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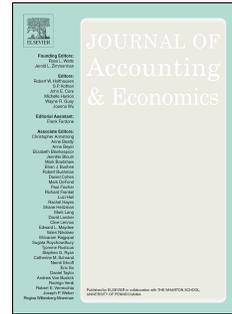
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Accounting Conservatism and Managerial Information Acquisition*

Christian Laux[†] and Volker Laux[‡]

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August 3, 2023

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1 Introduction

Debt contracts often include covenants that are based on accounting reports.¹ Poor reported performance triggers covenant violations and transfers control rights to lenders, allowing them to intervene and take corrective actions. However, accounting reports are not the only source of information when making intervention decisions. Managers who run the firm are in a unique position to acquire additional evidence about firm performance, and boards of directors can provide managers with optimal incentives to do so. In this paper, we study how the two sources of information interact: How do managers' incentives to gather information affect the optimal financial reporting system, and how does the reporting system affect managerial incentives?

We consider an investment problem with a board of directors, a manager, and a lender. The board acts in the interest of shareholders and raises debt to finance a project. The project's ex ante expected cash flow exceeds its liquidation value, so that it is optimal to continue the project unless negative information about its profitability arises. The debt contract includes an accounting-based covenant that transfers control rights to the lender when reported performance is poor. If the accounting report is the only source of information, it determines the project continuation decision: The lender liquidates the project following a covenant violation, and the project continues otherwise. However, after observing the report, the manager can exert effort to acquire additional information about the project's profitability. If the covenant is violated and the manager uncovers evidence that the accounting report was a false alarm, the lender waives the covenant and the project continues. If the covenant is not violated and the manager uncovers evidence that the report was unduly optimistic,

¹See Armstrong et al. (2010), Christensen et al. (2016), and Penalva and Wagenhofer (2019) on the role of accounting information for financial contracting and an overview of the literature.

the board and the lender renegotiate the debt contract and liquidate the project. The board's task is to choose the accounting system and the incentive pay plan for the manager that maximize shareholder value.

When information acquisition is prohibitively costly, the design of the accounting system involves the standard trade off between type I and type II errors. Liberal reporting rules increase the probability that the accounting report is unduly optimistic about firm performance, which results in the continuation of unprofitable projects. In contrast, conservative accounting increases the probability that a covenant violation is a false alarm, which results in the liquidation of profitable projects. Since the ex ante value of continuing the project exceeds its liquidation value, the expected cost of false alarms dominates the expected cost of undue optimism and the optimal accounting system is liberal, as in Gigler et al. (2009) and Li (2013).

The manager's ability to gather information to detect false alarms and undue optimism changes the trade offs underlying the optimal accounting system. Under optimally designed incentive pay plans, we find that conservative accounting can become optimal if the project is ex ante more likely to be of high quality than of low quality. In this case, the manager gathers more information under conservative accounting since she is more likely to uncover a false alarm under conservative accounting than to uncover undue optimism under liberal accounting. Thus, managerial information acquisition reduces the expected cost of false alarms by more than the expected cost of undue optimism and conservative reporting can be optimal. The benefit of conservatism further increases when the manager's cost of information acquisition declines because the effects of managerial information on the expected costs of false alarms and undue optimism strengthen.

The liquidation of the project (or the firm) negatively affects the manager's utility

because it can lead to the loss of perks, prestige, reputation, career opportunities, or future compensation.² The private benefits associated with the project provide the manager with asymmetric incentives to collect information, which in turn affects the optimal accounting system. Specifically, in the absence of a covenant violation, the default action is to continue the project, which is the manager's preferred action. The manager then has a disincentive to produce additional information because the project is liquidated if it turns out that the accounting report was unduly optimistic. To motivate information acquisition, the board must compensate the manager for the lost private benefits, which increases the cost of the incentive pay plan. In contrast, if the covenant is violated, the threat of lender intervention induces the manager to gather information, hoping to uncover evidence that persuades the lender to waive the covenant. The manager's private benefits then reduce the need for costly incentive pay to motivate information acquisition.³ As a result, the manager's ability to gather information and her preference for continuing the project render conservative accounting more attractive for shareholders and liberal accounting less attractive and hence increase the range of parameter values for which conservatism is optimal. As an analogy, consider students' re-grading requests after receiving their exams. Students have an incentive to search for and point out grading mistakes when they get a low grade, but they do not scrutinize a high grade. Thus, the number of undetected grading mistakes is lower if mistakes lead to an erroneously low grade than an erroneously high grade.⁴

²Managers' desire to continue projects, keep their jobs, or increase investment levels play an important role in the literature on corporate governance and accounting. See, e.g., Aghion and Tirole (1997), Ball (2001), Baldenius (2003), and Francis and Martin (2010).

³The effect is related to Cremer (1995), who shows that the manager's desire not to be fired is a substitute for incentive pay.

⁴Arya and Glover (2008) investigate a moral hazard problem with multiple performance measures

Our model is consistent with the empirical findings that lenders frequently waive debt covenants (Dichev and Skinner, 2002; Nini et al., 2012) and that conservative reporting increases the probability of a covenant violation (Zhang, 2008).⁵ A novel prediction of the model is that lenders are more likely to waive debt covenants after a covenant violation when firms adopt more conservative accounting policies. Conservative accounting reduces the precision of early warning signals, which increases the likelihood that managers find favorable evidence that persuades lenders to waive the covenant. This prediction is important because, if confirmed, it would indicate that conservative reporting indeed increases the incidence of false alarms, as argued by, e.g., Leuz (2001), Gigler et al. (2009), and Lambert (2010).

Empirical studies find that debt contract renegotiations also occur outside of covenant violations (Roberts and Sufi, 2009; Roberts, 2015). Our model suggests that renegotiations in the absence of a covenant violation are more likely when firms adopt more liberal accounting. Liberal accounting renders favorable accounting reports less informative about the firm's underlying performance, which increases the likelihood that managers find evidence that causes investors to renegotiate the debt contract.

Related to the previous predictions, the model suggests that managerial private benefits result in more covenant waivers following a covenant violation but less debt renegotiations outside of covenant violations. The asymmetry arises because man-

and show that it can be optimal to allow the agent to select which performance measures to appeal rather than to reevaluate all performance measures after an appeal.

⁵Garleanu and Zwiebel (2009), Caskey and Hughes (2012), and Guttman and Marinovic (2018) also address the empirical observation that debt contract renegotiations occur after covenant violations, but they examine different mechanisms. In these studies, renegotiation arises because the initial contract allocates control rights to the lender in order to deter asset substitution or misreporting, which are then returned ex post to the entrepreneur. In contrast, in our model, renegotiation arises because the manager can acquire additional information about the quality of the project.

agers that derive greater private benefits from their projects have stronger incentives to search for additional information after a covenant violation and weaker incentives to gather information in the absence of a violation.

Concerning the optimal reporting system, the model predicts that well-governed firms (that act in the best interest of shareholders) are more likely to adopt conservative accounting when managers have a greater preference for continuing their projects due to private benefits. This prediction is related to the arguments in Ball (2001) and Francis and Martin (2010) that conservative reporting has value because it prevents managers from continuing poorly performing projects to avoid the loss of private benefits and compensation. We show that conservative accounting does not just prevent managers from taking inefficient actions, but allows shareholders to take advantage of the managers' private benefits as a means to encourage information acquisition after a covenant violation. A related prediction of the model is that private benefits and lender intervention are negatively associated. This prediction does not follow because managers have the power to impede intervention. Instead, the manager's desire to protect her private benefits leads to more information acquisition after a covenant violation and less information acquisition in the absence of a covenant violation and both effects reduce the probability of intervention.

Our model contributes to the debate on the optimality of conservative accounting. Empirical studies generally find that conservative accounting is beneficial for debt contracting.⁶ The standard explanation is that conservatism increases the fre-

⁶Empirical studies that support the debt contracting role of conservatism include, e.g., Ball and Shivakumar (2005), Ball et al. (2008), Beatty et al. (2008), Wittenberg-Moerman (2008), Zhang (2008), Chen et al. (2010), Nikolaev (2010), Haw et al. (2014), Garcia Lara et al. (2016), and Donelson et al. (2017). An exception are Dyreng et al. (2017) who find that earnings measures used in covenants are adjusted to make them more predictive of future performance and that these measures do not exhibit asymmetric loss timeliness.

quency of early warning signals, which trigger covenant violations and allow lenders to take corrective actions (e.g., Ball, 2001; Watts, 2003). However, an important concern raised in the literature is that conservative reporting also increases the risk of false alarms, causing lenders to liquidate promising projects (Leuz, 2001; Gigler et al., 2009; Lambert, 2010). Gigler et al. (2009) show analytically that this trade off results in liberal accounting to be optimal for debt contracting. Building on Gigler et al. (2009), Li (2013) assumes that shareholders learn the quality of the project prior to the continuation decision and studies how renegotiation costs affect the optimal accounting system. If renegotiation is costless, as in our model, the accounting system is irrelevant. If contract renegotiation is costly, conservative reporting can be optimal because it reduces the expected cost of renegotiation. In a recent working paper, Gao et al. (2023) consider a setting where renegotiation is costly and the project quality is observable at the time of the continuation decision. Before signing the debt contract, the owner-manager can investigate whether extant accounting rules lead to perfect or biased reports and can eliminate the bias if she finds one. While eliminating the bias has the benefit of preventing costly renegotiation, the owner's investigation also leads to pre-contract information asymmetry. The option to strategically disclose or withhold information leads to socially excessive information acquisition, similar to Shavell (1994) and Guttman and Meng (2021). Jiang (2016) studies how the presence of a biased non-accounting information system affects the optimal bias in the accounting system. He finds that if the bias in the non-accounting system is conservative (liberal), the accounting system should also be conservative (liberal). For example, if the non-accounting system is conservative, the accounting system has the most value if it prevents investors from liquidating a good project after a low non-accounting signal. This is achieved if the accounting system generates precise high signals and

hence should be conservative as well. In our setting, there is no need to tailor the accounting system to the bias of the non-accounting signal because the information the manager generates is perfect. In contrast to this literature, we focus on a setting where information about project quality arises endogenously from managerial information acquisition. Further, we allow for optimal incentive contracts that induce the manager to gather information to uncover potential false alarms and undue optimism after observing the report, which affects the interim liquidation decision and, in turn, the properties of the optimal accounting system.

Another related strand of literature studies the value of conservatism for incentive contracting when the accounting report is used as a performance measure (e.g., Kwon et al., 2001; Kwon, 2005; Bertomeu et al., 2017). In these studies, conservatism reduces the expected bonus required to induce managerial effort because conservatism renders a high accounting report more informative about the manager's effort choice. Other related studies focus on the effects of conservatism on litigation risk (Kronenberger and Laux, 2022) and on managers' incentives to engage in earnings management (Chen et al., 2007; Gao, 2013; Bertomeu et al., 2017; Caskey and Laux, 2017).

Studies that follow the Bayesian persuasion literature assume that the principal can choose any information system, including one that is perfectly precise. One take-away in this literature is that the principal may prefer imprecise measurement over precise measurement.⁷ Huang (2016) considers a setting where the manager chooses the reporting system and where investors can acquire information about project quality before making the investment decision. She finds that the manager chooses either

⁷For example, Goex and Wagenhofer (2009), Kamenica and Gentzkow (2011), Bertomeu and Cheynel (2015), Friedman et al. (2020, 2022), Bertomeu et al. (2021), and Dordzhieva et al. (2022).

an uninformative or a liberal accounting system if the manager's and investors' objectives are misaligned due to the manager's private benefits. Her setting differs from ours in who chooses the accounting system (the manager, not the board), who acquires information (investors, not the manager), the absence of managerial incentive pay, and the possibility to choose a fully informative accounting system. In our setting, if it is possible to choose a fully informative accounting system at zero cost, the board will always implement it as it maximizes the expected cash flow to investors.

2 Model

We consider a model with three risk-neutral parties: A board of directors, acting on behalf of shareholders, a manager, and a lender. The board raises debt from the lender to finance a new project and hires the manager to run it.

The model has three dates. At date 1, the board chooses the properties of the firm's accounting system, offers the manager a bonus contract, and then raises debt to finance the project. At date 2, the accounting system generates a report that is imperfectly informative about the quality of the project. After the report is released, the manager can produce additional information about the project's prospects. The party in control chooses to liquidate or continue the project, possibly after renegotiating the debt contract. At date 3, payoffs are realized and shared according to the contracts in place.

Project. The project requires an investment of I and yields a cash flow at date 3. The cash flow depends on the project's quality, $\theta \in \{\theta_h, \theta_l\}$. A high-quality project, $\theta = \theta_h$, yields a cash flow of X , and a low-quality project, $\theta = \theta_l$, yields a cash flow of zero. The project's quality is initially unknown to all parties, but it is common

knowledge that the prior probability of a high-quality project, $\theta = \theta_h$, is $q \in (0, 1)$. The project can be continued or liquidated at date 2 and the project's liquidation value is L . We assume that all payoffs are verifiable and

$$qX > I > L. \quad (1)$$

The assumption $qX > L$ is standard in the literature and implies that liquidating the project is inefficient unless additional negative information about the project quality emerges (e.g., Gigler et al., 2009). Let $\underline{X} = L/q$ denote the lower bound for X such that $qX > L$ is satisfied.

Accounting system. At date 2, the firm's accounting system produces a report $R \in \{R_l, R_h\}$ that is informative about project quality θ , according to the following conditional probabilities:⁸

$$\Pr(R_h|\theta_h, c) = \lambda - c \text{ and } \Pr(R_l|\theta_l, c) = \lambda + c.$$

While λ is exogenously given, the board can choose $c \in [\underline{c}, \bar{c}]$, which reflects the degree of conservative (or liberal) accounting and is observable to all parties. $\Pr(R|\theta, c)$ denotes the probability that θ is mapped into report R , given c . To ensure that the conditional probabilities are between zero and one, we assume that $\underline{c} = -(1 - \lambda)$ and $\bar{c} = (1 - \lambda)$. We refer to the accounting system as neutral if $c = 0$, liberal if $c < 0$, and conservative if $c > 0$. Further, we assume that $\lambda > 0.5$ so that a high report R_h is good news and a low report R_l is bad news.

⁸Studies that use this or a similar statistical characterization of conservatism include Gigler and Hemmer (2001), Chen et al. (2007), Gigler et al. (2009), Drymiotis and Hemmer (2013), Li (2013), Nan and Wen (2014), Jiang (2016), Bertomeu et al. (2017), and Caskey and Laux (2017).

Let $\Pr(\theta|R, c)$ denote the interim posterior belief that the project quality is θ conditional on the report R and the level of conservatism c . Using Bayes's rule,

$$\Pr(\theta_h|R, c) = q \frac{\Pr(R|\theta_h, c)}{\Pr(R|c)},$$

where

$$\Pr(R|c) = q \Pr(R|\theta_h, c) + (1 - q) \Pr(R|\theta_l, c)$$

is the ex ante probability that the accounting report is R .

As c increases, the probability of a low report increases, but its information content decreases, $d\Pr(R_l|c)/dc > 0$ and $d\Pr(\theta_l|R_l, c)/dc < 0$. Further, an increase in c reduces the probability of a high report, but increases its information content, $d\Pr(R_h|c)/dc < 0$ and $d\Pr(\theta_h|R_h, c)/dc > 0$.

Given Assumption (1) and $\lambda > 0.5$, the expected cash flow from continuation exceeds the liquidation value when the report is high, that is, $\Pr(\theta_h|R_h, c)X > L$. For the accounting system to be relevant, we assume that the liquidation value exceeds the expected cash flow from continuation when the report is low, that is,

$$L > \Pr(\theta_h|R_l, c)X. \quad (2)$$

Assumption (2) implies that the precision of the accounting system, λ , is not too low since $\lambda \rightarrow 1/2$ implies $\Pr(\theta_h|R_l, c) \rightarrow \Pr(\theta_h|R_h, c)$, and that the cash flow in case of success, X , is not too high. Formally, Assumption (2) holds for all c if it holds for $c = \bar{c}$ since $\Pr(\theta_h|R_l, c)$ increases in c . Thus, X must not exceed an upper bound $\bar{X} = \frac{\Pr(R_l|\bar{c})}{q^2(1-\lambda)}L$.

Financial contract. At date 1, the board offers the lender a debt contract with face value D . Ex ante, the lending market is competitive and the lender finances the project if he expects to break even in equilibrium. The assumption $qX > I$ in (1) implies that the lender's participation constraint can be satisfied and shareholders find it optimal to carry out the project.

The debt contract includes a covenant that is violated if the accounting report is low, $R = R_l$. Following a covenant violation, the lender gains control and has the right to make the liquidation decision. If the report is high, $R = R_h$, the covenant is not violated and the board retains control.

The board and the lender can costlessly renegotiate the debt contract at any time. Renegotiation leads to a new face value of debt, D , such that the lender receives the share $\delta \in [0, 1]$ of the surplus from renegotiation and shareholders receive the remaining share $1 - \delta$. The possibility of renegotiation implies that the board and the lender will implement the action that maximizes the expected cash flow to investors (shareholders and the lender).⁹

Information acquisition. The manager can search for additional information about the quality of the project θ after observing the accounting report R at date 2. Given information acquisition effort $a \in [0, 1]$, the manager uncovers a signal $S \in \{\theta_h, \theta_l\}$ with probability a and does not uncover a signal with probability $(1 - a)$. The effort choice a is unobservable and involves a private cost of $0.5ka^2$ for the manager. We assume that the cost parameter k is sufficiently high so that the manager is not always

⁹The covenant minimizes the need for contract renegotiations or waivers by allocating control to the party that takes the action that maximizes the total cash flow to investors given the available accounting information. (See Lemma 1.) The assumption that renegotiation is costless implies that the optimal accounting system does not depend on the initial allocation of control rights, which allows us to focus on the interaction between optimal financial reporting rules and managers' incentives to gather additional information.

informed, that is, $a^* < 1$.

If the manager uncovers a signal, it is observable to all parties.¹⁰ However, the signal S is not contractible, which captures the notion that it is difficult to describe in an ex ante contract what exactly an informative signal constitutes (e.g., Hart and Moore, 1988). The assumption implies that financial contracts cannot be contingent on S , so that covenant waivers and renegotiations can play a role.

Managerial incentives. At date 1, the board implements an incentive system to provide the manager with incentives to collect information. The optimal contract pays the manager a reward $w_{fa} \geq 0$ if she uncovers that the accounting report was a false alarm and a reward $w_{uo} \geq 0$ if she uncovers that the report was unduly optimistic.¹¹ Since the signal S is not verifiable, the board implements these payments as follows: The manager is paid w_{fa} if the project continues after a low accounting report $R = R_l$ (which indicates the report was a false alarm) and w_{uo} if the project is liquidated after a high accounting report $R = R_h$ (which indicates the report was unduly optimistic). The manager is protected by limited liability and has a reservation utility of zero. The bonus contract is granted to the manager prior to raising debt and is observable by the lender.

In addition to the bonus, the manager derives private benefits $B \geq 0$ from continuing the project that she loses if the project is liquidated. These benefits can arise from perquisite consumption, reputation, prestige, and career opportunities as well as from incentive pay that induces the manager to implement the project. We assume that $B < \min\{L, X - L\}$, which implies that the optimal payments w_{fa} and w_{uo} are

¹⁰Our results do not change if the manager can strategically withhold the signal.

¹¹We assume that the bonus is paid out of the project's cash flow and is senior to the claim of the lender. Our results do not change if the manager's reward is paid directly out of the shareholders' pockets.

positive. We relax this assumption in the Online Appendix and show that our main results remain unchanged.

3 Optimal continuation decision and information acquisition

3.1 Optimal continuation decision

At date 2, the party in control makes the project continuation decision, possibly after renegotiating the debt contract. We obtain the following results:

Lemma 1 *The optimal continuation decision depends on the accounting report R and, if available, the signal S .*

(i) *After a low accounting report, $R = R_l$, the lender is in control and waives the covenant if $S = \theta_h$ and liquidates the project otherwise.*

(ii) *After a high accounting report, $R = R_h$, the board is in control and liquidates the project after renegotiating the debt contract if $S = \theta_l$ and continues the project otherwise.*

In what follows, we refer to an action as optimal if it maximizes the total cash flow to investors (i.e., shareholders and the lender). If the manager does not generate a signal S , the party in control will always implement the optimal action and there is no scope for renegotiation. Specifically, if $R = R_l$, the optimal action is to liquidate the project because $L > \Pr(\theta_h | R_l, c)X$ from (2). In this case, the lender is in control and he will choose to liquidate since liquidation yields him $\min\{L, D\} = L$, where $L < D$ follows from $L < I$ and the lender's participation constraint, and continuation

yields him $\Pr(\theta_h|R_l, c)D$, where D cannot exceed X . If $R = R_h$, the optimal action is to continue the project because $\Pr(\theta_h|R_h, c)X > L$ follows from (1). The board is then in control and it will continue the project because shareholders receive $X - D$ in case of a successful continuation and zero in case of liquidation.

If the manager generates a signal S that confirms the accounting report, the manager does not receive a bonus and the optimal actions do not change. However, if the manager uncovers a positive signal, $S = \theta_h$, after a low accounting report, $R = R_l$, project continuation becomes optimal because $X - w_{fa}^* > L$. The inequality follows because the manager's optimal bonus w_{fa}^* for uncovering information is strictly lower than the value of the information for investors $X - L$ (see also Proposition 1). In this case, the lender simply waives the covenant because $\min\{D, X - w_{fa}^*\} > L$. In contrast, if the manager uncovers a negative signal, $S = \theta_l$, after a high accounting report, $R = R_h$, shareholders are indifferent between continuing and liquidating the project because they receive zero in either case. However, the expected cash flow to investors from liquidation is positive, $L - w_{uo}^* > 0$, because the manager's optimal bonus w_{uo}^* for uncovering information is strictly lower than the value of the information L (see also Proposition 1). The parties then renegotiate the debt contract to liquidate the project. The new face value of debt is set equal to $\delta(L - w_{uo}^*)$, where δ represents the lender's bargaining power at the renegotiation stage. The bargaining power δ does not affect the optimal bonus or accounting system because the lender always receives I in expectation.

3.2 Information acquisition

The manager chooses the level of information acquisition a after observing the accounting report R , taking into account the continuation decision from Lemma 1.

Conditional on R_l and R_h , the manager's expected utility is

$$V(R_l, a) = \Pr(\theta_h|R_l, c)a(w_{fa} + B) - 0.5ka^2, \quad (3)$$

$$V(R_h, a) = B + \Pr(\theta_l|R_h, c)a(w_{uo} - B) - 0.5ka^2, \quad (4)$$

respectively. We obtain the manager's optimal information acquisition level, $a(R, c)$, by taking the first-order conditions of (3) and (4).

Lemma 2 *Given the accounting report $R \in \{R_l, R_h\}$, degree of conservatism $c \in [\underline{c}, \bar{c}]$, and pay plan $w_{uo} \geq 0, w_{fa} \geq 0$, the manager chooses information acquisition levels*

$$a(R_l, c) = \Pr(\theta_h|R_l, c)(w_{fa} + B)/k \quad (5)$$

$$a(R_h, c) = \Pr(\theta_l|R_h, c) \max\{0, (w_{uo} - B)/k\}. \quad (6)$$

Private benefits B provide the manager with incentives to correct low accounting reports and a disincentive to correct high accounting reports.

When the accounting report is low, the manager's private benefits B induce her to search for information that persuades the lender to continue the project. Private benefits B and the bonus w_{fa} are substitutes in inducing information acquisition, and a larger B reduces the need for monetary rewards. In contrast, when the accounting report is high, the manager has a disincentive to search for information because uncovering negative evidence leads to the liquidation of the project and the loss of private benefits. The manager acquires information only if the bonus for uncovering a negative signal compensates her for the lost benefits, that is, if $w_{uo} > B$.

4 Optimal incentive contract and accounting system

4.1 The board's optimization problem

The board chooses the level of conservatism c , pay plan (w_{uo}, w_{fa}) , and face value D that maximize shareholder value at date 1, subject to the manager's and lender's participation constraints and the manager's incentive constraints (5) and (6). The manager's participation constraint is always satisfied because her effort choices $a(R_h, c)$ and $a(R_l, c)$ maximize $V(R_h, a)$ and $V(R_l, a)$ and the manager's payments are non-negative. The optimal face value D ensures that the lender's participation constraint is satisfied as an equality.

Since the lender's participation constraint is binding, the board chooses the degree of conservatism c and pay plan (w_{uo}, w_{fa}) that maximize the total expected cash flow to investors, which is given by

$$\begin{aligned}
 U(c, w_{fa}, w_{uo}) & \tag{7} \\
 & = \underbrace{qX + (1 - q)L - I}_{\text{Project value with perfect information}} \\
 & \quad - \underbrace{q \Pr(R_l | \theta_h, c) [(1 - a(R_l, c)) (X - L) + a(R_l, c) w_{fa}]}_{\text{Expected cost of a false negative accounting report}} \\
 & \quad - \underbrace{(1 - q) \Pr(R_h | \theta_l, c) [(1 - a(R_h, c)) L + a(R_h, c) w_{uo}]}_{\text{Expected cost of a false positive accounting report}}.
 \end{aligned}$$

The first term in (7) is the expected cash flow to investors with perfect information about the quality of the project θ at date 2. The second term is the expected cost of a false alarm. With probability $q \Pr(R_l | \theta_h, c)$ the project has a high quality but

is misclassified by the accounting report. Absent additional information, the project is liquidated, yielding an opportunity cost of $X - L > 0$. If the manager uncovers additional evidence that shows that the report is a false alarm, investors avoid the opportunity cost and the manager is paid w_{fa} . The third term is the expected cost of a false positive accounting report. With probability $(1 - q) \Pr(R_h | \theta_l, c)$ the project has low quality and is continued in the absence of additional information. If the manager uncovers that the report was unduly optimistic, the opportunity cost L is avoided and the manager is paid w_{uo} .

4.2 Optimal incentive contract

We first derive the optimal pay plan (w_{fa}^*, w_{uo}^*) and equilibrium levels of information acquisition $(a^*(R_l, c), a^*(R_h, c))$. The next proposition states the pay plan that maximizes shareholder value.

Proposition 1 *The shareholders' optimal pay plan sets*

$$w_{fa}^* = (X - L - B) / 2, \quad (8)$$

$$w_{uo}^* = (L + B) / 2. \quad (9)$$

As the manager's private benefits B increase, the optimal bonus w_{fa}^ for uncovering a false alarm decreases, and the optimal bonus w_{uo}^* for uncovering undue optimism increases.*

When the manager uncovers evidence showing that a low accounting report was a false alarm, investors avoid an opportunity cost of $X - L$ and the manager gains $w_{fa}^* + B$. As the manager's private benefits B increase, the board optimally reduces

the bonus w_{fa}^* . When the manager uncovers evidence showing that a high accounting report was unduly optimistic, investors renegotiate the debt contract to avoid an opportunity cost of L and the manager gains $w_{uo}^* - B$. Private benefits B discourage the manager from information acquisition after a high report and the optimal bonus w_{uo}^* increases.

The manager receives a bonus only when she finds information that contradicts the accounting report. Since the probability of finding such information depends on c , the manager optimally takes c into account when choosing the level of information acquisition. (See Lemma 2.) For example, if $c = \bar{c}$, information acquisition has no value for investors after a high accounting report, and the manager optimally does not acquire any information because the probability that the report is unduly optimistic is zero.¹²

Substituting the optimal pay plan from Proposition 1 into the manager's effort levels (5) and (6), we obtain the following Proposition:

Proposition 2 *Given the optimal incentive contract, w^* , the equilibrium levels of information acquisition are*

$$a^*(R_l, c) = \Pr(\theta_h | R_l, c) (X - L + B) / (2k) \quad (10)$$

$$a^*(R_h, c) = \Pr(\theta_l | R_h, c) (L - B) / (2k). \quad (11)$$

¹²If the signal S were contractible, the incentive contract could award the manager a bonus for finding a signal irrespective of whether it contradicts the accounting report or not. In this case, the optimal bonus depends on c . For example, if $c = \bar{c}$ and the accounting report is high, information acquisition has no value for investors and the manager's bonus for obtaining a signal must be zero to prevent her from gathering information. While the optimal wages if S is contractible differ from those in Proposition 1, the expected cost of inducing information acquisition is the same as in the contract we consider. Thus, the board would implement the same levels of information acquisition, and the contractibility of the signal does not affect the optimal accounting rule.

(i) Information acquisition after a low report, $a^*(R_l, c)$, increases in the level of conservatism c , the manager's private benefits, B , the opportunity cost of a false alarm, $X - L$, the prior probability that the project has high quality, q , and decreases in the precision of the accounting system, λ , and the cost of information acquisition, k .

(ii) Information acquisition after a high report, $a^*(R_h, c)$, decreases in c , B , q , λ , and k and increases in the opportunity cost of undue optimism, L .

The comparative statics for B , $X - L$, L , and k follow directly from (10) and (11). We derive the comparative statics for c , λ , and q in the Appendix. More conservative accounting, c , and a higher prior probability that the project is of high quality, q , increase the probability $\Pr(\theta_l|R_l, c)$ that a low report is a false alarm and decrease the probability $\Pr(\theta_h|R_h, c)$ that a high report is unduly optimistic. As a result, $a^*(R_l, c)$ increases and $a^*(R_h, c)$ decreases in c and q . Further, if the precision of the accounting system, λ , increases, both errors decrease, which reduces both $a^*(R_l, c)$ and $a^*(R_h, c)$.

4.3 Optimal accounting system

We are now ready to derive the optimal accounting system. Using the optimal incentive contract $w^* = \{w_{fa}^*, w_{uo}^*\}$ from Proposition 1, we obtain the following preliminary result.

Lemma 3 *The optimal accounting system c is either as liberal or as conservative as possible with $c^* \in \{\underline{c}, \bar{c}\}$.*

The corner solution arises because the objective function $U(c, w^*)$ in (7) is convex in the degree of conservatism c , as we prove in the Appendix.¹³ To determine

¹³In many models on conservatism the optimal accounting system is a corner solution, see, e.g.,

the optimal accounting system c^* , the board compares the expected payoff under conservative accounting, $U(\bar{c}, w^*)$, with the expected payoff under liberal accounting, $U(\underline{c}, w^*)$. Using the objective function (7) and rearranging terms, conservative accounting is optimal if

$$\begin{aligned} \Psi(\bar{c}) &\equiv q \left((1 - a^*(R_l, \bar{c})) (X - L) + a^*(R_l, \bar{c}) w_{fa}^* \right) \\ &< \Psi(\underline{c}) \equiv (1 - q) \left((1 - a^*(R_h, \underline{c})) L + a^*(R_h, \underline{c}) w_{uo}^* \right), \end{aligned} \quad (12)$$

and liberal accounting is optimal if $\Psi(\bar{c}) > \Psi(\underline{c})$, where $\Psi(\bar{c})$ is the expected cost of a false negative report under conservative accounting and $\Psi(\underline{c})$ is the expected cost of a false positive report under liberal accounting.

As we show in the proof of Proposition 3, $\Psi(\bar{c})$ strictly increases in X , while $\Psi(\underline{c})$ does not depend on X . Thus, we can define a threshold \hat{X} that satisfies (12) with equality such that conservative accounting is optimal if $X < \hat{X}$ and liberal accounting is optimal if $X > \hat{X}$. Given the lower bound $\underline{X} \equiv L/q$ from (1), a necessary condition for conservative accounting to be optimal is $\hat{X} > \underline{X}$.

Proposition 3 *Let \hat{X} be the threshold that satisfies (12) with equality. Conservative accounting is optimal if $X < \hat{X}$ and liberal accounting is optimal if $X > \hat{X}$.*

(i) *If information acquisition is prohibitively costly ($k \rightarrow \infty$), then $\hat{X} = \underline{X}$ and the optimal accounting system is always liberal, $c^* = \underline{c}$, given $X > \underline{X}$.*

(ii) *The threshold \hat{X} increases as the manager's private benefits B increase. For*

Gigler et al. (2009) and Li (2013). In our model, an increase in conservative accounting increases the benefits of conservatism because it makes information acquisition after a low report more valuable. Similarly, an increase in liberal accounting reinforces the benefit of liberal accounting because it makes information acquisition after a high report more valuable. The convexity underlying the result in Lemma 3 is not an artifact of the quadratic information acquisition cost function. We prove in the Online Appendix that Lemma 3 holds for the more general cost function $\frac{1}{n}ka^n$, with $n > 1$.

$\widehat{X} > \underline{X}$, \widehat{X} also increases as the cost of information acquisition k decreases.

(iii) $\widehat{X} > \underline{X}$ if B exceeds a threshold \widehat{B} or if $q > 0.5$.

We prove Proposition 3 in the Appendix and focus here on the intuition. Part (i) replicates the result in Gigler et al. (2009). If information acquisition is prohibitively costly, the bonus and level of information acquisition are zero and $\widehat{X} = \underline{X}$. As a result, liberal accounting is always optimal since $X > \underline{X}$. Intuitively, $X > \underline{X}$ (or equivalently $qX > L$) implies that the project is sufficiently attractive so that investors continue it unless negative information arises. Investors are then more concerned about wrongful liquidation after a low report than about wrongful continuation after a high report. Absent managerial information acquisition, the only way to reduce the risk of wrongful liquidation after a low report is to choose a liberal accounting system.

Part (ii) states that private benefits B increase the threshold \widehat{X} and therefore the range of parameters for which conservative accounting is optimal. To explain the role of B in greater detail, the following Lemma is useful.

Lemma 4 *As the manager's private benefits B increase, the expected cost of conservative accounting, $\Psi(\bar{c})$, decreases and the expected cost of liberal accounting, $\Psi(\underline{c})$, increases.*

To explain Lemma 4, we take the derivatives of $\Psi(\bar{c})$ and $\Psi(\underline{c})$ with respect to B :

$$\frac{d\Psi(\bar{c})}{dB} = -q \frac{da^*(R_l, \bar{c})}{dB} (X - L - w_{fa}^*) + qa^*(R_l, \bar{c}) \frac{dw_{fa}^*}{dB} < 0, \quad (13)$$

$$\frac{d\Psi(\underline{c})}{dB} = -(1-q) \frac{da^*(R_h, \underline{c})}{dB} (L - w_{uo}^*) + (1-q)a^*(R_h, \underline{c}) \frac{dw_{uo}^*}{dB} > 0. \quad (14)$$

As B increases, the manager's information acquisition $a^*(R_l, \bar{c})$ increases and the optimal bonus w_{fa}^* decreases. Both effects reduce the expected cost of conservative

accounting $\Psi(\bar{c})$. In contrast, larger private benefits B reduce information acquisition $a^*(R_h, \underline{c})$ and increase the optimal bonus w_{uo}^* . Both effects increase the expected cost of liberal reporting $\Psi(\underline{c})$. These findings explain why the threshold \hat{X} below which conservative reporting is optimal increases when B increases.

Part (ii) of Proposition 3 also shows that if $\hat{X} > \underline{X}$, the threshold \hat{X} increases when the cost of information acquisition k declines. This follows because as k declines the expected cost of conservative accounting $\Psi(\underline{c})$ decreases faster than the expected cost of liberal accounting $\Psi(\bar{c})$. Intuitively, if the manager's ability to acquire information allows conservatism to be optimal (that is $\hat{X} > \underline{X}$), a higher level of information acquisition due to a lower cost k makes conservatism even more attractive and hence increases \hat{X} .

Part (iii) of Proposition 3 shows conditions under which managerial information acquisition can render conservative accounting optimal ($\hat{X} > \underline{X}$). Since \hat{X} increases in B , we obtain $\hat{X} > \underline{X}$ as long as B exceeds a threshold \hat{B} , where \hat{B} solves (12) as an equality. \hat{X} also exceeds \underline{X} if $q > 0.5$. To see why, note that $X = \underline{X}$ implies $q(X - L) = (1 - q)L$, so that in the absence of information acquisition, the expected cost of a false alarm under conservative accounting equals the expected cost of undue optimism under liberal accounting. If the project is ex ante more likely to be of high quality than of low quality, $q > 0.5$, the manager is more likely to be able to detect an error under conservative accounting than under liberal accounting. Thus, the manager will choose a higher level of information acquisition under the former than the latter regime, $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$. As a consequence, information acquisition reduces the expected cost of a false alarm by more than the expected cost of undue optimism, and conservative accounting can be optimal.

5 Discussion and Empirical Implications

5.1 Managerial preferences and conservative accounting

Our model offers an explanation for the empirical observation that conservatism is valuable for debt contracting.¹⁴ The key features in our setting are the board's ability to incentivize the manager to gather information about the project and the manager's desire to prevent liquidation. Proposition 3 yields the prediction that firms are more likely to adopt conservative accounting rules when managers have a greater desire to continue their projects due to the associated private benefits (such as perks, career prospects, or future incentive pay).¹⁵ This prediction is related to the notion that conservatism alleviates agency problems that arise from managers' reluctance to abandon projects to avoid the loss of private benefits (Ball, 2001; Francis and Martin, 2010). In our model, the manager's private benefits do not directly affect the liquidation decision because the manager does not have the authority to make the decision. However, private benefits have an indirect effect because they influence the manager's incentive to gather additional information. Conservative reporting can be optimal because it allows shareholders to take advantage of the manager's private benefits as a means to encourage the acquisition of additional information following a covenant violation.

¹⁴See footnote 6 for references.

¹⁵Caskey and Laux (2017) also study the link between managers' preferences for project continuation and the optimal degree of conservatism, but they predict a negative relation. In their model, the manager's desire to continue the project induces misreporting, which reduces the value of conservatism. Bertomeu et al. (2017) study an effort moral-hazard problem and show that a higher bonus for success (due to, e.g., higher agency frictions) increases earnings management incentives and reduces the optimal degree of conservatism.

5.2 Covenant violations and waivers

Extensive empirical evidence shows that lenders frequently waive covenants after covenant violations.¹⁶ Our model provides a novel explanation for this finding: Managers have incentives to gather additional information following a covenant violation and if they find that the accounting report was a false alarm, the lender waives the covenant and the project continues (from Lemma 1). The model is also consistent with Zhang (2008) who shows that conservative reporting increases the probability of covenant violations.

To present new predictions, we distinguish between the probability of a covenant waiver conditional on a covenant violation

$$\gamma_{R_t} \equiv \Pr(\theta_h | R_t, c) a^*(R_t, c), \quad (15)$$

and the unconditional (ex ante) probability of a covenant waiver

$$\begin{aligned} \gamma_{R_t}^u &\equiv \Pr(R_t | c) \gamma_{R_t} \\ &= q \Pr(R_t | \theta_h, c) a^*(R_t, c). \end{aligned} \quad (16)$$

Proposition 4 *Firms that adopt more conservative accounting policies (higher c) exhibit (i) a higher likelihood of covenant waivers conditional on covenant violations γ_{R_t} , and (ii) a higher ex ante likelihood of covenant waivers $\gamma_{R_t}^u$.*

The literature has long postulated that conservative reporting, by imposing lower verifiability standards for recognizing bad news, increases the risk that an early warn-

¹⁶See, e.g., Beneish and Press (1993, 1995), Chen and Wei (1993), Sweeney (1994), Dichev and Skinner (2002), Nini et al. (2012), and Nikolaev (2018).

ing signal is a false alarm (Leuz, 2001; Gigler et al., 2009; Lambert, 2010). Part (i) of Proposition 4 offers a framework to test this notion. Evidence that confirms part (i) indicates that conservative reporting increases the probability that a covenant violation turns out to be a false alarm, and hence is subsequently waived by the lender. The distinction between prediction (i) and (ii) is important here because evidence that confirms (ii) is also consistent with the notion that conservatism merely increases the likelihood of covenant violations without changing the probability of a waiver conditional on a violation.

To derive Proposition 4, we take the first derivatives of $\gamma_{R_h}^u$ and γ_{R_l} with respect to c :

$$\frac{d\gamma_{R_l}}{dc} = \frac{d\Pr(\theta_h|R_l, c)}{dc}a^*(R_l, c) + \Pr(\theta_h|R_l, c)\frac{da^*(R_l, c)}{dc} > 0, \quad (17)$$

$$\frac{d\gamma_{R_l}^u}{dc} = \frac{d\Pr(R_l|c)}{dc}\gamma_{R_l} + \Pr(R_l|c)\frac{d\gamma_{R_l}}{dc} > 0. \quad (18)$$

Conservative accounting reduces the precision of early warning signals, which increases the probability that the manager finds positive evidence after a covenant violation ($d\Pr(\theta_h|R_l, c)/dc > 0$) for a given $a^*(R_l, c) > 0$, and also increases the manager's incentive to search for information ($da^*(R_l, c)/dc > 0$). Both effects increase the probability of a covenant waiver following a covenant violation, γ_{R_l} , and explain the positive sign in (17). Conservatism also increases the unconditional probability of a covenant waiver, $\gamma_{R_l}^u$, because it increases the probability that a covenant is violated in the first place ($d\Pr(R_l|c)/dc > 0$).

Our model also offers predictions on the relation between the manager's private benefits and the likelihood of covenant waivers that follow from Proposition 4.

Corollary 1 *The conditional and unconditional probabilities of a covenant waiver increase when managers derive greater private benefits from the project, $\frac{d\gamma_{R_l}}{dB} \geq 0$ and*

$$\frac{d\gamma_{R_l}^u}{dB} \geq 0.$$

A higher preference for continuing the project (higher B) increases the manager's equilibrium effort $a^*(R_l, c)$ to uncover positive evidence after a covenant violation. Thus, the probabilities of conditional and unconditional covenant waivers (γ_{R_l} and $\gamma_{R_l}^u$) increase.¹⁷

5.3 Debt renegotiation outside covenant violations

Roberts and Sufi (2009) and Roberts (2015) find empirical evidence that debt contract renegotiations also occur in the absence of covenant violations. This finding is consistent with our model: Managers are incentivized to gather additional information and if they find evidence that the accounting report was unduly optimistic, the board and the lender renegotiate the contract to liquidate the project (from Lemma 1).

To derive predictions regarding the role of the accounting system, we distinguish between the probability of debt contract renegotiations in the absence of a covenant violation (i.e., after a high accounting report),

$$\gamma_{R_h} \equiv \Pr(\theta_l | R_h, c) a^*(R_h, c), \quad (19)$$

and the unconditional (ex ante) likelihood of renegotiations outside covenant viola-

¹⁷A higher B also increases the range of X values for which conservative accounting is optimal (from Proposition 3), which further increases γ_{R_l} and $\gamma_{R_l}^u$ since $d\gamma_{R_l}/dc > 0$ and $d\gamma_{R_l}^u/dc > 0$.

tions

$$\begin{aligned}\gamma_{R_h}^u &\equiv \Pr(R_h|c)\gamma_{R_h} \\ &= (1 - q)\Pr(R_h|\theta_l, c)a^*(R_h, c).\end{aligned}\tag{20}$$

Proposition 5 *In firms that adopt more conservative accounting policies (higher c), (i) the probability of debt contract renegotiations conditional on no covenant violations is lower (γ_{R_h} is lower), and (ii) the ex ante probability of debt contract renegotiations outside of covenant violations is lower ($\gamma_{R_h}^u$ is lower).*

To derive the proposition, we take the first derivatives of $\gamma_{R_h}^u$ and γ_{R_h} :

$$\frac{d\gamma_{R_h}}{dc} = \frac{d\Pr(\theta_l|R_h, c)}{dc}a^*(R_h, c) + \Pr(\theta_l|R_h, c)\frac{da^*(R_h, c)}{dc} < 0,\tag{21}$$

$$\frac{d\gamma_{R_h}^u}{dc} = \frac{d\Pr(R_h|c)}{dc}\gamma_{R_h} + \Pr(R_h|c)\frac{d\gamma_{R_h}}{dc} < 0.\tag{22}$$

Conservatism increases the precision of a high accounting report, which decreases the probability that the manager uncovers negative evidence ($d\Pr(\theta_l|R_h, c)/dc < 0$) for any effort $a^*(R_h, c) > 0$ and also reduces the manager's incentive to search for information ($da^*(R_h, c)/dc < 0$). Both effects reduce the probability of debt renegotiations conditional that no covenant is violated and explain the negative sign in (21). Conservative reporting also decreases the ex ante probability of contract renegotiations outside of covenant violations, $\gamma_{R_h}^u$, because it reduces the probability that no covenant is violated ($d\Pr(R_h|c)/dc < 0$).

Further, from Proposition 5, the model predicts a relation between the manager's preference for continuation and the likelihood of debt contract renegotiations absent covenant violations.

Corollary 2 *The conditional and unconditional probabilities of debt renegotiations absent covenant violations decrease when managers derive greater private benefits, $\frac{d\gamma_{R_h}}{dB} < 0$ and $\frac{d\gamma_{R_h}^u}{dB} < 0$.*

A stronger preference for continuing the project (higher B) reduces the manager's equilibrium effort $a^*(R_h, c)$ to uncover negative evidence after a high report and hence γ_{R_h} and $\gamma_{R_h}^u$.¹⁸

5.4 Corrective actions

In our model, project liquidation stands for a corrective action that can also take the form of divestment, abandonment of an expansion strategy, or corporate restructuring. The action negatively affects the manager's private benefits but is optimal for investors when negative information about the current corporate strategy emerges.

The manager's information acquisition plays an important role for the probability of corrective actions. The probability that firms take corrective actions is given by

$$\Lambda = q \Pr(R_l | \theta_h, c) (1 - a^*(R_l, c)) \quad (23)$$

$$\begin{aligned} &+ (1 - q) \Pr(R_l | \theta_l, c) + (1 - q) \Pr(R_h | \theta_l, c) a^*(R_h, c) \\ &= \Pr(R_l | c) - \gamma_{R_l}^u + \gamma_{R_h}^u. \end{aligned} \quad (24)$$

Using $\frac{d\gamma_{R_l}^u}{dB} > 0$ and $\frac{d\gamma_{R_h}^u}{dB} < 0$ from Corollaries 1 and 2, we can directly state the following Corollary.

Corollary 3 *The likelihood of corrective actions is lower in firms in which managers*

¹⁸A higher B also decreases the range of X values for which conservative accounting is optimal (from Proposition 3), which further decreases γ_{R_l} and $\gamma_{R_l}^u$ since $d\gamma_{R_h}/dc < 0$ and $d\gamma_{R_h}^u/dc < 0$.

derive greater private benefits from their projects ($d\Lambda/dB < 0$), controlling for firm fundamentals and the level of conservatism c .

Higher private benefits increase the manager's information acquisition $a^*(R_l, c)$ after a covenant violation and decrease her information acquisition $a^*(R_h, c)$ in the absence of a covenant violation. As a result, the manager is more likely to find evidence that prevents corrective actions and less likely to find evidence that causes them.

A negative relation between manager's private benefits and the incidence of corrective actions that curtail her benefits could be interpreted as evidence of managerial entrenchment. However, our model shows that there is an alternative, more positive, interpretation: Managers influence decisions by producing additional information, which increases efficiency.

6 Conclusion

Conservative accounting increases the frequency of early warning signals that allow lenders to take corrective actions, but can also lead to false alarms and excessive intervention. Managers' ability and incentives to gather additional evidence after observing the accounting report reduces both the risk of inefficient intervention following a covenant violation and the risk of inefficient continuation in the absence of a violation. When boards design the accounting system and incentive contracts for managers, they must take into consideration how the two interact: Managers' incentives to detect errors in financial reports affect the properties of the optimal accounting system and accounting choices affect managers' incentives to gather information.

We show conditions under which the interaction between reporting choices and managerial information acquisition renders conservative reporting more attractive for shareholders. Our analysis offers novel explanations for the empirical findings that conservative accounting plays a positive role for debt contracting and corporate governance and that covenants are frequently waived following covenant violations. The model also provides several novel predictions. For example, the model predicts that lenders are more likely to waive covenants following covenant violations when firms adopt more conservative accounting policies. We encourage empirical researchers to test this prediction because evidence that confirms it would indicate that conservatism indeed increases the frequency of false alarms, as has long been postulated in the literature.

Appendix

Proof of Proposition 1.

To determine the optimal wages, we take the first-order conditions of (7):

$$\frac{dU(c, w_{fa}, w_{uo})}{dw_{fa}} = q \Pr(R_l | \theta_h, c) \left[\frac{da(R_l, c)}{dw_{fa}} (X - L - w_{fa}) - a(R_l, c) \right] = 0, \quad (25)$$

$$\frac{dU(c, w_{fa}, w_{uo})}{dw_{uo}} = (1 - q) \Pr(R_h | \theta_l, c) \left[\frac{da(R_h, c)}{dw_{uo}} (L - w_{uo}) - a(R_h, c) \right] = 0. \quad (26)$$

Assume that $w_{uo} > B$, which implies that (6) is given by

$$a(R_h, c) = \Pr(\theta_l | R_h, c) (w_{uo} - B) / k > 0. \quad (27)$$

From (5) and (27) we obtain

$$\frac{da(R_l, c)}{dw_{fa}} = \Pr(\theta_h | R_l, c) / k, \quad (28)$$

$$\frac{da(R_h, c)}{dw_{uo}} = \Pr(\theta_l | R_h, c) / k, \quad (29)$$

and the first-order conditions (25) and (26) can be written as

$$\frac{\Pr(\theta_h | R_l, c)}{k} (X - L - w_{fa}) - a(R_l, c) = 0, \quad (30)$$

$$\frac{\Pr(\theta_l | R_h, c)}{k} (L - w_{uo}) - a(R_h, c) = 0, \quad (31)$$

which, after substitution of (5) and (27), simplify to

$$\frac{\Pr(\theta_h | R_l, c)}{k} (X - L - w_{fa} - (w_{fa} + B)) = 0, \quad (32)$$

$$\frac{\Pr(\theta_l | R_h, c)}{k} (L - w_{uo} - (w_{uo} - B)) = 0. \quad (33)$$

Rearranging terms yields the optimal pay plan (8) and (9). Finally, the optimal bonus $w_{uo}^* = (L + B)/2$ indeed implies that $w_{uo}^* > B$ for $B < \min\{L, X - L\}$. \square

Proof of Proposition 2.

To study the effects of c , λ , and q on $a^*(R_l, c)$, we take the derivative of

$$\Pr(\theta_h|R_l, c) = \frac{q(1 - \lambda + c)}{q(1 - \lambda + c) + (1 - q)(\lambda + c)}, \quad (34)$$

which yields:

$$\frac{d \Pr(\theta_h|R_l, c)}{dc} = \frac{q(1 - q)(2\lambda - 1)}{(q(1 - \lambda + c) + (1 - q)(\lambda + c))^2} > 0, \quad (35)$$

$$\frac{d \Pr(\theta_h|R_l, c)}{dq} = \frac{(1 - \lambda + c)(\lambda + c)}{(q(1 - \lambda + c) + (1 - q)(\lambda + c))^2} > 0, \quad (36)$$

$$\frac{d \Pr(\theta_h|R_l, c)}{d\lambda} = -\frac{q(2c + 1)(1 - q)}{(q(1 - \lambda + c) + (1 - q)(\lambda + c))^2} < 0. \quad (37)$$

To study the effects of c , λ , and q on $a^*(R_h, c)$, we take the derivative of

$$\Pr(\theta_l|R_h, c) = \frac{(1 - q)(1 - \lambda - c)}{q(\lambda - c) + (1 - q)(1 - \lambda - c)}, \quad (38)$$

which yields:

$$\frac{d \Pr(\theta_l|R_h, c)}{dc} = -\frac{q(1 - q)(2\lambda - 1)}{(q(\lambda - c) + (1 - q)(1 - \lambda - c))^2} < 0, \quad (39)$$

$$\frac{d \Pr(\theta_l|R_h, c)}{dq} = -\frac{(1 - \lambda - c)(\lambda - c)}{(q(\lambda - c) + (1 - q)(1 - \lambda - c))^2} < 0, \quad (40)$$

$$\frac{d \Pr(\theta_l|R_h, c)}{d\lambda} = -\frac{(1 - q)q(1 - 2c)}{(q(\lambda - c) + (1 - q)(1 - \lambda - c))^2} < 0, \quad (41)$$

where the last inequality follows because the assumption $\lambda > 0.5$ implies $c < 0.5$. \square

Proof of Lemma 3.

To prove the lemma, we prove that the shareholders' objective function $U(c, w_{fa}^*, w_{uo}^*)$ in (7) is convex in the degree of conservatism c , given the optimal bonuses $w_{fa}^* = \frac{X-L-B}{2}$ and $w_{uo}^* = \frac{L+B}{2}$ in Proposition 1 and equilibrium levels of information acquisition $a^*(R_l, c) = \Pr(\theta_h|R_l, c)\frac{X-L+B}{2k}$ in Propositions 2.

Substituting $w^* = (w_{fa}^*, w_{uo}^*)$ and $\Pr(R_l|\theta_h, c) = 1-\lambda+c$ and $\Pr(R_h|\theta_l, c) = 1-\lambda-c$ into the shareholders' objective function (7) yields

$$\begin{aligned} U(c, w_{fa}^*, w_{uo}^*) &= qX + (1-q)L - I & (42) \\ &- q(1-\lambda+c) \left(X - L - a^*(R_l, c) \frac{X-L+B}{2} \right) \\ &- (1-q)(1-\lambda-c) \left(L - a^*(R_h, c) \frac{L-B}{2} \right), \end{aligned}$$

and

$$\begin{aligned} \frac{dU(c, w_{fa}^*, w_{uo}^*)}{dc} &= & (43) \\ &- q \left[X - L - \left(a^*(R_l, c) + (1-\lambda+c) \frac{da^*(R_l, c)}{dc} \right) \frac{X-L+B}{2} \right] \\ &+ (1-q) \left[L - \left(a^*(R_h, c) - (1-\lambda-c) \frac{da^*(R_h, c)}{dc} \right) \frac{L-B}{2} \right]. \end{aligned}$$

Using

$$\frac{da^*(R_l, c)}{dc} = \frac{(1-q)(2\lambda-1)}{\Pr(R_l|c)(1-\lambda+c)} a^*(R_l, c) > 0 \quad (44)$$

$$\frac{da^*(R_h, c)}{dc} = -\frac{q(2\lambda-1)}{\Pr(R_h|c)(1-\lambda-c)} a^*(R_h, c) < 0, \quad (45)$$

(43) simplifies to

$$\begin{aligned} \frac{dU(c, w^*)}{dc} = & -q \left[X - L - \left(1 + \frac{(1-q)(2\lambda-1)}{\Pr(R_l|c)} \right) a^*(R_l, c) \frac{X-L+B}{2} \right] \\ & + (1-q) \left[L - \left(1 + \frac{q(2\lambda-1)}{\Pr(R_h|c)} \right) a^*(R_h, c) \frac{L-B}{2} \right]. \end{aligned} \quad (46)$$

Taking the second derivative and using $\frac{d\Pr(R_l|c)}{dc} = 1$ and $\frac{d\Pr(R_h|c)}{dc} = -1$ yields

$$\begin{aligned} \frac{d^2U(c, w^*)}{dc^2} = & \\ q \left[\left(1 + \frac{(1-q)(2\lambda-1)}{\Pr(R_l|c)} \right) \frac{da^*(R_l, c)}{dc} - \frac{(1-q)(2\lambda-1)}{\Pr(R_l|c)^2} a^*(R_l, c) \right] \frac{X-L+B}{2} & \\ - (1-q) \left[\left(1 + \frac{q(2\lambda-1)}{\Pr(R_h|c)} \right) \frac{da^*(R_h, c)}{dc} + \frac{q(2\lambda-1)}{\Pr(R_h|c)^2} a^*(R_h, c) \right] \frac{L-B}{2}. & \end{aligned} \quad (47)$$

Substituting $a^*(R_l, c)$ and $a^*(R_h, c)$ from (44) and (45) into (47), yields

$$\begin{aligned} \frac{d^2U(c, w^*)}{dc^2} = & q \left(1 + \frac{(1-q)(2\lambda-1)}{\Pr(R_l|c)} - \frac{(1-\lambda+c)}{\Pr(R_l|c)} \right) \frac{da^*(R_l, c)}{dc} \frac{X-L+B}{2} \\ & - (1-q) \left(1 + \frac{q(2\lambda-1)}{\Pr(R_h|c)} - \frac{(1-\lambda-c)}{\Pr(R_h|c)} \right) \frac{da^*(R_h, c)}{dc} \frac{L-B}{2}, \end{aligned} \quad (48)$$

which, using $\Pr(R_l|c) = q(1-\lambda+c) + (1-q)(\lambda+c)$ and $\Pr(R_h|c) = q(\lambda-c) + (1-q)(1-\lambda-c)$, simplifies to

$$\begin{aligned} \frac{d^2U(c, w^*)}{dc^2} = & \frac{q(1-q)(2\lambda-1)}{\Pr(R_l|c)} \frac{da^*(R_l, c)}{dc} (X-L+B) \\ & - \frac{q(1-q)(2\lambda-1)}{\Pr(R_h|c)} \frac{da^*(R_h, c)}{dc} (L-B). \end{aligned} \quad (49)$$

$\frac{d^2U(c, w^*)}{dc^2} > 0$ follows because $\frac{da^*(R_l, c)}{dc} > 0$ and $\frac{da^*(R_h, c)}{dc} < 0$ from (44) and (45).

Thus, (7) is convex in c . \square

Proof of Proposition 3.

To prove Proposition 3, it is useful to first prove two preliminary results that we state as Lemma A.1 and Lemma A.2.

Lemma A.1 $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if $q > 0.5$ or if B or X are sufficiently high.

Proof of Lemma A.1. From Proposition 2 we obtain $a^*(R_l, \bar{c}) = \Pr(\theta_h | R_l, \bar{c}) \frac{X-L+B}{2k}$ and $a^*(R_h, \underline{c}) = \Pr(\theta_l | R_h, \underline{c}) \frac{L-B}{2k}$. Thus, $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if

$$\Pr(\theta_h | R_l, \bar{c})(X - L + B) > \Pr(\theta_l | R_h, \underline{c})(L - B). \quad (50)$$

If inequality (50) holds for $B = 0$ and $X = \underline{X}$, it holds for all $B \geq 0$ and $X \geq \underline{X}$. Substituting $B = 0$, $X = \underline{X}$, $\Pr(\theta_h | R_l, \bar{c}) = \frac{2q(1-\lambda)}{\Pr(R_l | \bar{c})}$, and $\Pr(\theta_l | R_h, \underline{c}) = \frac{2(1-q)(1-\lambda)}{\Pr(R_h | \underline{c})}$ into (50) and rearranging terms yields

$$\Pr(R_h | \underline{c}) > \Pr(R_l | \bar{c}), \quad (51)$$

which is satisfied if $q > 0.5$. Thus, $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if $q > 0.5$.

We show next that if $q < 0.5$, then $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ when either X or B is sufficiently large. For the argument we exploit the fact that $a^*(R_l, \bar{c})$ increases in X and B and that $a^*(R_h, \underline{c})$ decreases in B . (50) is equivalent to

$$\frac{q(X - L + B)}{\Pr(R_l | \bar{c})} > \frac{(1 - q)(L - B)}{\Pr(R_h | \underline{c})}. \quad (52)$$

To show that $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if X is sufficiently large for any $B \geq 0$, note

that if $X = \bar{X} = L \frac{\Pr(R_l|\bar{c})}{2q(1-\lambda)}$ and $B = 0$, then (52) is equivalent to

$$-3 + 4\lambda(2 - \lambda) > 0, \quad (53)$$

where we use $\Pr(R_l|\bar{c}) = q2(1 - \lambda) + (1 - q)$ and $\Pr(R_h|\underline{c}) = q + (1 - q)2(1 - \lambda)$. Observe that (53) is satisfied for all $\lambda > 0.5$. Hence, for $B = 0$, there is a threshold $X_1 < \bar{X}$, such that $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if $X > X_1$. As B increases, the threshold X_1 decreases.

To show that $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if B is sufficiently large for any $X \geq \underline{X}$, note that if $X = \underline{X} = \frac{L}{q}$ and $B = L$, (52) is equivalent to

$$\frac{L}{\Pr(R_l|\bar{c})} > 0. \quad (54)$$

Hence, there is a threshold $B_1 < L$ such that $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if $B > B_1$. As X increases, the threshold B_1 decreases. \square

Lemma A.2 *The \hat{X} that solves (12) as an equality is unique, and $\Psi(\bar{c}) < \Psi(\underline{c})$ if and only if $X < \hat{X}$.*

Proof of Lemma A.2. Using (12), \hat{X} is the level of X that solves

$$q \underbrace{[(X - L) - a^*(R_l, \bar{c}) (X - L - w_{fa}^*)]}_{\Psi(\bar{c})} = (1 - q) \underbrace{[L - a^*(R_h, \underline{c}) (L - w_{uo}^*)]}_{\Psi(\underline{c})}, \quad (55)$$

where the effort levels are given in Proposition 2 and the optimal contract is given in Proposition 1. $\Psi(\underline{c})$ does not change with X . Thus, the Lemma holds if $\Psi(\bar{c})$ is strictly increasing in X .

From Propositions 1 and 2, the optimal bonus and effort level are $w_{fa}^* = \frac{X-L-B}{2}$

and $a^*(R_l, \bar{c}) = \Pr(\theta_h | R_l, \bar{c})^{\frac{X-L+B}{2k}}$, and $\Psi(\bar{c})$ can be written as

$$\Psi(\bar{c}) = q \left[(X - L) - a^*(R_l, \bar{c}) \left(\frac{X - L + B}{2} \right) \right], \quad (56)$$

and

$$\frac{d\Psi(\bar{c})}{dX} = q \left[1 - \frac{da^*(R_l, \bar{c})}{dX} \left(\frac{X - L + B}{2} \right) - \frac{1}{2} a^*(R_l, \bar{c}) \right] \quad (57)$$

$$= q [1 - a^*(R_l, \bar{c})] > 0. \quad (58)$$

□

Proof of part (i) of Proposition 3. For $k \rightarrow \infty$, $a^*(R_l, \bar{c}) = a^*(R_h, \underline{c}) = 0$ and \hat{X} solves

$$q(X - L) = (1 - q)L, \quad (59)$$

which yields $\hat{X} = L/X$. Thus, liberal accounting is optimal for all $X > \underline{X} \equiv L/X$. □

Proof of part (ii) of Proposition 3. To show that \hat{X} increases as B increases, observe that: (i) when B increases, $\Psi(\bar{c})$ decreases because $\frac{da^*(R_l, \bar{c})}{dB} > 0$, $\frac{dw_{fa}^*}{dB} < 0$, and $X - L - w_{fa}^* > 0$; and (ii) $\Psi(\underline{c})$ increases because $\frac{da^*(R_h, \underline{c})}{dB} < 0$, $\frac{dw_{uo}^*}{dB} > 0$, and $L - w_{uo}^* > 0$. To satisfy (55) as an equality, \hat{X} must increase as B increases because we know from Lemma A.2 that $\Psi(\bar{c})$ increases in X and $\Psi(\underline{c})$ does not change in X .

We next show that if $\hat{X} > \underline{X}$, the threshold \hat{X} below which conservative accounting is optimal increases as the cost of information acquisition k declines. The derivatives

of the left-hand side and right-hand side of (12) with respect to k are

$$\frac{d\Psi(\bar{c})}{dk} = q \frac{a^*(R_l, \bar{c})}{k} (X - L - w_{fa}^*), \quad (60)$$

$$\frac{d\Psi(\underline{c})}{dk} = (1 - q) \frac{a^*(R_h, \underline{c})}{k} (L - w_{uo}^*). \quad (61)$$

We know that $\hat{X} > \underline{X}$ if (62) holds. From (62) it follows that $\frac{d\Psi(\bar{c})}{dk} > \frac{d\Psi(\underline{c})}{dk}$. As a result, if k decreases, conservative accounting becomes relatively more attractive for shareholders and the threshold \hat{X} below which conservatism is optimal increases. \square

Proof of part (iii) of Proposition 3. To determine the conditions under which $\hat{X} > \underline{X}$, observe that $\hat{X} > \underline{X}$ if inequality (12) is satisfied for $X = \underline{X}$. $X = \underline{X}$ implies $q(X - L) = (1 - q)L$ and (12) simplifies to

$$qa^*(R_l, \bar{c}) (X - L - w_{fa}^*) > (1 - q)a^*(R_h, \underline{c}) (L - w_{uo}^*). \quad (62)$$

From Propositions 1 and 2, we have $w_{fa}^* = \frac{X-L-B}{2}$, $w_{uo}^* = \frac{L+B}{2}$, $a^*(R_l, \bar{c}) = \Pr(\theta_h | R_l, \bar{c})^{\frac{X-L+B}{2k}}$, and $a^*(R_h, \underline{c}) = \Pr(\theta_l | R_h, \underline{c})^{\frac{L-B}{2k}}$, and (62) becomes

$$q(X - L + B) a^*(R_l, \bar{c}) > (1 - q)(L - B) a^*(R_h, \underline{c}). \quad (63)$$

Since $q(X - L) = (1 - q)L$, (63) is satisfied if $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$. From Lemma A.1, $a^*(R_l, \bar{c}) > a^*(R_h, \underline{c})$ if $q > 0.5$. If $q < 0.5$, then (63) is satisfied if B lies above a threshold $\hat{B} < L$ since the left hand side of (63) increases in B , and the right hand side decreases in B and reaches zero for $B \rightarrow L$. Thus, there is a threshold \hat{B} that solves (63) as an equality, and $\hat{X} > \underline{X}$ if $B > \hat{B}$. \square

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