B above the red line report $m = m_H$ and invest while those below the red line (in the non-shaded area) do not invest.



(b) Firms with high-valued assets in place

Figure 3: Equilibrium project payoff thresholds as a function of the cost of misreporting

The results are roughly in line with the results from the four-type model discussed in the previous section, though the degree of equilibrium underinvestment is now a continuous function of c. When c is relatively low (less than 0.1803), there are firms with low-quality assets in place and negative NPV projects that invest because their debt is highly-subsidized. There are also firms with high-quality assets in place and positive NPV projects that do not invest because of adverse selection in the capital market. An increase in c in this range reduces both overinvestment and underinvestment.

Matters are more complex when c is moderate (between 0.1803 and 0.2336). When $c = 0.1803$, there is no overinvestment. As c increases from this point, overinvestment returns and grows. As the threshold value of B above which a firm with low-quality assets in place reports $m = A_H$ increases, there is more pooling below this threshold, leading to more cross-subsidization and therefore overinvestment of firms with negative NPV projects. However, underinvestment declines, as firms that truly have high-quality assets in place face less adverse selection (less pooling with firms possessing low-quality assets in place but claiming to have high-quality assets in place) in the capital market. At some value of c (approximately 0.227), underinvestment disappears completely, and beyond this point there is overinvestment among firms with high-quality assets in place as well.

When c reaches 0.2336, the threshold value of B above which firms with low-quality assets in place report $m = A_H$ reaches $\overline{B}$, and beyond this point no firm misreports. There is overinvestment among firms with both low-quality and high-quality assets in place. Equilibrium actions do not change for values of c greater than 0.2336.

Figure 4 shows the total value created by investment, normalizing the number of firms in the economy to one. At levels of c just above 0.1803, an increase in c reduces both overinvestment and underinvestment, and therefore has an unambiguously positive effect on investment efficiency. At values of c below 0.1803, an increase in c increases overinvestment and reduces underinvestment. The value destroyed by the marginal project now pursued by firms with low-quality assets in place is small relative to the value created by the marginal project now pursued by firms with high-quality assets in place, so an increase in c increases overall value created by investment. This is true as long as $c < 0.2$. Beyond this point, the value destroyed by the marginal project pursued by firms with low-quality assets in place is larger than the value created by the marginal project pursued by firms with high-quality assets in place (which is negative for even higher values of c), and an increase in c decreases overall value created by investment. Beyond $c = 0.2336$, there is no further change in value created.

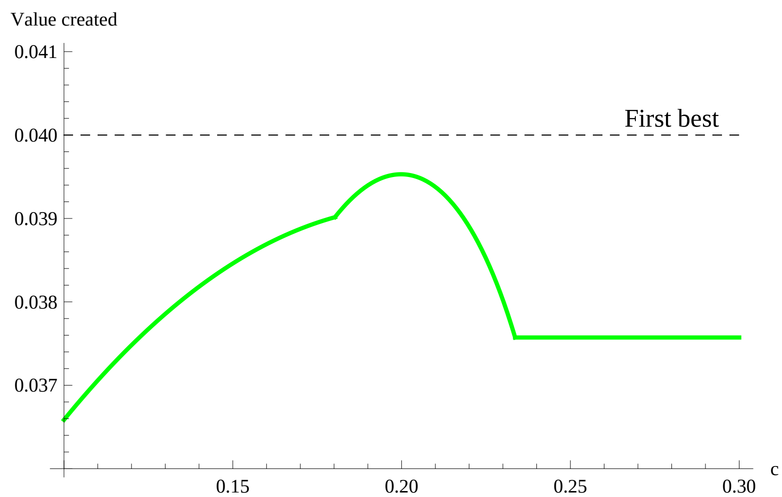


Figure 4: Equilibrium value created as a function of the cost of financial report manipulation

The level of c that maximizes investment efficiency in this example then is 0.2. This differs slightly from the conclusion in the previous section for the four-type model. In the four-type model, the value of c that maximizes investment efficiency is generally the lowest value of c such that firms with high-quality assets in place and high-quality projects still invest. In the continuous project type case, underinvestment, when it occurs, is continuous in c. As a result, the level of c that maximizes investment efficiency does result in some underinvestment, though the foregone projects would create only a small amount of value if pursued.

5 Extensions

In this section, I consider three extensions to the base model described in Section 2 and analyzed in Section 3. In the first, I consider the case where the firm finances new investment by issuing equity rather than debt. In the second, I consider the possibility that the expected cost of misreporting depends on the firm's realized cash flow. In the third, I consider the implications for the model of internal agency conflicts within the firm.

5.1 Equity issuance

The firm in the model finances new investment by issuing debt. Suppose now instead that the firm finances new investment by issuing equity instead, and that the insider maximizes the value of existing shareholders' claims less any costs he bears from misreporting. Let $1 - s(m)$ be the fraction of the firm's equity that is given to outside investors when the firm raises capital if it has reported $m \in \{A_L, A_H\}$. If reports have at least some credibility, then $s(A_H)$ will be larger than $s(A_L)$ since outside investors demand a larger share of the firm in exchange for capital when they expect the firm to have lower cash flow.

Suppose for a moment that a firm can commit to investing at the time it raises capital. Then the payoff to current shareholders of a type ij firm if the firm raises capital is $s(m)(a_i + b_j)$. Now suppose that a firm has issued equity. The expected payoff to its original shareholders is $s(m)(a_i + b_j)$ if the firm invests and $s(m)(a_i + I)$ if the firm retains the capital it has raised. Since $b_L < I < b_H$, only a firm with a high-quality project will invest after it raises capital. This differs from the debt financing case, since an all-equity firm has no incentive to invest in risky, negative NPV projects.

The expected payoff to current shareholders if the firm raises capital then is $s(m)(a_L + b_H)$ if the firm is type LH and $s(m)(a_L + I)$ if the firm is type LL. The benefit to current shareholders from reporting $m = A_H$ instead of $m = A_L$ is $[s(A_H) - s(A_L)](a_L + b_H)$ if the firm is type LH and $[s(A_H) - s(A_L)](a_L + I)$ if the firm is type LL. For $s(A_H) > s(A_L)$,

$[s(A_H) - s(A_L)](a_L + b_H) > [s(A_H) - s(A_L)](a_L + I)$ since $b_H > I$. This confirms that Proposition 2 continues to hold. Just as when the firm issues debt to finance investment, a firm with a better projet has an advantage exaggerating its report when the firm issues equity. This result then appears quite general.

It can easily be shown that the equilibrium is qualitatively the same as the one described in Proposition 3 for debt financing, with one important exception. There is no overinvestment in the equity financing case. Thus, even though a higher cost of misreporting leads to more capital-raising in a mixed reporting equilibrium, this does not result in less efficient investment. However, this ignores the considerable deadweight costs that are, in reality, associated with issuing equity. These costs include fees that must be paid to investment bankers and lawyers as well as the diversion of time and effort. Even though a higher cost of misreporting does not lead to less efficient investment per se in the equity financing case, it would still lead to more wasteful behavior in a mixed reporting equilibrium once these deadweight costs are taken into account.

5.2 Cash flow-dependent cost of misreporting

The cost of misreporting enters into the model in a very simplistic way: The insider simply bears a fixed cost if he lies. One might imagine that, in reality, the expected cost that an insider faces from issuing a false report varies with the firm's realized cash flow. The most natural reason for such a dependence is that report inflation is likely to be easier to detect and/or prove if a firm subsequently experiences poor performance.

Formally, suppose that the cost of misreporting is now given by $c(x)$, where x is the firm's realized cash flow, and $c'(x) < 0$. The net benefit to a firms with low-quality assets in place from reporting $m = A_H$ instead of $m = A_L$ is now $\hat{\Delta}(B_j) = \Delta(B_j) - E[c(x)|A_L, B_j])$, where $\Delta(B_j) = E_{Lj}(d_H) - E_{Lj}(d_L)$. Proposition 2 shows that $\Delta(B_H) > \Delta(B_L)$ as long as $d(A_H) < d(A_L)$. Now note that $E[c(x)|A_L, B_H] < E[c(x)|A_L, B_L]$, since $\tilde{x} = \tilde{a} + \tilde{b}$, and the cash flow $\tilde{b}$ from a high-quality project first order stochastic dominates cash flow from a low-quality project. Therefore, allowing the expected cost of false reporting to decrease with future cash flow strengthens the conclusions of Proposition 2. Intuitively, a firm with a high-quality project has two advantages in misreporting over one with a low-quality project: its shareholders benefit more and the insider bears a lower expected cost of misreporting.

5.3 Internal agency conflicts

Up to this point, I have assumed that the insider fully internalizes shareholder value creation, as would be the case, for example, if he owned 100% of the firm. Suppose now that the insider owns a fraction $\beta < 1$ of the firm and maximizes the value of his own stake less any cost of misreporting. Proposition 3 can easily be re-derived, with two differences. First, the seven threshold values of c shown before Proposition 3 are pre-multiplied by β. In other words, the lowest value of c that implements a mixed reporting equilibrium is βc_M rather than c_M, and the value of c that delineates a mixed reporting equilibrium from a truthful reporting equilibrium is βc_T rather than c_T. Second, in a mixed reporting equilibrium, the LH type will report $m = A_H$ with probability $\psi(\frac{c}{\beta})$ instead of $\psi(c)$. In a mixed reporting equilibrium, then, the effect of an increase in β would be equivalent to a decrease in c.

These results indicate that, holding c fixed, an increase in β will generally lead to less honest reporting. This is not surprising, since shareholders of a firm with low-quality assets in place benefit from misreporting, and a higher β better aligns the interests of the insider with those of shareholders. More interestingly, a high β, holding c fixed, will generally lead to less overinvestment but more underinvestment. The level of β that maximizes investment efficiency will generally be interior even if shareholders bear no cost from granting the insider higher pay-performance sensitivity. If c is relatively low, "selling the firm" to the manager will not be optimal.

6 Conclusion

This paper considered a model of investment under asymmetric information with financial reporting. It shows that when an insider is held more accountable for the accuracy of the firm's reports, the incidence of underinvestment declines but overinvestment increases. The cost of misreporting that maximizes investment efficiency is not maximal, but rather is low enough to ensure some misreoprting in equilibrium.

These conclusions are important for the policy debate over how responsible executives should be for the financial reports that their firms issue. They also show that considering information asymmetries about both assets in place and investment opportunities is important when considering the real effects of a financial reporting system. Finally, the model generates a sharp empirical prediction that could be tested with appropriate data on investment payoffs and the cost that firms face when they miresport.

A Proofs of Propositions

Proof of Proposition 1

Suppose that all firms are constrained to report truthfully. The worst possible belief about a firm with assets in place of quality A_i is that it is of type iL. The payoff to a firm of type iH from investing under these beliefs is $E_{iH}(d_{iL})$, which is strictly greater than its payoff from not investing, a_i, by Assumption 3. So a firm of type iH, for $i = L, H$, always raises capital and invests with probability 1. Suppose that a firm of type iL raises capital with probability ϕ_i. If it is indifferent between investing and not investing, $a_i = E_{iL}(d(A_i))$, or equivalently $d(A_i) = E_{iL}^{-1}(a_i)$. Outside investors' breakeven condition requires that $I = \frac{q_{iH} D_{iH}(d(A_i)) + q_{iL}\phi_i D_{iL}(d(A_i))}{q_{iH} + q_{iL}\phi_i}$. Substituting the iL type's indifference condition into this expression and solving for ϕ_i yields the expression in (4).

To see that $\phi_i > 0$, observe first that $I - D_{iL}(E_{iL}^{-1}) = I - (a_i + b_L) + E_{iL}(E_{iL}^{-1}(a_i)) = I - b_L > 0$. Thus the denominator of the expression for ϕ_i is positive. Next, observe that $D_{IH}(E_{iL}^{-1}(a_i)) - I > D_{iH}(d_{iH}) - I = 0$, where the inequality follows from Assumption 1 and the equality from the definition of d_{iH}. Thus the numerator of the expression for ϕ_i is also positive, and therefore $\phi_i > 0$.

To see that $\phi_i < 1$, rearrange the definition of $d_{iL,iH}$ to get $q_{iH}[D_{iH}(d_{iL,iH}) - I] = q_{iL}[I - D_{iL}(d_{iL,iH})]$. Since $E_{iL}(d_{iL,iH}) < a_i$ by Assumption 3, we have $q_{iH}[D_{iH}(E_{iL}^{-1}(a_i)) - I] < q_{iL}[I - D_{iL}(E_{iL}^{-1}(a_i))]$. So the numerator of ϕ_i is less than the denominator, and therefore $\phi_i < 1$. ■

Proof of Proposition 2

Using the expression for $E_{ij}(d)$ from equation (1),

$$E'_{ij}(d) = -\int_0^d \int_{d-\tilde{a}}^{\infty} f_i(\tilde{a}) g_j(\tilde{b})] \,\mathrm{d}\tilde{b}\,\mathrm{d}\tilde{a} - [1 - F_i(d)].$$

By first order stochastic dominance, $\int_0^d \int_{d-\tilde{a}}^{\infty} f_i(\tilde{a}) g_H(\tilde{b})] \,\mathrm{d}\tilde{b}\,\mathrm{d}\tilde{a} > \int_0^d \int_{d-\tilde{a}}^{\infty} f_i(\tilde{a}) g_L(\tilde{b})] \,\mathrm{d}\tilde{b}\,\mathrm{d}\tilde{a}$, so $E'_{LH}(d) < E'_{LL}(d)$. Therefore, $\Delta(B_H) > \Delta(B_L)$. ■

Proof of Lemma 3

Suppose first that the LH type mixes between reporting $m = A_H$ and $m = A_L$. Then, by Lemma 2, the LL type mixes between not investing and reporting $m = A_L$ and investing, which requires that $E_{LL}(d(A_L)) = a_L$, or equivalently that $d(A_L) = E_{LL}^{-1}(a_L)$. For the LH type to be indifferent between reporting $m = A_H$ and $m = A_L$, we must have $E_{LH}(d(A_H)) - c = E_{LH}(d(A_L))$, or substituting in for $d(A_L)$ from the LL types' indifference condition and solving, $d(A_H) = d_1 \equiv E_{LL}^{-1}(E_{LH}(E_{LL}^{-1}(a_L)) + c)$. The HL type at least weakly prefers raising capital over not raising capital if and only if $E_{HL}(d(A_H)) \geq a_H$, or equivalently if $d(A_H) \leq d_2 \equiv E_{HL}^{-1}(a_H)$. Suppose that $d_2 < d_1$. Then $E_{HL}^{-1}(a_H) < E_{LL}^{-1}(E_{LH}(E_{LL}^{-1}(a_L)) + c)$, or equivalently $E_{LH}(E_{HL}^{-1}(a_H)) - c > E_{LH}(E_{LL}^{-1}(a_L))$. But this expression implies that the LH type strictly prefers reporting $m = A_H$ to reporting $m = A_L$. ■

Proof of Proposition 3

Establishing the equilibrium:

(i) (Truthful reporting equilibrium) Suppose that $c \geq c_T$ and that the equilibrium described holds. Since all types report truthfully, by Proposition 1 the iL type is indifferent between not investing and reporting $\hat{A} = A_i$ and investing, and the iH type prefers reporting $\hat{A} = A_i$ and raising capital over not raising capital for $i = L, H$. It remains to be shown that, for $j = L, H$, the Lj type does not prefer to report $m = A_H$. Since the iL type is indifferent between investing and not investing in the equilibrium, we must have $d(A_i) = E_{iL}^{-1}(a_i)$ for $i = L, H$. A type LH firm prefers reporting $m = A_H$ and raising capital only if $E_{LH}(d(B_H)) - c \geq E_{LH}(d(B_L))$, or, substituting in for $d(A_L)$ and $d(A_H)$ and solving for c, if $c < E_{LH}(E_{HL}^{-1}(a_H)) - E_{LH}(E_{LL}^{-1}(a_L)) = c_T$. Thus, the LH type prefers reporting $m = A_L$ over reporting $m = A_H$ if $c > c_T$. By Proposition 2, the LL type never reports $m = A_H$, and the equilibrium holds.

(ii) (Partial lying equilibrium) Suppose that $c \in [c_M, c_T)$ and that the equilibrium described holds. The derivation of equation (6) shows that the LH type is indifferent between reporting $A = A_L$ and $A = A_H$ when $\sigma_{LH}^{A_H} = \psi(c)$. By Lemma 2, the LL type is indifferent between not investing and reporting $\hat{A} = A_L$ and investing when $\sigma_{LL}^L = \phi_L[1 - \psi(c)]$. Since the LH type mixes between reporting $\hat{A} = A_L$ and $\hat{A} = A_H$, we must have $E_{LH}(d(B_H)) - c = E_{LH}(d(B_L))$. Since the LL type mixes between not investing and investing, we must have $d(B_L) = E_{LL}^{-1}(a_L)$. Substituting this expression into the LH type's indifference condition and solving for $d(B_H)$, we get $d(B_H) = E_{LH}^{-1}(E_{LH}(E_{LL}^{-1}(a_L)) + c)$. The HH type raises capital if and only if $E_{HH}(d(B_H)) \geq a_H$. Substituting in for $d(B_H)$ and solving shows that the HH type raises capital invests if and only if $c \geq E_{LH}(E_{HH}^{-1}(a_H)) - E_{LH}(E_{LL}^{-1}(a_L)) = c_M$. By Lemma 3, the HL type does not invest. Finally, $\psi(c_T) = 0$ and $\psi'(c) < 0$, so $\psi > 0$ for $c < c_T$. Also, $\psi(c) \geq 1$ for $c \geq c_M$ would imply that $E_{HH}(d_{LH,HH}) \geq a_H$, which is ruled out by Assumption 2.

(iii) (Underinvestment equilibrium) (a) Suppose that the equilibrium holds and that outside investors believe that a firm playing the out-of-equilibrium move report $\hat{A} = A_H$ and raise capital is the LH type. Then $d(A_H) = d_{LH}$. Under Assumption 2, HL and HH types do not raise capital. The LL type reports $\hat{A} = A_L$ and raises capital with probability ϕ_L by Lemma 1, and never reports $\hat{A} = A_H$ by Proposition 2. The LH type reports $\hat{A} = A_L$ if $E_{LH}(d_{LH}) - c < E_{LH}(d(B_L))$, or substituting in $d(B_L) = E_{LL}^{-1}(d(B_L))$ (the LL type's indifference condition) and noting that $E_{LH}(d_{LH}) = a_L + b_H - I$, if $c \geq c_U^{1-}$. Out-of-equilibrium beliefs are sustained under the intuitive criterion as long as the LH type prefers reporting $\hat{A} = A_H$ rather than playing its equilibrium strategy for some belief about the type of firm reporting $\hat{A} = A_H$. The best possible belief is that the firm is of type HH, which would result in $d(A_H) = d_{HH}$. Thus the out-of-equilibrium belief is sustainable if $E_{LH}(E_{LL}^{-1}(a_L)) < E_{LH}(d_{LH}) - c$, or equivalently if $c < c_U^{1+}$. Thus the equilibrium holds, supported by the belief that a firm reporting $\hat{A} = A_H$ and raising capital is of type LH, if $c \in [c_U^{1-}, c_U^{1+})$.

Now suppose that instead outside investors believe a firm playing the out-of-equilibrium move report $\hat{A} = A_H$ and raise capital is the LL type. The LL type strictly prefers his equilibrium payoff $E_{LL}(E_{LL}^{-1}(a_L)) = a_L$ to his payoff from reporting A_H, $E_{LL}(d_{LL}) - c =$

$a_L + b_L - I - c$, since $b_L < I$. The out-of-equilibrium belief is sustained as long as the LL type prefers reporting $\hat{A} = A_H$ rather than playing its equilibrium strategy for some belief about the type of firm reporting $\hat{A} = A_H$. The best possible belief again is that the firm is of type HH. The out-of-equilibrium belief is sustainable if $E_{LL}(E_{LL}^{-1}(a_L)) < E_{LL}(d_{HH}) - c$, or equivalently if $c < c_U^{3+}$.

(iii) (b) Suppose that the equilibrium holds and that outside investors believe that a firm playing the out of equilibrium move report $\hat{A} = A_L$ and raise capital is of type LL, the worst possible type. Then $d(A_L) = d_{LL}$. Since only the LH type reports $\hat{A} = A_H$ and raises capital, $d(A_H) = d_{LH}$. Under Assumption 2, the HL and HH types do not raise capital. The LH type prefers to report $\hat{A} = A_H$ rather than $\hat{A} = A_L$ as long as $E_{LH}(d_L H) - c = a_L + b_H - I - c \geq E_{LH}(d_{LL})$, or equivalently if $c < c^{U_2^+}$. The LL type prefers not raising capital to reporting A_L and raising capital, since $a_L > E_{LL}(d_{LL}) = a_L + b_L - I$. The LL type prefers not raising capital to reporting $\hat{A} = A_H$ and raising capital as long as $a_L \geq E_{LL}(d_{LH}) - c$, or equivalently if $c \geq c_U^{2-}$. The belief that a firm playing the out-of-equilibrium move is the LL type is always supportable under the intuitive criterion since the LL type's equilibrium payoff, a_L, would be less than his payoff from reporting $\hat{A} = A_L$ and raising capital if outside investors believed that the type playing this move were type LH (under Assumption 1). Thus the equilibrium holds, supported by the belief that a firm reporting $\hat{A} = A_L$ and raising capital is of type LL, if $c \in [c_U^{2-}, c_U^{2+})$.

(iii) (c) Suppose that the equilibrium holds. Again, the belief that a firm reporting $m = A_L$ and raising capital is of type LL, the worst possible type, is sustainable. Suppose that this belief holds. Then $d(A_L) = d_{LL}$. For the LL type to be indifferent between not raising capital and reporting $m = A_H$ and raising capital, we must have $E_{LL}(d(A_H)) - c = a_L$, or $d(A_H) = E_{LL}^{-1}(a_L + c)$. Outside investors' breakeven condition requires that that $I = \frac{q_{LH} D_{LH}(d(A_H)) + q_{LL} \sigma_{LL}^{A_H} D_{LL}(d(A_H))}{q_{LH} + q_{LL} \sigma_{LL}^{A_H}}$, or equivalently that $\sigma_{LL}^{H} = \eta(c)$. $\eta(c) > 0$ is equivalent to $c < c_U^{1-}$. Note that $\eta'(c) < 0$ and $\eta(0) = \phi_L$, so $\eta \in (0, 1)$ for $c \in [0, c_U^{2-})$. Since the LL type reports $\hat{A} = A_H$ and raises capital with positive probability, the LH type reports

$m = A_H$ and raises capital with probability one by Proposition 2. Under Assumption 2, the LH and HH type do not raise capital.

Establishing the relations among thresholds:

To see that $c_M > 0$, observe that $E_{HH}^{-1}(a_H) < d_{LH,HH}$, which is just Assumption 2 rewritten, and $d_{LH,HH} < d_{LH} < E_{LL}^{-1}(a_L)$, where the first inequality is due to higher expected cash flow when a firm might be the LH or HH type than when the firm is the LH type for sure, and the second inequality is due to Assumption 1. To see that $c_M < c_T$, note that $E_{HH}^{-1}(a_H) > E_{HL}^{-1}(a_H)$. To see that $c_U^{1-} > 0$, observe that $a_L + b_H - I = E_{LH}(d_{LH})$ and $d_{LH} < E_{LL}^{-1}(a_L)$ since $E_{LL}(d_{LH}) > a_L$ by Assumption 1. To see that $c_U^{1-} < c_U^{1+}$, note again that $a_L + b_H - I = E_{LH}(d_{LH})$ and observe that $d_{HH} < d_{LH}$. That $c_U^{2-} > 0$ follows directly from Assumption 1. To see that $c_U^{2-} < c_U^{2+}$, note that this is equivalent to $E_{LH}(d_{LH}) - E_{LH}(d_{LL}) > E_{LL}(d_{LH}) - E_{LL}(d_{LL})$. From the proof of Proposition 2, $\frac{\partial E_{LH}(d)}{\partial d} < \frac{\partial E_{LL}(d)}{\partial d}$. Since $d_{LH} < d_{LL}$, the result follows. Finally, to see that $c_U^{3+} > 0$, note that $E_{LL}(d_{HH}) > E_{LL}(d_{LH})$ since $d_{HH} < d_{LH}$, and that $E_{LL}(d_{LH}) > a_L$ by Assumption 1. ■

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