Increasing Internal Controls Incentives and Welfare Through Conservative Accounting

Ralf Ewert

and

Alfred Wagenhofer

Abstract

This paper examines whether accounting conservatism affects management's incentives to improve the effectiveness of internal controls and whether this is desirable from a welfare perspective. We employ an agency model in which an owner incentivizes the manager to take a productive action through optimal compensation that also creates incentives for earnings management and possibly for an enhancement of internal controls. We find that conservatism increases management's incentives to enhance internal controls, increases firm value, and limits managers' rents. Total welfare can increase or decrease, and we show that an increase crucially depends on the enhancement of internal controls. We also find that conservatism has an ambiguous effect on earnings quality that depends on specific factors.

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Ralf Ewert
University of Graz, Universitaetsstrasse 15, A-8010 Graz, Austria
Tel.: +43 (316) 380 7168, Email: ralf.ewert@uni-graz.at

Alfred Wagenhofer
University of Graz, Universitaetsstrasse 15, A-8010 Graz, Austria
Tel.: +43 (316) 380 3500, Email: alfred.wagenhofer@uni-graz.at

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1. Introduction

Internal controls over the accounting processes in firms aim to reduce misstatements and are an important mechanism to improve the quality of financial reporting. For example, the Sarbanes-Oxley Act (SOX) of 2002 introduced requirements for firms to maintain internal controls, which impose considerably costs to firms, and to disclose material weaknesses (see also PCAOB Standard AS 2201. Usually, mechanisms to improve internal controls are discussed in the corporate governance domain without considering their interaction with the accounting system. But, arguably, these characteristics can reinforce, or work against, the quality of internal controls. In this paper we show that conservatism, a fundamental characteristic of current accounting systems, increases incentives of management to improve internal controls, increases firm value, and can increase total welfare through the better internal controls.

Conservatism introduces a bias in the information, leading to understating equity and underreporting earnings in early periods. Whether conservative accounting is beneficial or harmful is highly controversial. Accounting standard setters, including the International Accounting Standards Board and the U.S. Financial Accounting Standards Board, reject conservatism in favor of neutrality (IASB 2010, FASB 2010), and in its deliberations of a new Conceptual Framework, the IASB is about to reintroduce conservatism, although in the form of caution in the face of uncertainty, thus still trying to avoid bias (IASB 2015). The accounting literature has shown several instances in which conservatism is desirable. Some of the work addresses the decision usefulness objective the standard setters have in mind, whereas the majority finds benefits of conservatism in contracting settings.[1] This paper adds to the contracting literature by identifying a novel benefit of conservatism, which arises through its induced improvements of internal controls.

We develop an agency model in which the manager, besides providing productive effort, can enhance the quality of the accounting process through internal controls and engage in earnings management. Misstatements can result from errors in the underlying accounting process and from

[1] For surveys of conservatism see, e.g., Watts (2003) and Ewert and Wagenhofer (2011). More specific references are discussed later in this Introduction.

deliberate earnings management. The owner of the firm designs management compensation, based on reported earnings, to provide incentives for productive effort. This compensation also induces incentives for earnings management and may provide incentives to the manager to improve internal controls. Internal controls are important because they mitigate errors in and improve the precision of the accounting process. Earnings management, on the other hand, is commonly viewed as detrimental to the usefulness of earnings. Conservatism biases reported earnings towards lower values, which affects management's incentives and, because of the anticipation of these effects, the owner's optimal compensation design. We examine the effect of conservatism on the following economic outcomes: two welfare measures: firm value (the owner's expected utility) and total welfare (sum of the owner's and the manager's expected utilities),[2] and earnings quality. The owner maximizes firm value, but can be interested in total welfare; regulators are presumably interested in total welfare, and accounting standard setters are interested in earnings quality.

Our main findings are: More conservatism increases management's incentives to enhance internal controls; strictly increases firm value; can increase total welfare only if the manager enhances internal controls; and can increase or decrease earnings quality depending on several factors, including whether earnings management is mainly corrective or misstating. These effects are consequences of the endogenous provision of incentives to the manager and the manager's resulting choices of improving internal controls and earnings management. They are gross of any direct costs of varying the accounting characteristics.

Our analysis starts with the benchmark setting where the manager provides productive effort and engages in earnings management, but excludes internal controls effort. We show that a separate increase in either accounting error always decreases firm value and total welfare, which is intuitive. In contrast, increasing conservatism always increases firm value, but total welfare always declines. Conservatism reduces the probability of overpaying the manager, which benefits the owner at the cost of the manager due to the increase in information precision, but at the same

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[2] In our setting, the manager earns an expected rent, which is affected by the degree of conservatism. Hence, firm value and total welfare differ.

time increases the probability of low preliminary earnings, which induces more earnings management in expectation. We show that the reduction of the manager's expected payment is greater than the welfare increase of the owner, thus resulting in lower total welfare.

We then add internal controls and show that the manager enhances internal controls only if, *ex ante*, the accounting system is such that the likelihood of an understatement of actual earnings is higher than the likelihood of an overstatement. The incentive depends on the characteristics of the accounting system and the production technology, both of which determine the probability distribution of earnings. As in the benchmark setting, one would expect that an increase of the probability of any error is harmful; perhaps surprisingly, our analysis reveals that increasing the probability of an understatement is actually desirable to the firm. More understatement encourages the manager to exert more effort to enhance internal controls, and the resulting improvement of the accounting system overcompensates the decrease of precision caused by more understatement as long as the understatement error is not too small. In this full setting, more conservatism strictly increases firm value as in the benchmark setting, but it can also increase total welfare, and this result rests on the beneficial effect of improved internal controls.[3]

Our results highlight that the characteristics of the accounting system are important determinants for implementing high-quality internal controls by the manager. In the regulatory debate, it appears that this effect is often disregarded. Many regulatory actions aim at enhancing internal controls in firms – we show that the trend to neutral accounting standards implicitly works against this regulatory objective.

We also consider the effect of accounting conservatism on earnings quality. We define earnings quality as the probability that, *ex ante,* the financial report coincides with the firm's true outcome. Our main finding is that varying conservatism can either increase or decrease earnings quality. We present conditions under which one or the other effect prevails. This result suggests that earnings quality behaves quite independently from economic welfare, and it would be an

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[3] Thus, our paper complements other papers that show benefits of conservative accounting, such as Chen, Hemmer, and Zhang (2007), Chen, Mittendorf, and Zhang (2010), and Gao (2013).

unreliable metric if one is interested in whether implementing a particular measure enhances welfare. This result supports the view that the objectives of decision usefulness and stewardship are not fully congruent, contrary to what the FASB (2010) and the IASB (2010) assume in their Conceptual Frameworks. Our finding is similar in spirit to the general result in Gjesdal (1982) and subsequent papers, such as Feltham and Xie (1994) and Drymiotes and Hemmer (2013).[4]

Our paper speaks to empirical literature that has been motivated by the enactment of SOX and studies relations between internal controls and several accounting characteristics or earnings quality measures. For example, Goh and Li (2011) find a positive association between conditional conservatism and the quality of internal controls. They argue that the disclosure of material weaknesses after SOX induces firms to enhance internal controls, which then helps them to report more conservatively. While we find a similar association, we show the reverse causality that firms use accounting conservatism to enhance internal controls. Other papers, such as Doyle, Ge, and McVay (2007) and Ashbaugh-Skaife, Collins, Kinney, and LaFond (2008), find that internal control weaknesses are associated with lower accrual quality, measured by abnormal accruals and an accruals noise proxy because better internal controls reduce random (unintended) errors in the accounting process and mitigate income-increasing earnings management. We address both random errors and earnings management in our model and show that internal controls are inherently substitutes for (expected) earnings management, consistent with those empirical findings.

The model we employ is a specific multi-action agency model with a productive action and other actions that affect the performance measure. Prior literature includes Feltham and Xie (1994) who consider productive effort and earnings management ("window dressing") in a LEN model in which earnings management is implicitly induced by providing incentives for productive effort. Our model structure extends Kwon, Newman, and Suh (2001) and Bertomeu, Darrough, and Xue (2015) in several ways: we add an effort to improve internal controls and we consider the desirability of conservatism on total welfare and earnings quality. Kwon, Newman, and Suh

[4] See also Lambert (2001) and Christensen and Demski (2003).

(2001) consider an agency model in which the manager takes a productive action, but cannot perform other activities that influence the accounting report. Conservatism is beneficial because the manager's compensation is bounded from below and too much precision on unfavorable signals is useless, so more precision can be shifted to favorable signals. Bertomeu, Darrough, and Xue (2015) introduce *ex ante* earnings management to this setting. They find that conservative accounting is optimal because the benefit of having more precise favorable signals is larger than the cost of increased earnings management incentives. This trade-off gives rise to a desirable interior level of conservatism. In an extension, they discuss *ex post* earnings management and find that (maximum) conservatism increases firm value, as we do in the present paper.[5] Our paper reconfirms these results and goes beyond them by highlighting the incentives from conservative accounting on management's implementation of internal controls.

Drymiotes (2011) examines a setting in which the firm's owner can increase the precision of the accounting system (what is labeled as monitoring) and studies the effect on earnings management incentives. He finds that making the accounting system more precise can increase earnings management. Chan (2016) studies the effect of the SOX requirement to disclose internal control weaknesses on investment in internal controls and audit effort. He focuses on the interaction between internal controls and the compensation contract set by the owner, earnings management, and auditing. Chan finds that the disclosure of internal control weaknesses increases audit effort, but can increase or decrease investment in internal controls. Both papers assume the owner rather than the manager sets the internal control level and they do not consider conservatism.

Ewert and Wagenhofer (2016) develop an agency model with productive effort and earnings management and examine the interaction between auditing and enforcement activities and their resulting effects on managerial incentives. They show that increasing enforcement can have detrimental effects on firm value and on earnings quality because for highly effective

[5] In a related setting in which the manager receives a different piece of information, Gigler and Hemmer (2001) find that conservatism makes it more difficult to elicit truth-telling and is therefore undesirable.

enforcement, enforcement crowds out auditing and mitigates earnings management that may be "good" in the sense that it corrects understatement errors in the accounting system. Glover and Levine (2015) consider asymmetric information about measurement quality and also show that earnings management can be "good" in that it reduces understatement. A similar effect surfaces for earnings quality in the present paper.

Providing incentives to enhance internal controls bears some resemblance to controlling managers' activities to control risk in the production process. For example, Meth (1996) and Chen, Mittendorf, and Zhang (2010) study agency models in which the manager takes two actions, one to increase the average outcome and the other to influence its variance or spread. In these models, inducing less risky production choices improves the informativeness of the accounting system. In particular, Chen et al. find that conservatism is useful to motivate the mean-increasing action, but a liberal bias is necessary to induce the spread-reducing activity. Gao and Zhang (2016) consider peer pressure for earnings management and show that firms do not internalize this positive externality, thus, underinvest in internal controls.

Internal controls are also studied in the analytical auditing literature, such as, e.g., Nelson, Ronen, and White (1988), Smith, Tiras, and Vichitlekarn (2000), Pae and Yoo (2001), and Patterson and Smith (2007, 2016). These models consider strategic interactions between the manager's or the owner's implementation of internal controls and the auditor's audit activities. These papers focus on different auditor liability regimes, changes in audit requirements and/or penalties for the manager and their impact on firm value. Compared to the present paper, they do not explicitly consider optimal contracting, but focus on auditors' strategies.

The paper proceeds as follows: Section 2 develops the model and Section 3 derives the optimal contract, the manager's choice of different activities and the economic effects of varying conservatism in the benchmark setting without internal controls effort. Section 4 presents our main results, which include the effects of varying conservatism on incentives for earnings management and improving internal controls, on firm value, total welfare, and earnings quality. Section 5 concludes. All proofs are in appendix A.

2. Model

We consider a firm consisting of a representative owner and a manager in a one-period agency model. The manager exerts productive effort, can improve internal controls of the accounting system, and has the opportunity to manage earnings. Each of these actions is personally costly to the manager. To provide incentives to the manager to work hard, the owner writes a compensation contract based on reported earnings (in a broad sense).

Production technology

The firm owns a production technology and installs an accounting system to track performance. Output is binary and measured by a monetary amount $x \in \{x_L, x_H\}$ with $0 < x_L < x_H$. Production of the firm's output depends on managerial effort $a \in \{a_L, a_H\}$ and other stochastic production factors. The manager incurs a private cost of productive effort of 0 for a_L and $V^a > 0$ for a_H. The effort determines the probability with which a low or a high output occurs: x_H occurs with probability p upon high effort a_H, and with probability q upon low effort, where $p > q$ and p and q are strictly within (0, 1). The difference between p and q captures the incremental productivity of high effort.

The output accrues to the shareholders who are represented by a controlling owner or by a board of directors (henceforth referred to as the "owner"), who compensates the manager for the effort exerted. We assume the owner wants the manager to take higher productive action a_H, which requires that the net outcome for the owner, $(p - q)(x_H - x_L) - V^a$, is sufficiently large. Otherwise there is no incentive problem and a fixed compensation would implement a_L. The owner designs a compensation contract $s(\cdot)$ written on the financial report $m \in \{m_L, m_H\}$; we describe the details below. The actual output x is unobservable and non-contractible, for example, because it is a long-term profit that cannot be captured fully by a one-period performance measure or it includes non-financial benefits.

The owner is risk neutral and maximizes the expected output less expected compensation,

$$E(U^O) = \left[(1-p)x_L + px_H\right] - \left[\text{prob}(m_L)s(m_L) + \text{prob}(m_H)s(m_H)\right]. \quad (1)$$

Because we assume the owner induces a_H, the first term, expected output, is constant and the owner's problem reduces to minimizing the second term, the expected compensation subject to the manager agreeing to the contract and choosing a_H.

The manager is risk neutral and protected by limited liability. Specifically, we assume the manager has a zero reservation utility and compensation s cannot be negative. We explicitly state the manager's expected utility after introducing the accounting system.

Accounting system

The owner installs an accounting system that produces an accounting signal $y \in \{y_L, y_H\}$, where $y_L < y_H$. We also refer to the signal as preliminary earnings. It provides imperfect information about the output x, whose precision we capture by the two types of errors that can occur: α is the "α-error", i.e., the probability that it reports y_L, although the output is x_H; and β is the "β-error" with which it reports y_H, although the output is x_L. $\alpha, \beta \in [0, 0.5]$, where $\alpha = \beta = 0$ is the special case of a perfect information system and $\alpha = \beta = 0.5$ is a totally uninformative system. The errors in the accounting system arise from the book-keeping and other accounting processes, e.g., inventory sampling, misrecording book entries, double-booking, not booking transactions or events, individual mistakes and misjudgments, but also earnings management or fraud at lower levels of the firm.[6] In a binary information setting, the error probabilities fully determine its information content and changing either of them affects the decisions taken by the owner and the manager and the resulting economic outcomes.

We assume that the accounting system is characterized by base errors $\alpha_0, \beta_0 \in [0, 0.5]$ and we distinguish two characteristics of the accounting system, precision and bias. Precision is measured by the sum of the conditional error probabilities, $\alpha_0 + \beta_0$. Thus, lowering either α_0 or β_0, or both of them, increases precision. Bias is determined by the relation between α_0 and β_0. Following prior literature (e.g., Gigler, Kanodia, Sapra, and Venugopalan 2009) we define the base accounting system as neutral if $\alpha_0 = \beta_0$, conservative if $\alpha_0 > \beta_0$, and aggressive if $\alpha_0 < \beta_0$. An

[6] We do not model such decisions explicitly but capture them within the α- and β-errors.

accounting system is more conservative the greater the difference $\alpha_0 - \beta_0$ becomes. Conservatism makes it more likely that, given some production technology, the low signal y_L rather than the high signal y_H realizes, that is, conservative accounting tends to understate rather than overstate earnings in the period a transaction or event is recognized. This is consistent with conditional conservatism. At the same time, the signal y_L becomes less precise and the signal y_H more precise regarding the underlying actual output *x*.

Precision and bias are related. For example, if $\alpha_0 > \beta_0$, then lowering α_0 decreases conservatism; if $\alpha_0 < \beta_0$, then decreasing α_0 increases aggressiveness. Moreover, the lower α_0 and β_0 are, the less bias is possible. In the extreme, if an accounting system is fully precise ($\alpha_0 = \beta_0 = 0$) then there cannot be a bias.

To isolate the effects of conservatism, we hold the precision constant and parameterize both error probabilities by δ, which serves as our measure of conservatism: An accounting system $(\alpha_0', \beta_0') \equiv (\alpha_0 + \delta, \beta_0 - \delta)$ is more conservative the greater is δ, assuming $0 < \delta < \max\{0.5 - \alpha_0, \beta_0\}$. Intuitively, δ biases the original accounting system towards reporting bad news more likely than good news. In the subsequent analysis, we do not explicitly spell out δ in the equations, but use it only to derive comparative statics for a variation of conservatism.

The total precision of the accounting system depends on the base characteristics determined by $\alpha_0, \beta_0 \in [0, 0.5]$, the conservatism parameter δ and managerial effort that can increase the basic precision, which we refer to as internal controls (IC) effort. The IC effort is unobservable and determined before the accounting system reports signal *y*. For example, the manager can invest in or enhance the quality of the accounting processes to improve the precision of the accounting system. The manager incurs a private cost of IC effort, $V^\varepsilon \varepsilon$, where $V^\varepsilon > 0$. We symbolize the IC effort by $\varepsilon \geq 0$, which alters the α- and β-errors in the following way:

$$\alpha = \alpha_0 \exp(-\varepsilon) \text{ and } \beta = \beta_0 \exp(-\varepsilon). \tag{2}$$

Greater ε reduces the errors by a percentage that is concave increasing in ε because $\exp(-\varepsilon) = 1$ if $\varepsilon = 0$, $\exp(-\varepsilon) \to 0$ if $\varepsilon \to \infty$, $\exp(-\varepsilon)' < 0$, and $\exp(-\varepsilon)'' > 0$. We assume that the manager cannot influence the precision of the α- and the β-error independently.

Earnings management

After exerting productive effort and IC effort, the accounting system reports a signal *y* representing, for example, the raw profit from the list of accounts of the period. The manager privately observes *y* and can then engage in earnings management to manipulate the signal and to realize a financial report (earnings) $m \in \{m_L, m_H\}$. For example, after fiscal year-end, there are many accounting procedures that require professional judgment, estimations, forecasts, and the like, which the manager can distort in order to achieve a desirable report. The financial report *m* is publicly observable and contractible and is used as the performance measure in the manager's compensation contract.

The manager's earnings management (EM) effort $B_i \geq 0$ ($i = L, H$) determines the probability with which the report *m* deviates from *y*,

$$b_i = 1 - \exp(-B_i)\,. \tag{3}$$

b_L is the probability that the financial report becomes m_H, although the accounting signal was y_L, and b_H is the probability that $m = m_L$ although $y = y_H$. The probability $b_i \in [0, 1)$ increases and is strictly concave in B_i.

The manager incurs a personal cost of EM effort of $V^m B_i$, where $V^m > 0$ is a constant scaling factor. V^m captures, e.g., the manager's energy or direct costs and opportunity costs of time of manipulating the results of the accounting system; it can also be a psychological cost of manipulation. A lower V^m indicates that the accounting system is easier to manipulate. We do not explicitly model the mechanisms that affect the level of V^m; they can be a result of the accounting standards, which can provide more or less flexibility, but also of more effective controls, auditing, better enforcement, or more effective litigation.

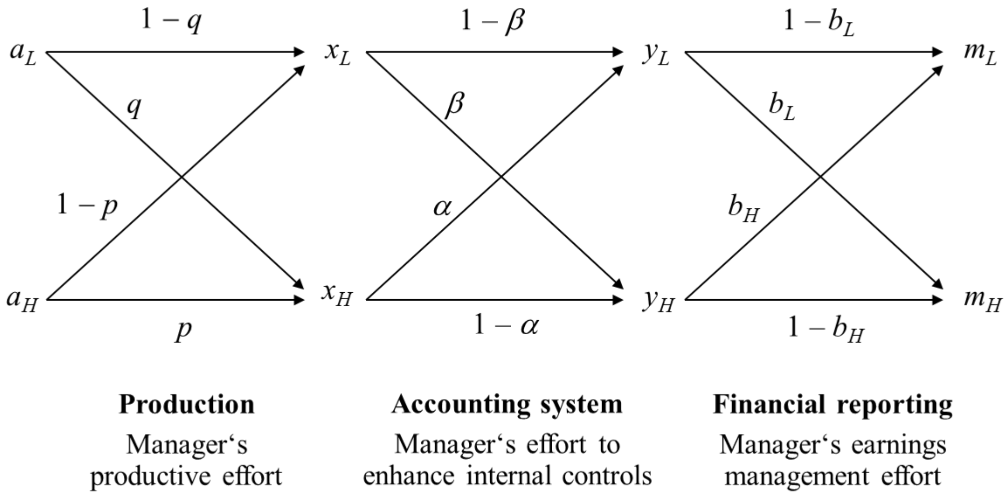
The manager receives compensation from the owner for participating in the firm. Compensation $s(\cdot)$ is written on the financial report *m*, and both $s(m_L)$ and $s(m_H)$ are non-negative. The manager's expected utility is

$$\begin{aligned} E[U^M | a_H, \varepsilon, B_L, B_H] = {} & \text{prob}(m_L | \varepsilon, B_L, B_H) s(m_L) + \text{prob}(m_H | \varepsilon, B_L, B_H) s(m_H) - V^a - V^\varepsilon \varepsilon \\ & - V^m (\text{prob}(y_L | \varepsilon) B_L + \text{prob}(y_H | \varepsilon) B_H)\,. \end{aligned} \tag{4}$$

We assume that there are no other contractible signals. Bertomeu, Darrough, and Xue (2015) consider a setting in which the manager is asked to report y truthfully, so the compensation can also depend on the manager's report about y. Because of truth-telling, earnings management does not occur in equilibrium. We assume that the manager cannot report y due to its complexity, and contracting on the reported y is not enforceable. If it was easy to report y then it would also be easy to implement a mechanism that provides this information to the owner or to audit that information.[7] In Appendix B we show that all our results qualitatively continue to hold for a truth-telling contract, except for Proposition 7 (ii).

Figure **1** depicts the stages of the production and the accounting system.

Figure 1: Production and accounting structure



The time line is as follows:

1. Design of the base accounting system (α_0, β_0) and conservatism δ.

[7] If the cost of earnings management arises from an audit, then in our binary setting (which is also used in Bertomeu, Darrough and Xue 2015) then inducing truth-telling will eliminate the incentives of an auditor to substantially audit because there is no earnings management in equilibrium by design. The manager anticipates this outcome and will engage in earnings management, contrary to the assumed truth-telling equilibrium.

2. Owner offers compensation contract $s(m)$ to manager (and manager accepts).
3. Manager chooses productive effort a_H and IC effort ε.
4. Manager observes signal y_i from the accounting system and chooses earnings management (EM) effort B_i.
5. Manager issues financial report m_i.
6. Manager is paid according to the contract.

3. Benchmark without internal controls effort

3.1. Optimal contract

We begin the analysis with a benchmark setting in which there is no IC effort, i.e., $\varepsilon = 0$. This scenario arises endogenously in the full setting if the cost V^ε of IC effort is sufficiently high.

To induce productive effort, the compensation must be greater for the high signal than for the low signal because the desirable productive effort a_H is more likely to produce x_H; that is, $s(m_H) > s(m_L)$. Because compensation is non-negative and the reservation utility is zero, the owner optimally pays a bonus if m_H is realized and no bonus otherwise, i.e., $s \equiv s(m_H) > s(m_L) = 0$. The manager has an incentive to engage in earnings management only if $y = y_L$ to increase the probability that $m = m_H$. Underreporting earnings (i.e., reporting m_L although $y = y_H$) is never in the best interest of the manager. Therefore, $B \equiv B_L \geq 0$ and $B_H = 0$. Using these choices, the manager's expected utility becomes

$$E[U^M | a_H, B] = \text{prob}(m_H | B)s - V^a - \text{prob}(y_L)V^m B. \tag{5}$$

The subsequent analysis is by backward induction, starting with the last stage, the EM effort. The relevant components of the manager's expected utility, conditional on a_H and observing y_L, are the expected compensation and the cost of earnings management. The manager maximizes

$$\begin{aligned}\max_B E[U^M | a_H, y_L] &= \text{prob}(m_H | y_L)s - V^m B \\ &= \left(1 - \exp(-B)\right)s - V^m B.\end{aligned}$$

The first-order condition yields the optimal earnings management[8]

[8] The second-order condition is satisfied by virtue of the concavity of the decision problem.

$$B = \begin{cases} \ln(s/V^m) > 0 & \text{if } s > V^m, \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

The probability that earnings management $B > 0$ is effective is $b_L = 1 - \exp(-B) = 1 - \frac{V^m}{s}$.

Given the optimal earnings management, the incentive compatibility constraint to induce the manager to choose a_H is

$$E[U^M | a_H] \geq E[U^M | a_L]$$

or

$$\text{prob}(m_H | B)s - V^a - \text{prob}(y_L)V^m B \geq \text{prob}\left(m_H | a_L, B\right)s - \text{prob}\left(y_L | a_L\right)V^m B. \tag{7}$$

Formally, if the manager were to choose a_L (out-of-equilibrium) he would possibly consider a different earnings management $B(a_L)$. But according to (6), B is independent of the productive action because the manager decides on earnings management only after observing low preliminary earnings y_L.

Finally, the owner maximizes her expected utility with respect to the bonus,

$$\max_s E\left[U^O\right] \triangleq \min_s E\left[s\right] = \text{prob}(m_H)s, \tag{8}$$

subject to the incentive compatibility constraint and the participation constraint. Since the manager's reservation utility is zero and the manager is protected by limited liability, the participation constraint is redundant and the manager always earns a rent in expectation.

The following result characterizes the optimal solution.

Proposition 1: Assume $\varepsilon = 0$. The optimal contract promises a bonus s for high earnings as follows:

$$s = \begin{cases} \bar{V}^m & \text{if } \bar{V}^m \leq V^m, \\ \exp\left(\frac{\bar{V}^m}{V^m} - 1 + \ln\left(V^m\right)\right) & \text{if } \bar{V}^m > V^m. \end{cases}$$

where $\bar{V}^m \equiv \frac{V^a}{(p-q)(1-\alpha_0-\beta_0)}$.

The incentive compatibility constraint provides a lower bound on s to induce the high productive effort, and since the owner's expected utility strictly decreases in expected compensation, the incentive compatibility constraint determines the optimal bonus. The two cases in the proposition state the case that V^m is sufficiently high ($V^m \geq \bar{V}^m$) that it deters earnings management ($B = 0$), and the case of earnings management ($B > 0$).

3.2. Effects of varying conservatism

Firm value and total welfare

We consider two welfare measures: the value of the firm, which equals the expected utility of the owner, and total welfare, which we define as the sum of the expected utilities of the owner and the manager (other parties that might be affected by financial reporting are outside our model). These two measures do not coincide because the manager's expected utility is not constant, but he earns a rent from employment due to limited liability. Which of these two measures is relevant depends on who determines the level of conservatism in the accounting system. If it is the firm's owner, she is interested in maximizing her expected utility, which is firm value. If a regulator or standard setter is in charge of designing the accounting system, it would probably be more interested in total welfare than in firm value because maximizing total welfare seems economically more defensible due to Pareto optimality.

We define firm value FV as the owner's expected utility,

$$\text{FV} = E[U^O] = \left[(1-p)x_L + px_H\right] - \text{prob}(m_H)s(m_H). \tag{9}$$

As long as the optimal contract induces high productive effort, the expected outcome (the term in square brackets) is constant and changes in FV with a variation of the conservatism arise through its effect on the expected compensation.

Total welfare TW is the sum of firm value and the manager's expected utility,

$$\text{TW} = E\left[U^O\right] + E\left[U^M\right]. \tag{10}$$

$$\text{TW} = \begin{cases} E\left[x\right] - V^a & \text{if } B = 0, \\ E\left[x\right] - V^a - \left(p\alpha_0 + (1-p)(1-\beta_0) + \delta\right)V^m \ln\left(\dfrac{s}{V^m}\right) & \text{if } B > 0. \end{cases}$$

Expected compensation cancels out in total welfare, so TW eventually captures only the expected outcome for high productive effort less the agent's effort disutility and the expected cost of earnings management. The following proposition records comparative statics results for a variation of accounting characteristics.

Proposition 2: Assume $\varepsilon = 0$. (i) Firm value strictly decreases in α_0 and β_0, but strictly increases in conservatism δ. (ii) Total welfare decreases in each parameter, α_0, β_0, and δ; the decrease is strict if optimal earnings management is positive.

Both firm value and total welfare decrease in individual precision, i.e., with an increase in either α_0 or β_0. This reflects the fact that reducing the precision of the accounting system due to larger individual accounting errors reduces the stewardship value of the accounting system.

Varying the precision of the accounting system directly affects both the required bonus to preserve incentive compatibility and the probability that the manager receives the bonus. In addition, there is an indirect effect: An increase in either error decreases the action-induced probability spread for the high accounting signal, thus requiring a larger bonus to motivate the manager to exert high productive effort. Specifically, a higher α_0 increases the bonus, but it also decreases the probability that the manager earns the bonus. As shown in the proof, the latter effect is outweighed by the bonus effect, and therefore increasing α_0 reduces firm value. Increasing the overstatement error β_0, the lower precision again increases the bonus, but it also increases the probability of earning it. Both effects reduce firm value.

The effect of conservatism δ depends on which welfare measure is applied. Firm value strictly increases if the accounting system becomes more conservative, whereas total welfare decreases. The result that firm value increases for greater conservatism is a consequence of a trade-off between a decline in firm value due to higher α_0 and the simultaneous increase in firm value due to lower β_0. In fact, we show in the proof that the bonus s is unaffected by a change of δ because the effects of varying both errors α_0 and β_0 in different directions cancel out. Thus, the effect of δ on firm value arises solely through the strict decline of the probability prob(m_H) that a bonus is awarded and the owner strictly benefits from more conservatism. This result is in line with Kwon, Newman, and Suh (2001) and Bertomeu, Darrough, and Xue (2016), but in their models there is an interior optimal level of conservatism. A direct consequence of more conservatism is an increase of the probability that the manager engages in earnings management.

Because the level of the bonus is unchanged, the *ex ante* higher earnings management effort decreases the manager's expected utility in addition to the lower expected compensation. Indeed, this higher expected cost of induced earnings management reduces total welfare TW because the expected compensation cancels out in TW. Hence, TW strictly declines in conservatism.

Earnings quality

We also examine earnings quality that results in our optimal contracting setting. Accounting standard setters, such as the IASB and the FASB, focus on decision usefulness rather than on stewardship (IASB 2010, FASB 2010). Earnings quality is more in line with a general decision usefulness objective because it suggests a "neutral" and unbiased view of information useful for decision making. Note, however, that the usefulness of accounting information depends on the specific decision problem and a neutral accounting system need not provide the best information to the decision maker, particularly if one is interested in stewardship uses of accounting. For example, the net cost of an understatement may be significantly different to that of an overstatement. In our model, non-controlling shareholders may trade their shares, and the accounting standard setters aim to improve earnings quality to provide them more decision-useful information in the capital market.

To preserve "neutrality" of the measure, we define earnings quality EQ as the *ex ante* probability that the financial report *m* equals the actual output *x*, which is

$$\text{EQ} = p\,\text{prob}(m_H \,|\, x_H) + (1-p)\,\text{prob}(m_L \,|\, x_L). \tag{11}$$

Proposition 3: The effects of varying α_0, β_0, and δ on earnings quality EQ are indeterminate and depend on the parameters. Either one of the conditions $p\alpha-(1-p)(1-\beta) \leq 0$ or $B = 0$ is sufficient that EQ declines in α_0 and β_0. EQ increases in δ if $p < 0.5$ and decreases if $p > 0.5$.

The proof in appendix A derives the explicit conditions for an increase and decrease. The reason for the ambiguity in the results is that EQ depends on the expected sum of the α- and β-errors in equilibrium. Obviously, increasing either α_0 or β_0 has a direct negative effect on EQ. But there is also an indirect effect that arises from the necessary increase of the bonus *s* to preserve incentive compatibility. A larger bonus increases earnings management, i.e., reporting m_H despite

y_L occurs. Earnings management increases misreporting and reduces EQ if the accounting signal is correct, i.e., y_L realizes and x_L is the actual outcome, which occurs with probability $(1-p)(1-\beta)$. Conversely, it improves EQ if it corrects a mistake in the accounting signal, i.e., the accounting system reports y_L although x_H is the actual outcome. This case occurs with probability $p\alpha$. . If the sign of the difference

$$p\alpha-(1-p)(1-\beta) \tag{12}$$

is positive (negative), then higher earnings management has a positive (negative) impact on EQ. The total effect of increasing α_0 or β_0 on EQ depends on relative strength of the direct and indirect effect.

The proposition records two sufficient conditions for a strict decrease of EQ in α_0 and β_0: One is $p\alpha-(1-p)(1-\beta) \leq 0$, and the other is that the optimal contract does not induce earnings management ($B = 0$). The proof also reveals that the effect of α_0 and β_0 need not be in the same direction; i.e., it is possible that EQ increases in one error, but decreases in the other error; this predominantly depends on p.

The effect of an increase of conservatism δ is also ambiguous, but the direction depends only on the probability p that the outcome is x_H, i.e., the project is successful. EQ increases in δ if $p < 0.5$ and decreases if $p > 0.5$. The reason for this rather simple condition is that a change of δ does not change the optimal bonus and the level of earnings management. Conservatism solely shifts probability mass from the high to the low accounting signal. If p is less than 0.5, the expected increase in the understatement error (affecting EQ unfavorably) is smaller than the expected decrease in the overstatement error (affecting EQ favorably), inducing an increase in earnings quality, and vice versa.

4. Main results

We now turn to the full setting, including internal controls effort by the manager. The key issues are, first, to identify conditions under which the manager has an incentive to improve internal controls and, second, how internal controls effort changes the prior results. The analysis focuses on the more interesting case that the manager engages in earnings management ($B > 0$); we briefly discuss results for $B = 0$ later.

4.1. Optimal contract

Equilibrium internal controls effort

In the previous analysis we show that optimal earnings management is $B = \ln(s/V^m)$ if $B > 0$. This B is structurally unaffected by the introduction of IC effort ε, although the introduction of the IC effort changes the value of the bonus s. The manager's expected utility is

$$E[U^M | a_H, \varepsilon, B] = \text{prob}(m_H | \varepsilon, B)s - V^a - V^\varepsilon \varepsilon - \text{prob}(y_L | \varepsilon)V^m \ln(s/V^m).$$

Proposition 4: The manager improves internal controls ($\varepsilon > 0$) if and only if V^ε is sufficiently small and

$$T \equiv p\alpha_0 - (1-p)\beta_0 > 0. \tag{13}$$

If $\varepsilon > 0$ then it is equal to $\varepsilon = \ln\left(\frac{T\left[1+\ln(s/V^m)\right]V^m}{V^\varepsilon}\right)$.

The proposition states two conditions such that $\varepsilon > 0$. The first is that the cost of EM effort is sufficiently small (the proof in appendix A states the explicit condition). The second condition, $T > 0$, relates to the *ex ante* probability of two errors: $p\alpha_0$ is the expected error that the accounting system understates the output and $(1 - p)\beta_0$ is the expected error that the accounting system overstates the output given productive effort a_H. Note that higher ε reduces both types of errors. If understating is more likely than overstating, then increasing costly IC effort increases the probability that y_H realizes, which is beneficial for the manager because it increases the probability of receiving the bonus s. Conversely, if overstating is more likely than understating, the manager has no incentive to improve the accounting system. Therefore, if $p\alpha_0 > (1 - p)\beta_0$, then the advantage outweighs the disadvantage and the manager exerts IC effort $\varepsilon > 0$ if it is not too costly. Note that this condition $T > 0$ also implies that $p\alpha > (1 - p)\beta$ because any ε affects the original errors by the same percentage.

The proposition states the optimal ε if $\varepsilon > 0$. Holding s constant, ε increases in T and decreases in V^ε. Furthermore, it increases in V^m because a higher cost of earnings management reduces the manager's EM effort, which is partially substituted by an increase in IC effort. That is, from the manager's perspective enhancing internal controls has an effect that is reminiscent of *ex ante* earnings management.

Equilibrium productive effort and compensation

The owner solves for the optimal bonus,

$$\min_{s} \mathrm{E}\left[\tilde{s}\right] = \mathrm{prob}(m_H)s \tag{14}$$

subject to the incentive compatibility constraint to induce the manager to choose a_H,

$$\begin{aligned} &E[U^M \mid a_H] \geq E[U^M \mid a_L] \\ &\qquad = \mathrm{prob}\left(m_H \mid a_L, \varepsilon(a_L), B(a_L)\right)s - V^{\varepsilon}\varepsilon(a_L) - \mathrm{prob}\left(y_L \mid a_L, \varepsilon(a_L)\right)V^m B(a_L). \end{aligned} \tag{15}$$

$B(a_L)$ denotes the earnings management if the manager were to choose a_L out-of-equilibrium. The observation in the benchmark setting that B is independent of a still holds as B only depends on the realization of y_L, but now the IC effort varies for different a. Therefore, we need to distinguish three cases that imply structurally different incentive compatibility constraints:

Case 1: The manager engages in IC effort and would also engage in IC effort if he chose the out-of-equilibrium productive effort a_L. This is the case if $q\alpha_0 - (1-q)\beta_0 > 0$ (which implies $p\alpha_0 - (1-p)\beta_0 > 0$).

Case 2: The manager engages in IC effort but would not engage in IC effort if he chose the out-of-equilibrium productive effort a_L. The condition for this situation is $q\alpha_0 - (1-q)\beta_0 < 0$ and $p\alpha_0 - (1-p)\beta_0 > 0$.

Case 3: The manager never engages in positive IC effort. The condition $p\alpha_0 - (1-p)\beta_0 < 0$ is sufficient. This case is the benchmark setting in Section 3.

The next result characterizes the optimal contract.

Proposition 5: Assume $B > 0$. The optimal bonus s to induce high productive effort is defined in

$$\ln(s) = \frac{V^a}{(p-q)V^m} + \frac{V^{\varepsilon}}{(p-q)V^m}\ln\left(\frac{p\alpha_0 - (1-p)\beta_0}{q\alpha_0 - (1-q)\beta_0}\right) - 1 + \ln(V^m) \text{ in case 1,} \tag{16}$$

$$V^m\left(1+\ln(s/V^m)\right)\left[p-q(1-\alpha_0-\beta_0)-\beta_0\right]$$
$$-V^\varepsilon\left[1+\ln\left(\frac{V^m\left[1+\ln(s/V^m)\right](p\alpha_0-(1-p)\beta_0)}{V^\varepsilon}\right)\right]-V^a=0 \text{ in case 2,} \tag{17}$$

$$\ln(s)=\frac{V^a}{(p-q)(1-\alpha_0-\beta_0)V^m}-1+\ln\left(V^m\right) \text{ in case 3.}$$

Our subsequent analysis focuses on case 1 that involves all three activities by the manager. This case provides the most insights into the interactions between the action choices and their joint effects. For completeness, the proofs also contain an explicit analysis of case 2.

4.2. Effects of varying conservatism

Incentives to improve internal controls

We first state the effect of conservatism on the incentives to enhance internal controls.

Proposition 6: If the optimal IC effort $\varepsilon > 0$, then it strictly increases in conservatism δ.

The proposition states that a more conservative accounting system induces a higher IC effort. This result holds regardless of whether or not the manager engages in earnings management.

According to Proposition 4 and explicitly including δ, the optimal $\varepsilon > 0$ with $B > 0$ is defined as

$$\varepsilon=\ln\left(\frac{\left(p\left(\alpha_0+\delta\right)-\left(1-p\right)\left(\beta_0-\delta\right)\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right).$$

A change of δ has two effects: First, higher δ increases the probability difference term,

$$p(\alpha_0+\delta)-(1-p)(\beta_0-\delta)=p\alpha_0-(1-p)\beta_0+\delta,$$

which has a positive impact on the IC effort; and second, an increase of δ reduces the bonus s, which mitigates the IC effort. The proof establishes that the probability effect outweighs the compensation effect, so that ε unambiguously increases in conservatism.

As a result, conservatism has a strictly positive effect on the manager's incentive to engage in activities to enhance internal controls and to improve the precision of the accounting system.

Firm value and total welfare

The next result shows that conservatism always increases the owner's expected utility, but has an ambiguous effect on total welfare. The latter effect differs from the benchmark setting, where we show that total welfare strictly decreases in conservatism.

Proposition 7: Assume $B > 0$. Increasing accounting conservatism δ has the following effects:

(i) Firm value strictly increases.

(ii) Total welfare can increase or decrease, depending on the parameters.

Part (i) of the proposition states that firm value, which is the owner's expected utility, strictly increases in conservatism δ. Two effects drive this result: First, increasing δ reduces the probability that a bonus is paid,

$$\begin{aligned}\text{prob}(m_H) &= p\left(1-(\alpha+\delta)(1-b_L)\right)+(1-p)\left(b_L+(\beta-\delta)(1-b_L)\right)\\ &= p\left(1-\alpha(1-b_L)\right)+(1-p)\left(b_L+\beta(1-b_L)\right)-\delta(1-b_L).\end{aligned}$$

Second, greater δ strictly lowers the bonus s required to motivate the manager to pick the desirable productive effort. Note that in the benchmark setting, the bonus was independent of δ. Because of its impact on IC effort, the bonus can be reduced in the full setting.

Proposition 7 (ii) states that the impact of conservatism on total welfare TW is ambiguous. Recall that TW is the sum of the owner's and the manager's expected utility, both of which are affected by δ because the manager earns an expected rent. Expected compensation cancels out in the sum of the owner's and the manager's expected utilities because it is a direct wealth transfer between the owner and the manager. The other components include the costs of productive effort, IC effort, and earnings management, where the latter two depend on the degree of conservatism. Since IC effort is strictly positive in the optimal contract, the optimal bonus decreases in δ, which mitigates earnings management. The proof shows that the lower earnings management overcompensates the effect of the larger probability that y_L occurs, implying that expected earnings management and its associated cost declines with more conservatism. However, there is another effect: More conservatism increases the IC effort and the expected cost of this effort. The net effect on total welfare is indeterminate and depends on the specific parameters (the proof of the proposition shows the explicit expressions). As in the benchmark setting, the manager's expected utility always declines, but this loss is overcompensated by the increase in firm value in the cases in which total welfare increases.

The following corollary that immediately follows from the proposition underscores the importance of internal controls for our results.

Corollary 1: Assume $B > 0$. Strictly positive IC effort is a necessary condition that total welfare increases in conservatism.

Another effect of the IC effort arises if one examines an individual variation of α_0 and β_0. Proposition 2 states that an increase in either error reduces firm value. Adding IC effort, this result does not hold for α_0 anymore. Consider case 1 in which the manager chooses $\varepsilon > 0$ and $B > 0$, holding s constant. The optimal B is conditional on the realization of $y = y_L$; therefore, the variation of α_0 and β_0 does not directly affect the optimal B. A variation of α_0 and β_0 affects the probability that the manager earns a bonus, $\text{prob}(m_H)$, which influences his IC effort choice. According to Proposition 4, the optimal IC effort is

$$\underbrace{\left(p\alpha_0-(1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]\exp(-\varepsilon)}_{\equiv L}=V^{\varepsilon}.$$

Holding s constant, an individual increase in α_0 increases the IC effort because

$$\frac{d\varepsilon}{d\alpha_0}=-\left(\frac{\partial L}{\partial\alpha_0}\right)\left(\frac{\partial L}{\partial\varepsilon}\right)^{-1}=\frac{p}{p\alpha_0-(1-p)\beta_0}>0.$$

The greater IC effort ε even overcompensates the loss in base precision through the increase in α_0. In fact, given s, we can show that $d\alpha/d\alpha_0 < 0$.

In contrast, an individual increase in β_0 always increases the error because higher β_0 decreases IC effort,

$$\frac{d\varepsilon}{d\beta_0}=-\frac{1-p}{p\alpha_0-(1-p)\beta_0}<0\,.$$

Considering the induced adjustment of the bonus s, there is another indirect effect on the IC and the EM effort. The owner faces a trade-off between these different effects. The next proposition states the results.

Corollary 2: Assume $B > 0$.

(i) An increase in α_0 decreases firm value if $\alpha_0 < \hat{\alpha}$ and increases it if $\alpha_0 > \hat{\alpha}$.

(ii) An increase in β_0 always decreases firm value.

An increase in α_0 has positive and negative effects, and the corollary states that the net effect is positive if α_0 is sufficiently high. The threshold value $\hat{\alpha}$ is the α_0 that separates cases 1 and 2 from Proposition 1. The proposition shows that an increase in α_0 is strictly positive in case 1, but strictly negative in case 2. Generally, $\hat{\alpha}$ depends on the parameters of the setting, and there are settings in which $\hat{\alpha}$ is outside of the domain of α_0, in which increasing α_0 can never have a positive effect on the manager's expected utility.

Contingent on the existing level of α_0, an increase of the precision can have either a positive or a negative effect. Assume $\hat{\alpha} < 0.5$, then starting with the "worst" precision $\alpha_0 = 0.5$, an increase in precision (decrease in α_0) *reduces* the owner's expected utility until the threshold $\hat{\alpha}$ is reached. A further increase in precision for $\alpha_0 < \hat{\alpha}$ raises the owner's expected utility again. Therefore, the owner prefers a boundary solution with either an $\alpha_0 = 0$ or $\alpha_0 = 0.5$.

Corollary 2 also confirms that an increase of β_0 is always harmful. The reason here is that increasing β_0 never increases the manager's IC effort, so the precision of the accounting system always declines. Furthermore, it increases the probability prob(m_H) that the manager receives a bonus. The probability prob(y_L) that the manager engages in earnings management declines, which leads to a reduction of the required bonus. While this *per se* is advantageous to the owner, it further reduces internal controls. Consequently, the lower precision of the base accounting system unambiguously requires a higher expected compensation to induce the manager to pick the high productive effort a_H.

Finally, to complete the analysis, we show that the possibility of earnings management is also crucial for the results. Our main results were stated for $B > 0$. $B = 0$ if V^m is sufficiently high, i.e., $V^m > (p-q)(1-\alpha_0-\beta_0)/V^a$.

Proposition 8: Assume $B = 0$. Increasing accounting conservatism δ has the following effects, and both effects are strict if $\left(p\alpha_0-(1-p)\beta_0+\delta\right) > 0$:

(i) Firm value increases.

(ii) Total welfare decreases.

The proposition shows that the effects in Proposition 7 carry over to the case of no earnings management with one exception:[9] Total welfare always weakly decreases in conservatism, whereas it can increase if earnings management is positive. The latter ambiguity arises from a tradeoff between increasing the probability of paying the bonus and mitigating earnings management. This effect is absent if there is no earnings management in equilibrium.

Earnings quality

Earnings quality equals

$$\begin{aligned}\text{EQ} &= p\left(1+\alpha(b_L-1)\right)+(1-p)(1-\beta)(1-b_L)\\ &= p-\frac{V^m}{s}\left(p\alpha-(1-p)(1-\beta)\right).\end{aligned}$$

Conservatism δ has a direct effect on the probability term in this equation because

$$p\alpha-(1-p)(1-\beta)=p\alpha_0-(1-p)(1-\beta_0)+(1-2p)\delta.$$

Indirect effects arise from an adjustment of the IC effort ε that influences the optimal bonus s. The next result shows that the effect of conservatism on earnings quality is ambiguous, which echoes Proposition 3, but here the effect on the IC effort is an additional source for this ambiguity.

Proposition 9: The effect of δ on EQ is indeterminate and depends on the parameters.

In the proof we show that the impact of conservatism on EQ is jointly determined by the following three components:

$$\frac{d\text{EQ}}{d\delta}=\underbrace{\frac{V^m}{s}(1-2p)\exp(-\varepsilon)}_{\text{Direct effect }(E_1)}+\underbrace{\frac{V^m}{s^2}\frac{ds}{d\delta}\left(p\alpha-(1-p)(1-\beta)\right)}_{\text{Indirect effect from EM }(E_2)}+\underbrace{\frac{V^m}{s}\left(p\alpha+(1-p)\beta\right)\frac{d\varepsilon}{d\delta}}_{\text{Indirect effect from IC }(E_3)}. \quad (18)$$

[9] Another effect of δ is that it shifts the domain of the three different cases to the left, which means there is a broader range of situations in which strictly positive IC effort is provided.

The first component, E_1, results from the direct impact of δ on the accounting errors given the IC effort ε. The crucial variable that determines its sign is whether p is greater or less 0.5. The second component, E_2, captures the effect caused by the change in earnings management, which materializes through the adjustment of s. The third component, E_3, results directly from the adjustment of ε. The first component is also present in the benchmark setting, whereas the latter two components are a consequence of the internal controls effort.

We show that

$$E_2 \begin{cases} = 0 & \text{if } \varepsilon = 0; \\ > 0 & \text{if } \varepsilon > 0 \text{ and } p\alpha < (1-p)(1-\beta); \\ < 0 & \text{if } \varepsilon > 0 \text{ and } p\alpha > (1-p)(1-\beta). \end{cases}$$

If there is no earnings management ($B = 0$) or if $\varepsilon = 0$, then E_2 vanishes. If the manager exerts positive IC and EM efforts, the optimal bonus decreases in δ, which reduces earnings management in equilibrium. The sign of E_2 is determined by whether earnings management affects the expected deviation between reported earnings and the true outcome x positively or negatively. If $p\alpha < (1-p)(1-\beta)$ holds, then a decrease in earnings management increases EQ because the bias-induced correction of the α-error is less *ex ante* than the decrease in precision that the bias causes by misrepresenting a correct accounting signal.

Proposition 4 establishes that $p\alpha_0 - (1-p)\beta_0 > 0$ (implying $p\alpha - (1-p)\beta > 0$) is a necessary and sufficient condition to induce IC effort ($\varepsilon > 0$). Note that because $\beta < (1 - \beta)$ the sign of $\left(p\alpha - (1-p)(1-\beta)\right)$ is indeterminate and is not implied by the other condition, but depends on the specific parameter values.

The sign of the third effect in (18), E_3, is that of the sign of $\frac{d\varepsilon}{d\delta}$. As we record in Proposition 6, $\frac{d\varepsilon}{d\delta} \geq 0$ for $\varepsilon > 0$, and, therefore,

$$E_3 \begin{cases} = 0 & \text{if } \varepsilon = 0; \\ > 0 & \text{if } \varepsilon > 0. \end{cases}$$

Collecting the three terms, the effect of conservatism on earnings quality is ambiguous. Whether more conservatism increases or decreases EQ, depends not only on the sign of the components, but also on their respective strength. However, the next result presents a useful comparative statics result.

Corollary 3: If p is „small," then more conservatism increases EQ.

The reason is that if p is "small," all three errors are non-negative. Thus, for firms with projects that have a relatively low probability of success, more conservatism is associated with an increase in earnings quality. Presumably, these are highly innovative firms. Put alternatively, p must be sufficiently "large" in order to reverse this result. p is typically large for more traditional industries. Compared to the benchmark setting, the presence of IC efforts provides an additional path by which conservatism positively affects earnings quality. The difference to firm value is apparent because "small" p reduces the incentive to invest in internal controls, which is a necessary condition that conservatism increases total welfare.

While p is a significant factor that determines EQ, q is not because it only affects the out-of-equilibrium strategy of low productive effort and indirectly determines compensation s. Consequently, the marginal productivity of effort, measured by $p - q$, does not have a direct effect on EQ, whereas firm value is affected by it through the incentive compatibility constraint on productive effort.

Recall that firm value strictly increases in accounting conservatism. That suggests that firms, if they can choose the degree of conservatism, would prefer a conservative accounting system even if reduces earnings quality. However, if firms believe that earnings quality reduces their cost of capital or has other (unmodeled) benefits, they need to trade off these benefits against the contracting value of the accounting system.

5. Discussion and conclusions

This paper analyzes the effects of accounting conservatism on management incentives to enhance internal controls and on welfare and earnings quality. We develop an agency model with an owner who hires a manager to provide productive effort through incentive compensation based on accounting earnings. These incentives also induce incentives to engage in earnings management and to enhance internal controls.

We establish that the manager's incentives to enhance internal controls increases in accounting conservatism, i.e., increasing understatement and reducing overstatement of earnings. We show that conservatism increases firm value, so the firm's owner clearly desires more conservatism. In contrast, the manager prefers less conservatism because his expected utility declines. We also consider total welfare as a Pareto efficiency measure, defined as the sum of the owner's and the manager's expected utilities. Total welfare can increase or decrease for greater conservatism depending on the trade-off between (i) an increase of internal controls, which increases the cost of internal controls and (ii) a decrease of earnings management through the reduced bonus, which reduces the cost of earnings management.

Besides welfare, we study earnings quality. Arguably, the objective of accounting standard setters is to increase earnings quality. We show that conservatism has an ambiguous effect on earnings quality because it has a direct effect on the probability of the α- and β-errors and indirect effects on internal controls and on earnings management through the adjustment of the optimal compensation. This ambiguous result is in contrast to the strictly positive effect of conservatism on firm value, but in line with the (although distinct) ambiguous effect on total welfare. Specifically, we show that earnings quality of firms with a low probability of a successful project is more likely to increase with greater conservatism.

Table 1 summarizes the main findings of this paper.

Table 1: Effects of increasing conservatism on various outcomes

	No internal controls effort		Internal controls effort	
	No EM	**EM**	**No EM**	**EM**
Internal controls	–	–	↑ P6	↑ P6
Firm value	↑ P2	↑ P2	↑ P8	↑ P7
Total welfare	↔ P2	↓ P2	↓ P8	↑↓ P7
Earnings quality	↑↓ P3	↑↓ P3	↑↓ P9	↑↓ P9

EM … Earnings management, P# … Proposition showing this result.
– … not applicable, ↔ … no effect, ↑ … increases in conservatism, ↓ … decreases in conservatism, ↑↓ … ambiguous effect.

Our analysis establishes an interaction between accounting standards and corporate governance. More conservatism increases incentives to implement internal controls and welfare measures. This result suggests that a trend away from conservative towards neutral accounting implicitly works against other regulatory objectives that aim at enhancing internal controls in firms. We also show that conservatism constrains management pay, which is due to a more informative performance measure that allows the firm to reduce variable pay and still provide sufficient incentives to the manager.

As with any economic model, our results are based on a number of assumptions about the economic setting and the accounting system. We briefly discuss key assumptions in the following. The manager is risk neutral and an agency problem arises because of limited liability. In such a setting, the firm "overpays" the manager to induce the desirable effort choices, and this creates a distinction between firm value and total welfare, which does not arise in a setting in which the manager can always be held at the reservation utility. Both our production technology and the accounting system are binary. Moving to a continuous production technology could offer more detailed insights into the adjustments of the managerial effort due to conservatism. In the binary case, this adjustment is implicit in the three cases we study. A binary accounting system is determined by the probabilities of understatement and overstatement only, and both precision and bias are driven by this specification. We capture conservative accounting through the increase in the probability of understatement and an equal decrease in the probability of overstatement. We also assume that each of these variations is costless; introducing costs dampens some effects, but may enhance others by virtue of the existence of such exogenous costs.[10] If more precision were costlessly achievable, the owner would simply choose error probabilities of zero, which precludes any benefit from enhancing the quality of the accounting system in the first place.

The manager observes the realized accounting signal before engaging in earnings management. An alternative assumption is that the manager biases the probabilities with which the report m_i deviates from y_i, $i = L, H$, before observing y. Our modeling of the internal controls effort is akin to *ex ante* earnings management. *Ex ante* earnings management could be incorporated in our model by assuming that the effort to improve the accounting system can become negative, thus lowering the precision of the base accounting system. In that case, the cost of IC effort would increase from biasing the accounting system in either direction. It might also be interesting to consider a setting in which better internal controls make it more difficult for the manager to engage in earnings management.

We also assume that the unit cost of earnings management is unaffected by internal controls. In practice, some accounting standards and internal controls are explicitly designed to reduce discretion for earnings management. Our analysis can be extended to capture this aspect. We can show that increasing the unit cost of earnings management increases firm value, decreases the manager's expected utility, but increases total welfare; earnings quality increases if expected understatement is high because then earnings management is more likely to correct false understatements than misreporting high earnings.

We assume reported earnings are the only signal used for contracting. If there is other contractible information available, the value of the accounting information can decline and it may also be more useful to confirm other sources of information. Given one binary contractible signal, a simple bonus contract emerges. Alternatively, consider for example a setting in which the owner requests that the manager reports the accounting signal y directly and uses this report in addition to

[10] Note that the manager's effort to improve the accounting system bears an endogenous private cost that we study in this paper.

the earnings report *m* for compensating the manager, that is, compensation $s_{ij} \equiv s(\hat{y}_i, m_j)$. In this case, the revelation principle applies and the manager can be deterred from earnings management by paying no bonus if he misreports the actual y_L as $\hat{y}_H$ and earnings management is unsuccessful, so that $m = m_L$.[11] While such a contract eliminates earnings management in equilibrium, the *opportunity* for earnings management still influences the compensation and the expected utilities of the manager and the owner (see appendix B for a proof). Therefore, the main insights of the paper continue to hold for such a more sophisticated contract.

Our model captures one period. Conservatism has multi-period effects if one imposes a clean-surplus condition that the sum of the cash flows from a project equals the sum of its earnings, so that an understatement of earnings reverses in future periods. It would be interesting to extend our setting to a multi-period model and explicitly model the inter-period accounting process.

Finally, we consider a two-player agency setting with an owner and a manager. More realistic settings involve several players. For example, fruitful extensions might be to introduce a board of directors or a second manager that is responsible for the effectiveness of internal controls; or an auditor that examines the effectiveness of internal controls in place.

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[11] Bertomeu et al. (2015) consider a similar extension.

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Appendix A: Proofs of Propositions and Corollaries

Proof of Proposition 1

The manager's expected utility given the choice of productive effort a_H is (assuming $B > 0$ and $\varepsilon = 0$)

$$E[U^M | a_H] = \text{prob}(m_H | B)s - V^a - \text{prob}(y_L)V^m B,$$

where

$$\begin{aligned}\text{prob}(m_H | B) &= 1 - \text{prob}(y_L)(1-b_L) = 1 - \text{prob}(y_L)\exp(-B) \\ &= 1 - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)\frac{V^m}{s}.\end{aligned}$$

These probabilities change for $a = a_L$ by substituting q for p.

The manager's expected utility becomes

$$\begin{aligned}E[U^M | a_H] &= \text{prob}(m_H | B)s - V^a - \text{prob}(y_L)V^m B \\ &= s\left(1 - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)\frac{V^m}{s}\right) - V^a - V^m\left(p\alpha_0 + (1-p)(1-\beta_0)\right)\ln(s/V^m) \\ &= s - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)\left(1 + \ln(s/V^m)\right)V^m - V^a\end{aligned}$$

and the incentive compatibility constraint becomes

$$\begin{aligned}s - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)&\left(1+\ln(s/V^m)\right)V^m - V^a \\ &\geq s - \left(q\alpha_0 + (1-q)(1-\beta_0)\right)\left(1+\ln(s/V^m)\right)V^m\end{aligned}$$

$$\left[\left(q\alpha_0 + (1-q)(1-\beta_0)\right) - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)\right]\left(1+\ln(s/V^m)\right)V^m \geq V^a$$

$$\begin{aligned}\ln(s) &\geq \frac{V^a}{\left[\left(q\alpha_0 + (1-q)(1-\beta_0)\right) - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)\right]V^m} - 1 + \ln(V^m) \\ &= \frac{V^a}{\left[(p-q)(1-\alpha_0-\beta_0)\right]V^m} - 1 + \ln(V^m).\end{aligned}$$

If $B = 0$ then $\text{prob}(m_H | B) = 1 - \text{prob}(y_L)$, and the incentive compatibility constraint is

$$s\left(1 - \left(p\alpha_0 + (1-p)(1-\beta_0)\right)\right) - V^a \geq s\left(1 - \left(q\alpha_0 + (1-q)(1-\beta_0)\right)\right)$$

resulting in

$$s \geq \frac{V^a}{(p-q)(1-\alpha_0-\beta_0)}.$$

Since the owner minimizes expected compensation, $\text{prob}(m_H)s$, the incentive compatibility constraints determine the minimum *s*, resulting in the optimal *s* stated in the proposition. □

Proof of Proposition 2

(i) Assuming $a = a_H$, firm value is

$$\text{FV} = \left[(1-p)x_L + px_H\right] - \text{prob}(m_H)s.$$

Changes in the characteristics of the accounting system only affect the expected compensation

$$\begin{aligned}\text{prob}(m_H)s(m_H) &= \left[1-\text{prob}\left(m_L\right)\right]s = \left[1-\text{prob}\left(y_L\right)\left(1-b_L\right)\right]s \\ &\left[1-\left(p\alpha+\left(1-p\right)\left(1-\beta\right)\right)\frac{V^m}{s}\right]s \\ &= s-\left(p\alpha+\left(1-p\right)\left(1-\beta\right)\right)V^m \\ &= s-\left(p\alpha_0+\left(1-p\right)\left(1-\beta_0\right)+\delta\right)V^m.\end{aligned}$$

Consider $B > 0$. Then $\ln(s) = \dfrac{V^a}{\left(p-q\right)\left(1-\alpha_0-\beta_0\right)V^m} - 1 + \ln\left(V^m\right)$ and we have

$$\frac{1}{s}\frac{ds}{d\alpha_0} = \frac{1}{s}\frac{ds}{d\beta_0} = \frac{V^a}{\left(p-q\right)V^m}\frac{1}{\left(1-\alpha_0-\beta_0\right)^2},$$

which implies $\dfrac{ds}{d\alpha_0} = \dfrac{ds}{d\beta_0} = s\dfrac{V^a}{\left(p-q\right)V^m}\dfrac{1}{\left(1-\alpha_0-\beta_0\right)^2} > 0$.

Differentiating expected compensation with respect to α_0 yields

$$\begin{aligned}\frac{d\,\text{prob}(m_H|B)s}{d\alpha_0} &= \frac{ds}{d\alpha_0} - V^m p \\ &= s\frac{V^a}{\left(p-q\right)V^m}\frac{1}{\left(1-\alpha_0-\beta_0\right)^2} - V^m p.\end{aligned}$$

Substituting $V^m = \dfrac{V^a}{\left(p-q\right)\left(1-\alpha_0-\beta_0\right)}\dfrac{1}{\left(1+\ln\left(s/V^m\right)\right)}$, the derivative becomes

$$\frac{d\,\text{prob}(m_H|B)s}{d\alpha_0} = s\frac{V^a}{(p-q)V^m}\frac{1}{(1-\alpha_0-\beta_0)^2} - V^m p$$
$$= s\frac{\left(1+\ln\left(s/V^m\right)\right)}{(1-\alpha_0-\beta_0)} - V^m p > 0,$$

where the last inequality follows from

$$s > V^m \Rightarrow 0 < p < 1+\ln\left(s/V^m\right) < \frac{1+\ln\left(s/V^m\right)}{(1-\alpha_0-\beta_0)}.$$

$\frac{d\,\text{prob}(m_H|B)s}{d\beta_0}$ > 0 follows immediately from $\frac{ds}{d\beta_0} > 0$ and $\frac{d\,\text{prob}(m_H|B)}{d\beta_0} > 0$.

To prove $\frac{d\,\text{prob}(m_H|B)s}{d\delta} < 0$, recall that the expected cost

$$\text{prob}(m_H)s(m_H) = s - \left(p\alpha_0 + (1-p)(1-\beta_0) + \delta\right)V^m.$$

ln(s) does not depend on δ, so $\frac{ds}{d\delta}$ = 0. Therefore,

$$\frac{d\,\text{prob}(m_H|B)s}{d\delta} = \underbrace{\frac{ds}{d\delta}}_{=0} - V^m = -V^m < 0.$$

Now consider B = 0. The optimal bonus is

$$s = \bar{V}^m \equiv \frac{V^a}{(p-q)(1-\alpha_0-\beta_0)},$$

which is independent of δ. Therefore, the expected compensation strictly decreases in δ because prob(m_H) decreases in δ.

(ii) Total welfare is

$$\text{TW} = \begin{cases} E[x] - V^a & \text{if } B = 0, \\ E[x] - V^a - \left(p\alpha_0 + (1-p)(1-\beta_0) + \delta\right)V^m \ln\left(\frac{s}{V^m}\right) & \text{if } B > 0. \end{cases}$$

If B = 0, TW depends on neither α_0, β_0, and δ.

If B > 0 then

$$\text{TW} = E[x] - V^a - \left(p\alpha_0 + (1-p)(1-\beta_0) + \delta\right)V^m \ln\left(\frac{s}{V^m}\right).$$

Derivation of TW with respect to α_0 yields

$$\frac{d\text{TW}}{d\alpha_0} = -pV^m \ln\left(\frac{s}{V^m}\right) - \text{prob}(y_L)V^m \frac{1}{s}\underbrace{\frac{ds}{d\alpha_0}}_{>0} < 0.$$

Derivation of TW with respect to β_0 results in

$$\begin{aligned}
\frac{d\text{TW}}{d\beta_0} &= (1-p)V^m \ln\left(\frac{s}{V^m}\right) - \text{prob}(y_L)V^m \frac{1}{s}\frac{ds}{d\beta_0} \\
&= (1-p)V^m \ln\left(\frac{s}{V^m}\right) - \text{prob}(y_L)V^m \frac{V^a}{V^m(p-q)(1-\alpha_0-\beta_0)^2} \\
&= (1-p)V^m \ln\left(\frac{s}{V^m}\right) - \text{prob}(y_L)\frac{V^m\left(1+\ln\left(\frac{s}{V^m}\right)\right)}{(1-\alpha_0-\beta_0)} \\
&= V^m \ln\left(\frac{s}{V^m}\right)\left[(1-p) - \frac{\text{prob}(y_L)}{(1-\alpha_0-\beta_0)}\right] - \frac{\text{prob}(y_L)V^m}{(1-\alpha_0-\beta_0)} \\
&= V^m \ln\left(\frac{s}{V^m}\right)\left[\frac{(1-p)(1-\alpha_0-\beta_0) - (p\alpha_0 + (1-p)(1-\beta_0) + \delta)}{(1-\alpha_0-\beta_0)}\right] - \frac{\text{prob}(y_L)V^m}{(1-\alpha_0-\beta_0)} \\
&= V^m \ln\left(\frac{s}{V^m}\right)\left[\frac{-\alpha_0-\delta}{(1-\alpha_0-\beta_0)}\right] - \frac{\text{prob}(y_L)V^m}{(1-\alpha_0-\beta_0)} < 0.
\end{aligned}$$

Finally, differentiating TW with respect to δ yields $\frac{d\text{TW}}{d\delta} = -V^m \ln\left(\frac{s}{V^m}\right) < 0$ because $\frac{ds}{d\delta} = 0$. □

Proof of Proposition 3

Consider $B > 0$. Using $b_L = 1 - \frac{V^m}{s}$, EQ is

$$\begin{aligned}
\text{EQ} &= p(1+\alpha(b_L-1)) + (1-p)(1-\beta)(1-b_L) \\
&= p\left(1-\alpha\frac{V^m}{s}\right) + (1-p)(1-\beta)\frac{V^m}{s} \\
&= p + \frac{V^m}{s}((1-p)(1-\beta) - p\alpha) \\
&= p + \frac{V^m}{s}((1-p)(1-\beta_0) - p\alpha_0 + (1-2p)\delta).
\end{aligned}$$

The total derivatives are

$$\frac{d\text{EQ}}{d\alpha_0} = \frac{V^m}{s^2} \underbrace{\frac{ds}{d\alpha_0}}_{>0} \big(p\alpha - (1-p)(1-\beta) \big) - \frac{V^m}{s} p$$

$$\frac{d\text{EQ}}{d\beta_0} = \frac{V^m}{s^2} \underbrace{\frac{ds}{d\beta_0}}_{>0} \big(p\alpha - (1-p)(1-\beta) \big) - \frac{V^m}{s} (1-p).$$

We show in the proof or Proposition 2 that $\frac{ds}{d\alpha_0} = \frac{ds}{d\beta_0} > 0$. The sign of the two derivatives is indeterminate and depends on the sign of $p\alpha - (1-p)(1-\beta)$ and the relative value of the first and second term.

The total derivative with respect to δ is

$$\frac{d\text{EQ}}{d\delta} = \frac{V^m}{s}(1-2p)$$

because $\frac{ds}{d\delta} = 0$. Therefore, the sign of $\frac{d\text{EQ}}{d\delta}$ is positive if $p < 0.5$ and negative if $p > 0.5$.

For $B = 0$, EQ is equal to

$$\begin{aligned} \text{EQ} &= p(1-\alpha) + (1-p)(1-\beta) \\ &= 1 - p\alpha_0 - (1-p)\beta_0 + (1-2p)\delta, \end{aligned}$$

and $\frac{d\text{EQ}}{d\alpha_0} < 0$, $\frac{d\text{EQ}}{d\beta_0} < 0$, and $\frac{d\text{EQ}}{d\delta} > 0$ if $(1-2p) > 0$ follows immediately. □

Proof of Proposition 4

$$\begin{aligned} \text{prob}(m_H \,|\, \varepsilon, B) &= 1 - \text{prob}(y_L \,|\, \varepsilon)(1 - b_L) \\ & 1 - (1-p)\exp(-B) - \big(p\alpha_0 - (1-p)\beta_0\big)\exp(-\varepsilon)\exp(-B) \\ &= 1 - (1-p)\frac{V^m}{s} - \big(p\alpha_0 - (1-p)\beta_0\big)\exp(-\varepsilon)\frac{V^m}{s} \end{aligned}$$

and

$$\text{prob}(y_L \,|\, \varepsilon) = (1-p) + \big(p\alpha_0 - (1-p)\beta_0\big)\exp(-\varepsilon).$$

The manager's expected utility under the optimal B is

$$\begin{aligned} E[U^M \,|\, a_H, \varepsilon, B] &= \left(1 - (1-p)\frac{V^m}{s} - \big(p\alpha_0 - (1-p)\beta_0\big)\exp(-\varepsilon)\frac{V^m}{s} \right) s - V^a - V^\varepsilon \varepsilon \\ & - \Big((1-p) + \big(p\alpha_0 - (1-p)\beta_0\big)\exp(-\varepsilon)\Big) V^m \ln\big(s/V^m\big). \end{aligned}$$

$$\frac{\partial}{\partial \varepsilon} E[U^M | a_H, \varepsilon, B] = \left(p\alpha_0 - (1-p)\beta_0 \right) \exp(-\varepsilon) V^m + \left(p\alpha_0 - (1-p)\beta_0 \right) \exp(-\varepsilon) V^m \ln(s/V^m) - V^\varepsilon = 0$$

$$\left(p\alpha_0 - (1-p)\beta_0 \right) V^m \left[1 + \ln(s/V^m) \right] \exp(-\varepsilon) = V^\varepsilon .$$

This expression has a solution with $\varepsilon > 0$ if $p\alpha_0 - (1-p)\beta_0 > 0$ and if

$$\left(p\alpha_0 - (1-p)\beta_0 \right) V^m \left[1 + \ln(s/V^m) \right] > V^\varepsilon ,$$

which is the above expression substituting for $\varepsilon = 0$ because $\exp(-\varepsilon) \leq 1$. Otherwise, $\varepsilon = 0$.

The optimal ε is

$$\exp(-\varepsilon) = \frac{V^\varepsilon}{\left(p\alpha_0 - (1-p)\beta_0 \right) V^m \left[1 + \ln(s/V^m) \right]}$$

$$\varepsilon = \ln\left(\frac{\left(p\alpha_0 - (1-p)\beta_0 \right) V^m \left[1 + \ln(s/V^m) \right]}{V^\varepsilon} \right).$$

It is easy to see that ε increases in $p\alpha_0 - (1-p)\beta_0$, decreases in V^ε, and it increases in V^m for constant s because for $s > V^m$,

$$\frac{\partial\left(V^m \left[1 + \ln(s/V^m) \right] \right)}{\partial V^m} = \left[1 + \ln(s/V^m) \right] - V^m \frac{V^m}{s} \frac{s}{(V^m)^2} = \ln\left(\frac{s}{V^m} \right) > 0 . \qquad \square$$

Proof of Proposition 5

The incentive compatibility constraint implies that in order to induce the manager to exert effort a_H, the contract must promise an expected utility strictly greater than that for effort a_L. As in the benchmark setting, the expected utility for a_L is always nonnegative because the manager can choose a_L, $\varepsilon = 0$, and $B = 0$, so he bears no effort cost and receives positive expected compensation. Moreover, sequential rationality is ensured because, after observing y, the costs of productive and IC effort are sunk and the manager can still choose $B = 0$ and expect a positive expected utility, which is greater than the reservation utility. Since earnings management is chosen if it is advantageous, the manager's expected utility for a_L is clearly nonnegative and fulfills the participation constraint with reservation utility zero. It follows that if the contract satisfies incentive compatibility, it also satisfies the participation constraint.

Case 1: Using

$$\text{prob}(m_H | \varepsilon, B) = 1 - \frac{(1-p)V^m}{s} - \frac{V^\varepsilon}{s\left(1+\ln(s/V^m)\right)}$$

$$\text{prob}(y_L | \varepsilon) = (1-p) + \frac{V^\varepsilon}{V^m\left[1+\ln(s/V^m)\right]},$$

the manager's expected utility is

$$\begin{aligned}
E[U^M | a_H] &= \text{prob}(m_H | \varepsilon, B)s - V^a - V^\varepsilon \varepsilon - \text{prob}(y_L | \varepsilon)V^m B \\
&= s - (1-p)V^m - \frac{V^\varepsilon}{1+\ln(s/V^m)} - V^a - V^\varepsilon \varepsilon - V^m\left((1-p) + \frac{V^\varepsilon}{V^m\left[1+\ln(s/V^m)\right]}\right)\ln(s/V^m) \\
&= s - (1-p)V^m\left(1+\ln(s/V^m)\right) - V^a - V^\varepsilon\left(1+\varepsilon\right) \\
&= s - (1-p)V^m\left(1+\ln(s/V^m)\right) - V^a - V^\varepsilon\left(1+\ln\left(\frac{\left(p\alpha_0 - (1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)\right).
\end{aligned}$$

If $q\alpha_0 - (1-q)\beta_0 > 0$ then the manager would choose $\varepsilon > 0$ if he deviates to a_L (out-of-equilibrium strategy). Therefore, $E[U^M | a_L]$ is structurally similar to $E[U^M | a_H]$, replacing q for p,

$$E[U^M | a_L] = s - (1-q)V^m\left(1+\ln(s/V^m)\right) - V^\varepsilon\left(1+\ln\left(\frac{\left(q\alpha_0 - (1-q)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)\right).$$

The incentive compatibility constraint $E[U^M | a_H] \geq E[U^M | a_L]$ is

$$\begin{aligned}
&\left(p-q\right)V^m\left(1+\ln(s/V^m)\right) - \\
&\quad V^\varepsilon\left[\ln\left(\frac{\left(p\alpha_0 - (1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right) - \ln\left(\frac{\left(q\alpha_0 - (1-q)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)\right] \geq V^a
\end{aligned}$$

$$\left(p-q\right)V^m\left(1+\ln(s/V^m)\right) - V^\varepsilon \ln\left(\frac{p\alpha_0 - (1-p)\beta_0}{q\alpha_0 - (1-q)\beta_0}\right) \geq V^a$$

and

$$\ln(s) \geq \frac{V^a}{\left(p-q\right)V^m} + \frac{V^\varepsilon}{\left(p-q\right)V^m}\ln\left(\frac{p\alpha_0 - (1-p)\beta_0}{q\alpha_0 - (1-q)\beta_0}\right) - 1 + \ln(V^m).$$

The owner's program is

$$\min_s \text{prob}(m_H)s = s - (1-p)V^m - \frac{V^\varepsilon}{1+\ln(s/V^m)}$$

subject to $\ln(s) \geq \frac{V^a}{(p-q)V^m} + \frac{V^\varepsilon}{(p-q)V^m} \ln\left(\frac{p\alpha_0 - (1-p)\beta_0}{q\alpha_0 - (1-q)\beta_0} \right) - 1 + \ln(V^m)$.

The objective function increases in *s* because

$$\frac{\partial}{\partial s}\left(\frac{V^\varepsilon}{1+\ln\left(s/V^m\right)} \right) = -\left(\frac{V^\varepsilon}{\left(1+\ln\left(s/V^m\right)\right)^2} \right)\frac{1}{s} < 0 .$$

Hence, the optimal *s* is determined by the incentive constraint, assuming that ε and *B* are interior solutions.

Case 2: If $\varepsilon > 0$ and $q\alpha_0 - (1-q)\beta_0 < 0$ then the out-of-equilibrium IC effort in case the manager chose a_L is $\varepsilon(a_L) = 0$. The incentive compatibility constraint becomes

$$E[U^M | a_H] = s - (1-p)V^m\left(1+\ln(s/V^m)\right) - V^a - V^\varepsilon\left(1+\ln\left(\frac{\left(p\alpha_0 - (1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)\right)$$
$$\geq E[U^M | a_L, \varepsilon = 0] = s - \left(q\alpha_0 + (1-q)(1-\beta_0)\right)\left(1+\ln(s/V^m)\right)V^m.$$

Equating this condition determines the minimal *s*, which implicitly defines the optimal *s*,

$$V^m\left(1+\ln\left(s/V^m\right)\right)\left(p - q + q\alpha_0 - (1-q)\beta_0\right) - V^\varepsilon \ln\left(\frac{\left(p\alpha_0 - (1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right) = V^a + V^\varepsilon .$$

Using

$$\begin{aligned} p - q + q\alpha_0 - (1-q)\beta_0 &= p - q + (q + p - p)\alpha_0 - (1 - q + p - p)\beta_0 \\ &= (p-q)(1-\alpha_0-\beta_0) + p\alpha_0 - (1-p)\beta_0 \end{aligned}$$

and rearranging leads to

$$\begin{aligned} &V^m\left(1+\ln(s/V^m)\right)\left[(p-q)(1-\alpha_0-\beta_0) + p\alpha_0 - (1-p)\beta_0\right] \\ &\qquad - V^\varepsilon \ln\left(\frac{V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right) = V^a + V^\varepsilon + V^\varepsilon \ln\left(p\alpha_0 - (1-p)\beta_0\right) \end{aligned}$$

or

$$\begin{aligned} M(s) \equiv\ &V^m\left(1+\ln(s/V^m)\right)\left[p - q(1-\alpha_0-\beta_0) - \beta_0\right] \\ &\qquad - V^\varepsilon\left[1+\ln\left(\frac{V^m\left[1+\ln(s/V^m)\right](p\alpha_0 - (1-p)\beta_0)}{V^\varepsilon}\right)\right] - V^a = 0. \end{aligned}$$

There is no explicit solution to this equation for *s*.

Case 3 has been shown in Proposition 1. □

Proof of Proposition 6

Assume $B > 0$ first.

Case 1: The optimal bonus is defined by

$$V^m\left(1+\ln\left(s/V^m\right)\right)=\frac{V^a}{(p-q)}+\frac{V^\varepsilon}{(p-q)}\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right).$$

Inserting this into the first-order condition for ε,

$$\left(p\alpha_0-(1-p)\beta_0+\delta\right)V^m\left[1+\ln\left(s/V^m\right)\right]\exp(-\varepsilon)=V^\varepsilon,$$

yields

$$\left(p\alpha_0-(1-p)\beta_0+\delta\right)\left[\frac{V^a}{(p-q)}+\frac{V^\varepsilon}{(p-q)}\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]\exp(-\varepsilon)=V^\varepsilon$$

$$\underbrace{\left(p\alpha_0-(1-p)\beta_0+\delta\right)\left[V^a+V^\varepsilon\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]}_{\equiv L}=\exp(\varepsilon)(p-q)V^\varepsilon.$$

Then $\operatorname{sign}\left(\frac{d\varepsilon}{d\delta}\right)=\operatorname{sign}\left(\frac{\partial L}{\partial\delta}\right)$. We have

$$\begin{aligned}\frac{\partial L}{\partial\delta}&=\left[V^a+V^\varepsilon\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]\\&\quad-\left(p\alpha_0-(1-p)\beta_0+\delta\right)V^\varepsilon\frac{(p-q)(\alpha_0+\beta_0)}{\left(p\alpha_0-(1-p)\beta_0+\delta\right)\left(q\alpha_0-(1-q)\beta_0+\delta\right)}\\&=\left[V^a+V^\varepsilon\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]-(\alpha_0+\beta_0)\frac{(p-q)V^\varepsilon}{\left(q\alpha_0-(1-q)\beta_0+\delta\right)}.\end{aligned}$$

The first-order condition for $\varepsilon(a_L)$ implies

$$\left(q\alpha_0-(1-q)\beta_0+\delta\right)\left[V^a+V^\varepsilon\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]=\exp\left(\varepsilon\left(a_L\right)\right)(p-q)V^\varepsilon$$

$$\Rightarrow\frac{(p-q)V^\varepsilon}{\left(q\alpha_0-(1-q)\beta_0+\delta\right)}=\left[V^a+V^\varepsilon\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]\exp\left(-\varepsilon(a_L)\right).$$

Inserting this expression into the derivative yields

$$\frac{\partial L}{\partial \delta}=\left[V^{a}+V^{\varepsilon}\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]-(\alpha_0+\beta_0)\frac{(p-q)V^{\varepsilon}}{\left(q\alpha_0-(1-q)\beta_0+\delta\right)}$$
$$=\left[V^{a}+V^{\varepsilon}\ln\left(\frac{p\alpha_0-(1-p)\beta_0+\delta}{q\alpha_0-(1-q)\beta_0+\delta}\right)\right]\underbrace{\left[1-(\alpha_0+\beta_0)\exp\left(-\varepsilon(a_L)\right)\right]}_{>0}>0.$$

The inequality follows from $\alpha_0+\beta_0\leq 1$ and $\exp\left(-\varepsilon(a_L)\right)<1$ for $\varepsilon(a_L)>0$, and therefore $\frac{d\varepsilon}{d\delta}>0$.

Case 2: The first-order condition for ε is the same as in case 1, but there is no explicit expression for ε because the IC constraint yields an implicit equation for *s*. Consider the first-order condition for ε in the form

$$\underbrace{\left(p\alpha_0-(1-p)\beta_0+\delta\right)V^{m}\left[1+\ln\left(s/V^{m}\right)\right]}_{\equiv L}=\exp(\varepsilon)V^{\varepsilon}.$$

Differentiating *L* with respect to δ gives

$$\frac{dL}{d\delta}=V^{m}\left[1+\ln\left(s/V^{m}\right)\right]+\left(p\alpha_0-(1-p)\beta_0+\delta\right)\frac{V^{m}}{s}\frac{ds}{d\delta}$$
$$=V^{m}\left[1+\ln\left(s/V^{m}\right)\right]+\left(p\alpha_0-(1-p)\beta_0+\delta\right)\frac{V^{m}}{s}\left(-\left(\frac{\partial M(s,\delta)}{\partial\delta}\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1}\right).$$

Using $\frac{\partial M(s,\delta)}{\partial\delta}=V^{m}\left(1+\ln\left(s/V^{m}\right)\right)-\frac{V^{\varepsilon}}{p\alpha_0-(1-p)\beta_0+\delta}$, the derivative of *L* becomes

$$\frac{dL}{d\delta}=V^{m}\left[1+\ln\left(s/V^{m}\right)\right]+\frac{V^{m}}{s}\left(V^{\varepsilon}-\left(p\alpha_0-(1-p)\beta_0+\delta\right)V^{m}\left[1+\ln\left(s/V^{m}\right)\right]\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1}$$
$$=V^{m}\left[1+\ln\left(s/V^{m}\right)\right]+\frac{V^{m}}{s}V^{\varepsilon}\left(1-\exp(\varepsilon)\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1}.$$

Note that

$$\frac{\partial M(s,\delta)}{\partial s} = \frac{V^m}{s}\left((p-q)(1-\alpha_0-\beta_0)+p\alpha_0-(1-p)\beta_0+\delta\right)-\frac{V^\varepsilon}{\left(1+\ln\left(s/V^m\right)\right)}\frac{1}{s}$$

$$= \frac{1}{\left(1+\ln\left(s/V^m\right)\right)s}\left(V^m\left(1+\ln\left(s/V^m\right)\right)\left((p-q)(1-\alpha_0-\beta_0)+p\alpha_0-(1-p)\beta_0+\delta\right)-V^\varepsilon\right)$$

$$= \frac{1}{\left(1+\ln\left(s/V^m\right)\right)s}\left(V^a+V^\varepsilon\ln\left(\frac{\left(p\alpha_0-(1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)\right)$$

$$= \frac{1}{\left(1+\ln\left(s/V^m\right)\right)s}\left(V^a+V^\varepsilon\varepsilon\right)>0.$$

Inserting this expression into the derivative yields

$$\frac{dL}{d\delta}=\frac{V^m\left[1+\ln\left(s/V^m\right)\right]}{\left(V^a+V^\varepsilon\varepsilon\right)}\left[V^a+V^\varepsilon\varepsilon+V^\varepsilon\left(1-\exp\left(\varepsilon\right)\right)\right].$$

The first-order condition for ε implies

$$\left(p\alpha_0-(1-p)\beta_0+\delta\right)V^m\left[1+\ln\left(s/V^m\right)\right]=\exp\left(\varepsilon\right)V^\varepsilon,$$

and the IC constraint becomes

$$V^m\left(1+\ln\left(s/V^m\right)\right)\left((p-q)(1-\alpha_0-\beta_0)+p\alpha_0-(1-p)\beta_0+\delta\right)-V^\varepsilon=V^a+V^\varepsilon\varepsilon.$$

Inserting in $dL/d\delta$ yields

$$\frac{dL}{d\delta}=\frac{V^m\left[1+\ln\left(s/V^m\right)\right]}{\left(V^a+V^\varepsilon\varepsilon\right)}\left[V^m\left(1+\ln\left(s/V^m\right)\right)(p-q)(1-\alpha_0-\beta_0)\right]>0,$$

which implies $\frac{d\varepsilon}{d\delta}>0$.

Next, we prove the same result for the case of no earnings management (B = 0). The manager's expected utility reduces to

$$E[U^M\,|a_H,\varepsilon]=\text{prob}(m_H\,|\varepsilon)s-V^a-V^\varepsilon\varepsilon-\underbrace{\text{prob}(y_L\,|\varepsilon)V^mB}_{=0}$$

$$=\left(p-\left(p\alpha_0-(1-p)\beta_0+\delta\right)\exp(-\varepsilon)\right)s-V^a-V^\varepsilon\varepsilon.$$

The first-order condition for the optimal ε is

$$\left(p\alpha_0-(1-p)\beta_0+\delta\right)\exp(-\varepsilon)s=V^\varepsilon.$$

Inserting this expression into the manager's utility, we obtain

$$E[U^M | a_H, \varepsilon] = ps - V^a - V^\varepsilon (1+\varepsilon),$$

so the optimal $\varepsilon = \ln\left(\frac{(p\alpha_0 - (1-p)\beta_0 + \delta)s}{V^\varepsilon}\right)$.

Case 1: $\varepsilon > 0$ for both a_H and a_L: Rewriting

$$E[U^M | a_H, \varepsilon] = ps - V^a - V^\varepsilon (1+\varepsilon) \geq E[U^M | a_L, \varepsilon(a_L)] = qs - V^\varepsilon (1+\varepsilon(a_L))$$

yields

$$s = \frac{V^a}{(p-q)} + \frac{V^\varepsilon}{(p-q)}(\varepsilon - \varepsilon(a_L)) = \frac{V^a}{(p-q)} + \frac{V^\varepsilon}{(p-q)} \ln\left(\frac{p\alpha_0 - (1-p)\beta_0 + \delta}{q\alpha_0 - (1-q)\beta_0 + \delta}\right).$$

Inserting this s into the first-order condition for ε results in

$$(p\alpha_0 - (1-p)\beta_0 + \delta)\left[\frac{V^a}{(p-q)} + \frac{V^\varepsilon}{(p-q)} \ln\left(\frac{p\alpha_0 - (1-p)\beta_0 + \delta}{q\alpha_0 - (1-q)\beta_0 + \delta}\right)\right] \exp(-\varepsilon) = V^\varepsilon,$$

which is the same expression as with positive earnings management. Therefore, $\frac{d\varepsilon}{d\delta} > 0$.

Case 2: $\varepsilon > 0$ for a_H but $\varepsilon = 0$ for a_L. The incentive compatibility constraint is

$$E[U^M | a_H, \varepsilon] = ps - V^a - V^\varepsilon (1+\varepsilon) \geq E[U^M | a_L] = \left(q - (q\alpha_0 - (1-q)\beta_0 + \delta)\right)s,$$

which reduces to

$$M(s,\delta) \equiv s\left[p - q(1-\alpha_0-\beta_0) - \beta_0 + \delta\right] - V^\varepsilon (1+\varepsilon) - V^a = 0.$$

The first-order condition for ε yields

$$\underbrace{(p\alpha_0 - (1-p)\beta_0 + \delta)s}_{\equiv L} = \exp(\varepsilon) V^\varepsilon.$$

$$\begin{aligned}\frac{dL}{d\delta} &= s + (p\alpha_0 - (1-p)\beta_0 + \delta)\frac{ds}{d\delta} \\ &= s + (p\alpha_0 - (1-p)\beta_0 + \delta)\left(-\left(\frac{\partial M(s,\delta)}{\partial \delta}\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1}\right).\end{aligned}$$

Using $\frac{\partial M(s,\delta)}{\partial \delta} = s - \frac{V^\varepsilon}{p\alpha_0 - (1-p)\beta_0 + \delta} > 0$ leads to

$$\frac{dL}{d\delta} = s + \left(V^{\varepsilon} - s\left(p\alpha_0 - (1-p)\beta_0 + \delta\right)\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1} = s + V^{\varepsilon}\left(1 - \exp(\varepsilon)\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1}.$$

Inserting

$$\frac{\partial M(s,\delta)}{\partial s} = \left[p - q(1-\alpha_0-\beta_0) - \beta_0 + \delta\right] - V^{\varepsilon}\frac{1}{s} = \frac{1}{s}\left(V^a + V^{\varepsilon}(1+\varepsilon)\right) - V^{\varepsilon}\frac{1}{s}$$
$$= \frac{1}{s}\left(V^a + V^{\varepsilon}\varepsilon\right)$$

into the derivative yields

$$\frac{dL}{d\delta} = s + V^{\varepsilon}\left(1-\exp(\varepsilon)\right)\left(\frac{\partial M(s,\delta)}{\partial s}\right)^{-1} = s + \frac{s}{\left(V^a + V^{\varepsilon}\varepsilon\right)}V^{\varepsilon}\left(1-\exp(\varepsilon)\right)$$
$$= \frac{s}{\left(V^a + V^{\varepsilon}\varepsilon\right)}\left[V^a + V^{\varepsilon}(1+\varepsilon) - V^{\varepsilon}\exp(\varepsilon)\right].$$

Substituting $M(s, \delta)$ for $V^a + V^{\varepsilon}(1+\varepsilon)$ and L for $V^{\varepsilon}\exp(\varepsilon)$ results in

$$\frac{dL}{d\delta} = \frac{s}{\left(V^a + V^{\varepsilon}\varepsilon\right)}\left[s\left(p - q(1-\alpha_0-\beta_0) - \beta_0 + \delta\right) - \left(p\alpha_0 - (1-p)\beta_0 + \delta\right)s\right]$$
$$= \frac{s^2}{\left(V^a + V^{\varepsilon}\varepsilon\right)}\left[(p-q)(1-\alpha_0-\beta_0)\right] > 0,$$

implying $\frac{d\varepsilon}{d\delta} > 0$. □

Proof of Proposition 7

(i) Case 1: The optimal s is

$$\ln(s) = \frac{V^a}{(p-q)V^m} + \frac{V^{\varepsilon}}{(p-q)V^m}\left[\ln\left(p\alpha_0 - (1-p)\beta_0 + \delta\right) - \ln\left(q\alpha_0 - (1-q)\beta_0 + \delta\right)\right] - 1 + \ln(V^m).$$

Totally differentiating this expression with respect to δ yields

$$\frac{ds}{d\delta} = s\frac{V^{\varepsilon}}{(p-q)V^m}\left[\frac{(q-p)(\alpha_0+\beta_0)}{\left(p\alpha_0 - (1-p)\beta_0 + \delta\right)\left(q\alpha_0 - (1-q)\beta_0 + \delta\right)}\right]$$
$$= -s\frac{V^{\varepsilon}}{V^m}\left[\frac{(\alpha_0+\beta_0)}{\left(p\alpha_0 - (1-p)\beta_0 + \delta\right)\left(q\alpha_0 - (1-q)\beta_0 + \delta\right)}\right] < 0,$$

which implies that the optimal bonus decreases in greater conservatism δ. The effect on firm value FV is determined by the change of the expected compensation,

$$\text{prob}(m_H)s = s-(1-p)V^m - \frac{V^\varepsilon}{1+\ln(s/V^m)}.$$

The first-order derivative with respect to δ is

$$\frac{d\,\text{prob}(m_H)s}{d\delta} = \underbrace{\frac{ds}{d\delta}}_{<0}\underbrace{\left(1+\frac{V^\varepsilon}{s\left(1+\ln\left(s/V^m\right)\right)^2}\right)}_{>1} < 0.$$

Case 2: The change of *s* by increasing δ is given by

$$\frac{ds}{d\delta} = -\left(\frac{\partial M\left(s,\delta\right)}{\partial\delta}\right)\left(\frac{\partial M\left(s,\delta\right)}{\partial s}\right)^{-1},$$

where the incentive compatibility constraint for productive effort $M(s, \delta)$ is

$$M(s,\delta) = V^m\left(1+\ln\left(s/V^m\right)\right)\left(\left(p-q\right)\left(1-\alpha_0-\beta_0\right)+p\alpha_0-\left(1-p\right)\beta_0+\delta\right)$$
$$-V^\varepsilon\ln\left(\frac{\left(p\alpha_0-(1-p)\beta_0+\delta\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)-V^a-V^\varepsilon = 0.$$

$$\frac{\partial M\left(s,\delta\right)}{\partial\delta} = V^m\left(1+\ln(s/V^m)\right)-\frac{V^\varepsilon}{p\alpha_0-\left(1-p\right)\beta_0+\delta} > 0.$$

The inequality follows from the manager's first order condition for the AQ effort which is

$$\left(p\alpha_0-\left(1-p\right)\beta_0+\delta\right)V^m\left(1+\ln\left(s/V^m\right)\right)\exp\left(-\varepsilon\right) = V^\varepsilon,$$

noting that $\exp(-\varepsilon) < 1$ for $\varepsilon > 0$. Therefore,

$$\frac{ds}{d\delta} = -\left(\frac{\partial M\left(s,\delta\right)}{\partial\delta}\right)\left(\frac{\partial M\left(s,\delta\right)}{\partial s}\right)^{-1} < 0$$

because $\frac{\partial M\left(s,\delta\right)}{\partial s} > 0$ (see proof of Proposition 6).

Expected compensation is

$$\text{prob}\left(m_H\right)s = s-\left(1-p\right)V^m-\frac{V^\varepsilon}{1+\ln\left(s/V^m\right)}$$

which decreases in δ since *s* decreases in δ.

(ii) With positive IC effort, total welfare is

$$\begin{aligned}\text{TW} &= \mathrm{E}\left[U^O \left| a_H \right.\right] + \mathrm{E}\left[U^M \left| a_H \right.\right] \\ &= \mathrm{E}[x] - \text{prob}(m_H)s + \text{prob}(m_H)s - V^a - V^\varepsilon \varepsilon - V^m \text{prob}\left(y_L \left| a_H, \delta, \varepsilon\right.\right)\ln\left(s/V^m\right) \\ &= \mathrm{E}[x] - V^a - V^\varepsilon \varepsilon - V^m \text{prob}\left(y_L \left| a_H, \delta, \varepsilon\right.\right)\ln\left(s/V^m\right).\end{aligned}$$

In cases 1 and 2,

$$\begin{aligned}\text{prob}\left(y_L \left| a_H, \delta, \varepsilon\right.\right) &= (1-p) + \left(p\alpha_0 - (1-p)\beta_0 + \delta\right)\exp(-\varepsilon) \\ &= (1-p) + \frac{V^\varepsilon}{V^m\left(1+\ln\left(s/V^m\right)\right)},\end{aligned}$$

which increases in δ because s decreases in δ. Expected earnings management,

$$\text{prob}\left(y_L \left| a_H, \delta, \varepsilon\right.\right)\ln\left(s/V^m\right) = (1-p)\ln\left(s/V^m\right) + \frac{V^\varepsilon}{V^m}\left[\frac{\ln\left(s/V^m\right)}{1+\ln\left(s/V^m\right)}\right],$$

decreases in δ because

$$\begin{aligned}\frac{d\left(\text{prob}\left(y_L \left| a_H, \delta, \varepsilon\right.\right)\ln\left(s/V^m\right)\right)}{d\delta} &= (1-p)\frac{1}{s}\frac{ds}{d\delta} + \frac{V^\varepsilon}{V^m}\left(\frac{\frac{1}{s}\frac{ds}{d\delta}\left(1+\ln\left(s/V^m\right)\right) - \ln\left(s/V^m\right)\frac{1}{s}\frac{ds}{d\delta}}{\left(1+\ln\left(s/V^m\right)\right)^2}\right) \\ &= \frac{1}{s}\underbrace{\frac{ds}{d\delta}}_{<0}\left((1-p) + \frac{1}{\left(1+\ln\left(s/V^m\right)\right)^2}\right) < 0.\end{aligned}$$

Thus, the reduction of the bias overcompensates the greater probability of y_L. However, ε strictly increases in δ, which reduces welfare due to larger cost of exerting ε. The net effect of increasing δ on welfare is indeterminate and depends on parameters. □

Proof of Corollary 2

A variation of α_0 and β_0 has different effects in the three cases in Proposition 5. All else equal, increasing α_0 from 0 moves the setting from case 3 to 2 and 1, whereas increasing β_0 moves the setting from case 1 to 2 and 3.

Case 1: The optimal s is

$$\ln(s) = \frac{V^a}{(p-q)V^m} + \frac{V^\varepsilon}{(p-q)V^m}\ln\left(\frac{p\alpha_0-(1-p)\beta_0}{q\alpha_0-(1-q)\beta_0}\right) - 1 + \ln(V^m)$$
$$= \frac{V^a}{(p-q)V^m} + \frac{V^\varepsilon}{(p-q)V^m}\left[\ln\left(p\alpha_0-(1-p)\beta_0\right) - \ln\left(q\alpha_0-(1-q)\beta_0\right)\right] - 1 + \ln(V^m).$$

Totally differentiating this expression with respect to α_0 yields

$$\frac{1}{s}\frac{ds}{d\alpha_0} = \frac{V^\varepsilon}{(p-q)V^m}\left[\frac{p}{p\alpha_0-(1-p)\beta_0} - \frac{q}{q\alpha_0-(1-q)\beta_0}\right]$$
$$= \frac{V^\varepsilon}{(p-q)V^m}\left[\frac{\beta_0(q-p)}{\left(p\alpha_0-(1-p)\beta_0\right)\left(q\alpha_0-(1-q)\beta_0\right)}\right] < 0$$

and $$\frac{ds}{d\alpha_0} = -s\frac{V^\varepsilon}{V^m}\left[\frac{\beta_0}{\left(p\alpha_0-(1-p)\beta_0\right)\left(q\alpha_0-(1-q)\beta_0\right)}\right] < 0.$$

The owner's expected compensation is

$$\text{prob}(m_H)s = s - (1-p)V^m - \frac{V^\varepsilon}{1+\ln(s/V^m)}.$$

The first derivative with respect to α_0 is

$$\frac{d\,\text{prob}(m_H)s}{d\alpha_0} = \underbrace{\frac{ds}{d\alpha_0}}_{<0} + \underbrace{\frac{V^\varepsilon}{s\left(1+\ln\left(s/V^m\right)\right)^2}}_{>0}\underbrace{\frac{ds}{d\alpha_0}}_{<0} < 0.$$

Therefore, the owner's expected utility increases in α_0.

A similar calculation yields the signs of the change of s for an increase in β_0,

$$\frac{ds}{d\beta_0} > 0 \text{ and } \frac{d\,\text{prob}(m_H)s}{d\beta_0} > 0.$$

In case 2 the optimal s is implicitly defined by the incentive compatibility constraint,

$$M(s,\alpha_0) \equiv V^m\left(1+\ln\left(s/V^m\right)\right)\left((p-q)(1-\alpha_0-\beta_0) + p\alpha_0 - (1-p)\beta_0\right)$$
$$-V^\varepsilon \ln\left(\frac{\left(p\alpha_0-(1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right) - V^a - V^\varepsilon = 0.$$

Let $\bar{\alpha}$ denote the boundary value for α_0 such that $\varepsilon = 0$ is the manager's optimal choice of IC effort, i.e.,

$$\left(p\bar{\alpha}-(1-p)\beta_0\right)V^m\left(1+\ln\left(s\left(\bar{\alpha}\right)/V^m\right)\right)\exp(0)=V^\varepsilon .$$

The incentive compatibility constraint at $\bar{\alpha}$ becomes $M\left(s=s\left(\bar{\alpha}\right),\bar{\alpha}\right)=0$, which is

$$V^m\left(1+\ln\left(s\left(\bar{\alpha}\right)/V^m\right)\right)\left(\left(p-q\right)\left(1-\alpha_0-\beta_0\right)\right)+V^\varepsilon-V^\varepsilon\ln\left(\frac{V^\varepsilon}{V^\varepsilon}\right)-V^a-V^\varepsilon=0$$

or
$$V^m\left(1+\ln\left(s\left(\bar{\alpha}\right)/V^m\right)\right)=\frac{V^a}{\left(p-q\right)\left(1-\alpha_0-\beta_0\right)}.$$

This equation is equivalent to the definition of s in case 3. Hence $s\left(\bar{\alpha}\right)$ satisfies the incentive compatibility constraint at $\bar{\alpha}$ if $\varepsilon > 0$ for a_H only, implying that $s(\alpha_0)$ is continuous at $\bar{\alpha}$. To determine the sign of

$$\frac{ds}{d\alpha_0}=-\left(\frac{\partial M\left(s,\alpha_0\right)}{\partial\alpha_0}\right)\left(\frac{\partial M\left(s,\alpha_0\right)}{\partial s}\right)^{-1},$$

recall that using $M\left(s,\alpha_0\right)=0$

$$\frac{\partial M\left(s,\alpha_0\right)}{\partial s}=\frac{1}{\left(1+\ln\left(s/V^m\right)\right)s}\left(V^a+V^\varepsilon\ln\left(\frac{\left(p\alpha_0-(1-p)\beta_0\right)V^m\left[1+\ln(s/V^m)\right]}{V^\varepsilon}\right)\right)>0.$$

Furthermore,

$$\frac{\partial M\left(s,\alpha_0\right)}{\partial\alpha_0}=-qV^m\left(1+\ln\left(s/V^m\right)\right)-V^\varepsilon\frac{p}{p\alpha_0-\left(1-p\right)\beta_0}<0.$$

Therefore, $\frac{ds}{d\alpha_0}>0$ for $\bar{\alpha}<\alpha<\hat{\alpha}$, where $\hat{\alpha}$ is the threshold α value when case 1 applies. $\hat{\alpha}$ is implicitly defined by

$$\left(q\hat{\alpha}-(1-q)\beta_0\right)V^m\left[1+\ln\left(s\left(\hat{\alpha}\right)/V^m\right)\right]=V^\varepsilon,$$

which is the IC effort choice condition at $\exp(-\varepsilon)\big|_{\varepsilon=0}=1$. Because $M\left(s,\alpha_0\right)$ only provides an implicit solution for $s(\hat{\alpha})$, the above threshold cannot be solved explicitly.

To complete the proof note that for α_0 in the range of $\bar{\alpha}<\alpha<\hat{\alpha}$, the owner's expected compensation cost is

$$\text{prob}\left(m_H\left|a_H\right.\right)s=s-\left(1-p\right)V^m-\frac{V^\varepsilon}{1+\ln\left(s/V^m\right)},$$

which strictly increases in *s* and therefore in α_0.

A similar approach provides the results for an increase in β_0,

$$\frac{ds}{d\beta_0} > 0 \text{ and } \frac{d\,\mathrm{prob}(m_H)s}{d\beta_0} > 0. \qquad \square$$

Proof of Proposition 8

If there is no earnings management then $B = 0$ and $b_L = 0$. There are the same three cases as with earnings management, depending on the signs of $\left(p\alpha_0 - (1-p)\beta_0 + \delta\right)$ and $\left(q\alpha_0 - (1-q)\beta_0 + \delta\right)$. The proof is similar to that of Proposition 4 with the only difference that we substitute *s* for $V^m\left[1+\ln\left(s/V^m\right)\right]$.

First, from Proposition 3 we know for $B = 0$ that in cases 1 and 2, $\frac{d\varepsilon}{d\delta} > 0$, and in case 3, $\frac{d\varepsilon}{d\delta} = 0$.

(i) Substituting ε from above, the owner's expected utility is

$$\begin{aligned} \mathrm{E}[x] - \mathrm{prob}(m_H|\varepsilon)s &= \mathrm{E}[x] - \left(p - \left(p\alpha_0 - (1-p)\beta_0 + \delta\right)\exp(-\varepsilon)\right)s \\ &= \mathrm{E}[x] + V^\varepsilon - ps. \end{aligned}$$

This expression strictly decreases in *s*. We show in Proposition 4 that $\frac{ds}{d\delta} \le 0$, thus more conservatism increases the owner's expected utility. This effect is strict for cases 1 and 2.

(ii) Total welfare is given by

$$\begin{aligned} \mathrm{E}\left[U^O|a_H\right] + \mathrm{E}\left[U^M|a_H\right] &= \mathrm{E}[x] - \mathrm{prob}(m_H)s + \mathrm{prob}(m_H)s - V^a - V^\varepsilon\varepsilon \\ &= \mathrm{E}[x] - V^a - V^\varepsilon\varepsilon. \end{aligned}$$

From $\frac{d\varepsilon}{d\delta} \ge 0$, welfare decreases in δ. $\square$

Proof of Proposition 9

Using $b_L = 1 - \frac{V^m}{s}$, earnings quality can be written as

$$\begin{aligned}\text{EQ} &= p\left(1+\alpha\left(b_L-1\right)\right)+\left(1-p\right)\left(1-\beta\right)\left(1-b_L\right)\\ &= p\left(1-\alpha\frac{V^m}{s}\right)+\left(1-p\right)\left(1-\beta\right)\frac{V^m}{s}\\ &= p+\frac{V^m}{s}\left(\left(1-p\right)\left(1-\beta\right)-p\alpha\right).\end{aligned}$$

Note that $\alpha=\left(\alpha_0+\delta\right)\exp\left(-\varepsilon\right)$ and $\beta=\left(\beta_0-\delta\right)\exp\left(-\varepsilon\right)$. Therefore, the change of EQ by increasing δ is

$$\begin{aligned}\frac{d\text{EQ}}{d\delta} &= -\frac{V^m}{s^2}\frac{ds}{d\delta}\left(\left(1-p\right)\left(1-\beta\right)-p\alpha\right)-\frac{V^m}{s}\left(\left(1-p\right)\frac{d\beta}{d\delta}+p\frac{d\alpha}{d\delta}\right)\\ &= -\frac{V^m}{s^2}\frac{ds}{d\delta}\left(\left(1-p\right)\left(1-\beta\right)-p\alpha\right)-\frac{V^m}{s}\left(\left(2p-1\right)\exp\left(-\varepsilon\right)-\left(p\alpha+\left(1-p\right)\beta\right)\frac{d\varepsilon}{d\delta}\right)\\ &= \underbrace{\frac{V^m}{s}\left(1-2p\right)\exp\left(-\varepsilon\right)}_{\equiv E_1}+\underbrace{\frac{V^m}{s^2}\frac{ds}{d\delta}\left(p\alpha-(1-p)(1-\beta)\right)}_{\equiv E_2}+\underbrace{\frac{V^m}{s}\left(p\alpha+\left(1-p\right)\beta\right)\frac{d\varepsilon}{d\delta}}_{\equiv E_3}.\end{aligned}$$

The sign of E_1 is independent of δ and depends only on p. If $p < 0.5$ the $E_1 > 0$ and if $p > 0.5$ then $E_1 < 0$.

We show earlier that $\frac{ds}{d\delta} < 0$ for $\varepsilon > 0$, which implies

$$E_2\begin{cases}=0 \text{ if } \varepsilon=0\\ >0 \text{ if } \varepsilon>0 \text{ and } p\alpha<\left(1-p\right)\left(1-\beta\right)\\ <0 \text{ if } \varepsilon>0 \text{ and } p\alpha>\left(1-p\right)\left(1-\beta\right).\end{cases}$$

$E_3 > 0$ if $\varepsilon > 0$ because $\frac{d\varepsilon}{d\delta} > 0$. □

Appendix B: Truth-telling contract

In this appendix, we sketch the analysis of a truth-telling contracting setting in which the owner requests the manager to report $\hat{y}$ after observing the actual *y*. Compensation can be based on $\hat{y}$ and *m*,

$$s_{ij} \equiv s(\hat{y}_i, m_j)\,,\ \ i, j \in \{L, H\}\,.$$

Applying the revelation principle, there is an outcome-equivalent contract that induces truth-telling ($\hat{y}_i = y_i$) and, therefore, prevents earnings management. Compensation must be higher for m_H than for m_L to induce the desired productive effort. Therefore, if the manager observes y_H, he has no incentive to report $\hat{y}_L$ and engage in earnings management to induce m_H. If the manager observes y_L and reports truthfully, then the compensation must be independent of m_j to prevent earnings management, i.e., $s(\hat{y}_L, m_L) = s(\hat{y}_L, m_H) \equiv s_L$. Furthermore, reporting y_L and receiving s_L must provide the agent the same net benefit as engaging in earnings management and possibly reporting y_H. Set $s(\hat{y}_H, m_L) = 0$, which is the lowest possible compensation in case of misreporting *y* and being unsuccessful in managing earnings upwards. Finally, let $s \equiv s(\hat{y}_H, m_H) > 0$.

If y_L occurs but $\hat{y}_H$ is reported, optimal earnings management is similar to that in the main analysis, i.e., $B_L(\hat{y}_H) = \ln\left(s/V^m\right)$, and the manager's net *ex post* utility given a report $\hat{y}_H$ is

$$\begin{aligned} b_L(\hat{y}_H)s - B_L(\hat{y}_H)V^m &= \left(1-\exp\left(-B_L(\hat{y}_H)\right)\right)s - \ln\left(s/V^m\right)V^m \\ &= \left(1-\frac{V^m}{s}\right)s - \ln\left(s/V^m\right)V^m \\ &= s - V^m\left(1+\ln\left(s/V^m\right)\right). \end{aligned}$$

The truth-inducing compensation for y_L is

$$s_L = s - V^m\left(1+\ln\left(s/V^m\right)\right),$$

where *s* is the compensation for m_H, which is again similar to that in the original contract with no reporting. The manager's expected compensation is

$$\left(1-\Pr(y_L)\right)s + \Pr(y_L)s_L = s - (s - s_L)\Pr(y_L) = s - V^m\left(1+\ln\left(s/V^m\right)\right)\Pr(y_L),$$

and the *ex ante* utility becomes

$$E\left[U^M \middle| a_H, \varepsilon, s, s_L\right] = s - V^m\left(1+\ln\left(s/V^m\right)\right)\Pr\left(y_L\right) - V^a - V^\varepsilon \varepsilon .$$

Substituting $\Pr\left(y_L\right) = (1-p) + \left(p\alpha_0 - (1-p)\beta_0\right)\exp(-\varepsilon)$ yields

$$E\left[U^M \middle| a_H, \varepsilon, s, s_L\right] = E\left[U^M \middle| a_H, \varepsilon, B\right],$$

i.e., the manager's *ex ante* utility under the truth-telling contract equals the utility for the contract with no reporting of *y* and earnings management. With a similar argument, it also follows for the low productive action a_L that $E\left[U^M \middle| a_L, \varepsilon, s, s_L\right] = E\left[U^M \middle| a_L, \varepsilon, B\right]$.

As a consequence, all results that are based on the characteristics of the manager's utility (in particular, optimal internal controls and incentive compatibility constraints) are structurally the same, implying that the related qualitative results from the original setting carry over to the truth-telling contract.

For the most interesting case of $\varepsilon > 0$, the owner's expected compensation cost is

$$\begin{aligned}\left(1-\Pr\left(y_L\right)\right)s + \Pr\left(y_L\right)s_L &= s - \left(s - s_L\right)\Pr\left(y_L\right)\\ &= s - V^m\left(1+\ln\left(s/V^m\right)\right)\Pr\left(y_L\right)\\ &= s - V^m\left(1+\ln\left(s/V^m\right)\right)\left((1-p) + \frac{V^\varepsilon}{V^m\left(1+\ln\left(s/V^m\right)\right)}\right)\\ &= s - V^m\left(1+\ln\left(s/V^m\right)\right)(1-p) - V^\varepsilon.\end{aligned}$$

The expected compensation is less than that under the original contract,

$$\Pr\left(m_H\right)s = s - (1-p)V^m - \frac{V^\varepsilon}{1+\ln\left(s/V^m\right)}.$$

To see this, note that because of $s > V^m$,

$$\begin{aligned}&\left(1-\Pr\left(y_L\right)\right)s + \Pr\left(y_L\right)s_L - \Pr\left(m_H\right)s\\ &= s - V^m\left(1+\ln\left(s/V^m\right)\right)(1-p) - V^\varepsilon - \left(s - (1-p)V^m - \frac{V^\varepsilon}{1+\ln\left(s/V^m\right)}\right)\\ &= \frac{V^\varepsilon}{1+\ln\left(s/V^m\right)} - V^\varepsilon - V^m\ln\left(s/V^m\right)(1-p)\\ &= -V^\varepsilon\frac{\ln\left(s/V^m\right)}{1+\ln\left(s/V^m\right)} - V^m\ln\left(s/V^m\right)(1-p) < 0.\end{aligned}$$

The owner is strictly better off with the truth-telling contract mainly because she saves compensating the manager for the cost of earnings management. Despite that, the manager's *opportunity* for earnings management plays a role in this contract because it determines the compensation $s_L > 0$. The owner's expected cost of compensation under the truth-telling contract also increases in s because

$$\frac{\partial\left(\left(1-\Pr\left(y_L\right)\right)s+\Pr\left(y_L\right)s_L\right)}{\partial s}=\frac{\partial\left(s-V^m\left(1+\ln\left(s/V^m\right)\right)\left(1-p\right)-V^\varepsilon\right)}{\partial s}=1-\frac{V^m}{s}\left(1-p\right)>0.$$

Thus, the optimal contract is determined by the incentive compatibility constraint, and because the manager's utility is structurally unchanged, all results that rely on the characteristics of the incentive compatibility constraint continue to hold for the truth-telling contract.

Differences between the properties of the truth-telling equilibrium and those based on the original contract including earnings management occur in two respects: First, as regards welfare, the truth-telling equilibrium contains no earnings management and total welfare becomes

$$\mathrm{TW}=\mathrm{E}\left[U^O\left|a_H\right.\right]+\mathrm{E}\left[U^M\left|a_H\right.\right]=\mathrm{E}\left[x\right]-V^a-V^\varepsilon\varepsilon.$$

It follows that an increase in IC effort due to conservatism always implies a decrease in total welfare as there is no countervailing impact on expected costs of earnings management. Thus the effects as stated in Proposition 7 (ii) cannot exist in a truth-telling contract. Second, regarding earnings quality EQ in a truth-telling contract, due to no earnings management $E_1 = 0$, but the other two terms E_2 and E_3 are similar. Since they can be positive or negative, the total effect of a change of δ on EQ is also ambiguous and depends on the parameters.