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Accounting conservatism and relational contracting[☆]

Jonathan Glover [a, *], Hao Xue [b]

[a] Columbia University, Graduate School of Business, United States
[b] Duke University, Fuqua School of Business, United States

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ABSTRACT

This paper develops a positive role for accounting conservatism in fostering relational contracts between two agents in a two-period model of moral hazard. Building on Kreps (1996), the principal in our model designs a conservative measurement system and optimal contracts to create multiple equilibria that foster a team-based corporate culture. Accruals introduced by conservatism increase each agent's stake in the future of the relationship when it matters most—when it is going badly. This makes staying in the relationship worthwhile for the agents, even if they plan to play a low payoff equilibrium in the second period to punish first-period free-riding. In turn, this allows the principal to use lower-powered (and less costly) team incentives in the first period of the relationship. In contrast, deferred compensation increases each agent's stake in the future of the relationship when it is going well, making it less efficient in fostering relationships.

1. Introduction

Conservatism is a pervasive feature of accounting (Basu, 1997).[1] While much of the recent literature on accounting conservatism emphasizes its role in capital markets, conservatism pre-dates capital markets. For example, Francesco di Marco of Prato's accounts of 1406 contained a write-down of inventories (Vance, 1943). Citing Penndorf (1930), Basu (1997) notes, "[h]istorical records from early 15th century trading partnerships show that accounting in medieval Europe was conservative." The early roots of accounting conservatism seem to be in balance sheet valuations designed with the mindset that "all assets will be converted into cash and should not be stated at an amount greater than their cash equivalent" (Hoffman, 1962 as cited in Mueller, 1964). As Watts (2003) notes, to the extent that payouts to some stakeholders are tied to balance sheet valuations, conservatism protects other stakeholders who do not receive those payouts.

In recent years, there has been a growing recognition that meaningful and persistent differences in firm performance are driven by corporate culture (e.g., Guiso et al., 2015). In this paper, we develop a positive role for accounting conservatism in fostering a desirable corporate culture. The notion of corporate culture we adopt is due to Kreps (1996), who treats corporate culture as a coordination mechanism that helps regulate beliefs and behavior within the firm. In our model, accounting

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* Corresponding author.
E-mail address: jg3463@columbia.edu (J. Glover).

[1] Accounting conservatism has also been the subject of much criticism—by regulators, standard setters, and academics. For example, Paton and Paton (1952) write, "[i]s there anything essentially conservative … in a valuation scheme that merely shifts income from one period to the next."

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conservatism creates beliefs that support relational contracts between managers. Unlike explicit contracts that are enforced by the courts, relational contracts must be self-enforcing through repeated play (Levin, 2003; MacLeod, 2007). Accruals introduced by conservatism increase each manager's stake in the future of the relationship when it matters most—when it is going badly. This makes staying in the relationship worthwhile for the managers, even if they plan to play a low payoff equilibrium in the second period to punish first-period free-riding.[2] In turn, this allows the firm to use lower-powered (and less costly) team incentives rather than higher-powered individual incentives in the first period of the relationship. Conservatism fosters trust and long-term relationships that would be jeopardized by more aggressive measurement.

Repeated relationships between various partners (management teams, buyers and suppliers, creditors and debtors, marriages, etc.) create opportunities for parties to make and keep promises that could not be enforced in one-shot interactions. However, repeated play is not sufficient for such promises to be self-enforcing. The payoff from keeping the promise and continuing the relationship on good terms must be greater than the next-best alternative payoff. When markets provide access to substitute partners that are just as good as current partners, the threat of ending the relationship is of no value in making promises credible. Relationship-specific investments that make the existing partnership more productive than alternative partnerships can restore credibility by creating a wedge between the value of the existing relationship and alternative relationships (Halac, 2015). Roughly stated, conservatism in our model plays a similar role in creating credibility by making it worthwhile to stay in the current relationship even when the next period's play will involve a punishment.

We study a two-period model of a principal and two agents who work closely enough with each other to observe each other's actions, as in Arya et al. (1997). We view the principal in our model as representing an owner and the agents as a top management team (e.g., Guay et al., 2019; Li, 2021). A conservative accounting system imposes higher verification standards on the reporting of good news than on the reporting of bad news and, therefore, has the tendency to delay the recognition of good performance (Watts, 2003).[3] Here, conservatism is conditional in the sense that it captures asymmetric timeliness in the recognition of bad vs. good news. To capture this idea simply, we assume that true first-period high performance is delayed and reported in period two with some probability, while true first-period low performance is always reported early. The role of conservatism in our inter-temporal setting is to foster a punishment equilibrium in period two that the agents can use if anyone free-rides in period one. We show that the (partial) *inter-temporal* aggregation of good news introduced by accounting conservatism creates room for a team-based and long-term oriented culture when the culture would otherwise be an individualistic and myopic one.

It is tempting to view conservatism as a form of deferred compensation in our model. However, deferred compensation increases the value of retaining the relationship when it is going well, i.e., when first-period performance is high. In contrast, conservatism increases the agents' stake in the future of the relationship when it is going badly, i.e., when first-period performance is low. This is because agents understand that a report of low performance in the first period might have been understated due to the asymmetric verification standard and will be reversed in the next period. As a result, conservatism makes the agents more willing to stay in the relationship when it matters most—when it is going badly and a punishment is called for. That is, the way conservatism enters the picture is not by limiting payouts per se, but rather in creating beliefs that foster stability of the management team in a way that benefits the owner. We show that an optimal conservative accounting system dominates any deferred compensation scheme (with an unbiased accounting system) in our model. One might also expect optimal conservatism to be maximal conservatism. However, this is not the case. Maximal conservatism turns the relationship into the equivalent of two one-shot encounters.

If accounting conservatism can be used to shape corporate culture for the better and corporate culture is an important unrecognized intangible asset, we should expect to see larger market-to-book ratios for firms that adopt more conservative accounting, even after adjusting for the conservative measurement bias. In our model, when the agents' reservation utilities are above a threshold, a firm using conservative accounting is able to motivate high effort using low-powered team incentives, while a firm using unbiased accounting would have to employ high-powered individual incentives. Ceteris paribus, the market value of the conservative firm should be greater than the market value of the firm using unbiased accounting by an amount equal to the present value of the difference in expected compensation. If accounting choices can be used to improve corporate culture as our model suggests, the benefits are likely to extend well beyond reducing the cost of compensation in practice, for example, by improving the work climate and, hence, the attractiveness of employment.

To the extent that reporting on environmental, social, and governance (ESG) factors can be viewed as an attempt to report on relationships (e.g., with employees, suppliers, and customers) and conservatism fosters those relationships, we should expect to see conservative reporting associated with good ESG outcomes (e.g., low employee turnover and fair trading practices). Guay et al. (2019) use the team incentive models of Arya et al. (1997) and Che and Yoo (2001) to link a team-based culture in the C-suite to the use of common/joint rather than customized/individual performance measures and to lower turnover within the C-suite. Extending their arguments to include the link between conservatism and a team-based culture, one should also expect to see conservatism associated with the use of common performance measures and low turnover.

[2] We see team production and its free-riding problem as generic features of firms (Alchian and Demsetz, 1972) and hope our analysis will spur a new direction of inquiry related to accounting and corporate culture.

[3] The models of accounting conservatism that use the information economics framework have largely studied single-period settings. A recent exception is Glover and Lin (2018), which studies the inter-temporal properties of conservatism in providing incentives to a single agent.

One way to think about our model is that it connects two existing lines of thinking: (i) conservatism reduces agency conflicts (Watts, 2003) and, hence, fosters the firm's ability to continue as a going concern, and (ii) stability (repeated play by the same agents) is important in promoting a team culture (e.g., Arya et al., 1997; Che and Yoo, 2001; Guay et al., 2019; Li, 2021). In our model, conservatism promotes relationships between managers within the firm rather than between the firm and external parties. As Watts (2003) observes, conservatism helps deal with horizon and limited liability problems. Lafond and Roychowdhury (2008) argue that managers with longer horizons will be less subject to agency problems and the related demand for conservatism. However, managerial horizons are, at least in part, endogenous. In our model, conservatism mitigates the horizon problem by encouraging managers to stay in their positions and, hence, maintain their relationships with each other.

Over the past 20 or so years, information economics has been used to study accounting conservatism.[4] Closest to our paper is the line of research that studies the role of conservatism in labor contracts subject to moral hazard. In Kwon et al. (2001), accounting aggregates underlying continuously distributed transactions into binary accounting reports. Conservative measurement imposes a stricter threshold for reporting a high accounting report.[5] Whether conservatism reduces or increases the cost of providing incentives depends on the likelihood ratios induced by the accounting cutoff and whether the agent is risk-averse or risk neutral (and subject to bankruptcy constraints). Gigler and Hemmer (2001) study the interaction between mandatory and voluntary reporting (communication of the agent's post-decision private information) in a model of moral hazard when the mandatory accounting report that disciplines the agent's communication is liberal, unbiased, or conservative. Gao (2013) shows that a conservative rule is an optimal response when the manager can inflate the report. Chen et al. (2007) show that earnings management reduces accounting numbers' stewardship value, and conservative accounting can improve risk sharing and, hence, contract efficiency.

Another line of research studies the role of conservatism in debt contracting. Gigler et al. (2009) and Li (2013) build on and challenge arguments made by Basu (1997) and Watts (2003) about the role of conservatism in debt contracting and the relationship between accounting earnings and stock prices (the role of accounting in providing information to equity markets rather than merely capturing information already impounded in stock prices). Bigus and Hakenes (2017) study the role of conservatism in enhancing relationship lending. In their model, early lending is essentially a loss leader a bank offers to obtain an information advantage over other lenders, thereby generating future rents when the borrower raises additional debt. The role of conservatism in their paper is to create opacity in the financial statements provided to non-relationship banks rather than to facilitate a relational contract.

Our repeated game setting brings the folk theorems for repeated games to mind (e.g., Fudenberg and Maskin, 1986; Fudenberg et al., 1994). Most closely related to our paper is Benoit and Krishna (1985), which develops a folk theorem for finitely repeated games. The main connection is that they use multiple equilibria in the one-shot game to support behavior in earlier periods that is not an equilibrium of the one-shot game. The key difference between our setting and theirs is that the game we study is endogenous (depends on an optimal contract) and is a different game in the first period than in the second. Benoit and Krishna (1993) study renegotiation in finitely repeated games, arguing that an agreement to punish (off-equilibrium) deviant behavior by playing a Pareto-dominated one-shot equilibrium is not renegotiation proof. Our two-period model is subject to this criticism. In the online Appendix, we extend our model to an infinitely repeated setting in which the criticism does not apply, because the players punish each other using the unique (up to payoff equivalence) equilibrium of their one-shot game.[6]

We also extend our model to allow for agent risk aversion, as in Arya et al. (1997). With agent risk aversion in our two-period model, conservatism imposes greater risk on the agents by deferring the recognition of some good performance to the second period when incentives are higher-powered (bonuses are larger). This new cost to conservatism is not shared by deferred compensation, which simply moves payments from the first period to the second. With risk-averse agents, deferred compensation or conservatism can each be optimal, depending on the level of complementarity between the agents' actions (which favors conservatism) and the level of risk aversion (which favors deferred compensation).

The remainder of the paper proceeds as follows. Sections 2 and 3 present the model and main results, respectively. Section 4 extends the analysis to include risk-averse agents. Section 5 discusses implications for empirical researchers, regulators, and standard setters. Section 6 concludes.

[4] The role of accounting conservatism in equity valuation has also been the subject of extensive theoretical and empirical research in accounting (e.g., Zhang, 2000; Penman and Zhang, 2002; Penman and Zhang, 2020).

[5] Prior studies have examined recognition thresholds in various settings. Demski (1973) demonstrates the impossibility of generic rankings of accounting standards, viewed as a partition of the state space. Dye (2002) studies classification manipulation, where a threshold cutoff is employed to designate when a continuous signal will be reported as good instead of bad (absent manipulation). The possibility of manipulation gives rise to a shadow threshold that determines whether the signal will actually be reported as good or bad. Dye et al. (2015) builds on the ideas of Demski (1973) and Dye (2002) to develop an impossibility result about financial engineering-proof standards. They also discuss tradeoffs associated with recognition thresholds, viewed as limiting the events that are incorporated into accounting reports. Gao and Jiang (2020) model recognition thresholds and compare them to continuous measurements, demonstrating that recognition thresholds can be preferred because they limit manipulation.

[6] The main insight from the infinitely repeated setting is that both the bonus rate and the level of conservatism are decreasing in the common discount factor. As the discount factor increases, future punishments become more meaningful, lowering both the required bonus and the required level of conservatism. So, conservatism plays a larger role for impatient agents than for patient agents, which is somewhat counterintuitive.

2. Model

A principal (e.g., an owner) contracts with two ex ante identical agents (e.g., a top management team), $i = A, B$, over two periods. The agents simultaneously provide personally costly efforts $e_t^i = \{0, 1\}$ in period t, $t = 1, 2$. Denote by $\mathbf{e}_t = (e_t^A, e_t^B)$ the period-t effort profile. In a joint and stochastic fashion, these efforts result in concurrent team output, $x_t \in \{L, H\}$, with $L = 0 < H$. The production technology is stationary. Let

$$p_H \equiv Pr(x_t = H|\mathbf{e}_t = (1,1)) > p \equiv Pr(x_t = H|\mathbf{e}_t = (1,0)) = Pr(x_t = H|\mathbf{e}_t = (0,1)) > p_L \equiv Pr(x_t = H|\mathbf{e}_t = (0,0)).$$

The agents' efforts exhibit a productive complementarity, defined as $p_H - p \geq p - p_L$. The productive complementarity implies that agent i's marginal productivity is higher if the other agent is working ($e = 1$) rather than shirking ($e = 0$). Cross-functional teams, including those employed in modern manufacturing environments, are often described as having such productive complementarities.[7] We normalize the probability $p_L = 0$ in the main model to simplify notation and analysis. (We consider $p_L > 0$ in the extension where we model risk-averse agents.)

Neither the principal nor the agents observe the team output x_t. Instead, they observe a verifiable accounting report y_t. The accounting system is either unbiased or conservative. Similar to Kwon et al. (2001), we think of conservatism as imposing higher verification standards on the reporting of good news than on the reporting of bad news. A conservatism accounting system therefore has the tendency to delay the recognition of good performance (Watts, 2003). To model this idea simply, we assume that true first-period low performance $x_1 = L$ is recognized immediately as $y_1 = L$, while true first-period high performance $x_1 = H$ is recognized as $y_1 = L$ with probability c. Any delayed recognition or mis-measurement in the first period (i.e., $y_1 - x_1$) is an accrual and will reverse in the second period. That is, the sum of the two periodic accounting reports equals the total output.

$$x_1 + x_2 = y_1 + y_2.$$

The parameter c captures the conservatism of the accounting system.[8] We ignore any explicit cost associated with changing c.

One may wonder why the agents do not observe the actual team output rather than only the accounting report on that output. We think of the agents as representing the top management team of the firm who base their decisions, at least in part, on accounting reports rather than direct observation of all the firm's underlying transactions. One might also ask if the reporting system used for compensation could be a different one than the one used to prepare external financial reports. We are agnostic on this point in that our model is of the conservatism of whatever performance measurement system is used to compensate the agents. However, there seems to be significant use of financial accounting performance measures, albeit with various adjustments, in determining the bonuses of top management teams (Guay et al., 2019).

All players are risk neutral. We ignore the time value of money in our two-period game. The agents are protected by limited liability. That is, the wage agent i receives in period t must satisfy $w_t^i \geq 0$. Agent i's payoff in period t is $w_t^i - e_t^i$. Over the two periods, the principal's payoff is $x_1 + x_2 - \sum_i (w_1^i + w_2^i)$. We assume the agents' efforts are important enough (specifically, that $(p_H - p)H$ is large enough) that the principal finds it optimal to elicit high effort from each agent in each period.

The sequence of events is as follows. The principal first publicly chooses the measurement system c. The contracting relationship is at-will. At the beginning of each period t, the principal offers each agent a short-term linear contract consisting of a fixed salary α_t^i and a bonus component β_t^i that is linear in the reported performance y_t. Each agent then either accepts or rejects the period t contract. If the period t contract is accepted, each agent i chooses effort level e_t^i. The measurement system reports performance y_t, and the agents are paid according to the contract they agreed to. Each agent i's total compensation in period is t is $w_t^i = \alpha_t^i + \beta_t^i \times y_t$. In our setting, it is without loss of generality to confine attention to symmetric contracts, i.e., $\alpha_t^i = \alpha_t$ and $\beta_t^i = \beta_t$ for $\forall i$. We will drop the agent superscript i whenever it does not cause confusion. However, the restriction to short-term contracts is a critical one (intended to make the co-mingling of performance across periods meaningful), which we relax in Section 3.4.

Accruals tied to conservatism and their reversals connect the first- and second-period contracting problems. Let $U_1(\mathrm{e}_1)$ be each agent's first-period payoff plus expected second-period compensation due to first-period efforts e_1. That is, $U_1(\mathrm{e}_1)$ includes the impact of a first-period accrual that is reversed in period two. Given the linear contract (α_t, β_t), we know

$$U_1(\mathbf{e}_1) = \alpha_1 + \Pr(x_1 = H|\mathbf{e}_1)(1 - c)\beta_1 H + \Pr(x_1 = H|\mathbf{e}_1)c\beta_2 H - e_1^i.$$

The level of conservatism c appears in $U_1(\mathrm{e}_1)$ because first-period good news $x_1 = H$ is reported as $y_1 = L$ with probability c, in which case the accrual $x_1 - y_1$ will reserve and be rewarded at the rate β_2 in the second period. Similarly, denote by $U_2(\mathrm{e}_2)$ an agent's second-period payoff without the incremental compensation due to a first-period accrual reversal. That is,

[7] See, for example, Milgrom and Roberts (1992, 1995).

[8] We could also introduce a probability of over-statement $b = \Pr(y_1 = H|x_1 = L)$. However, in our model, it would be optimal to set $b = 0$.

$$U_2(\mathbf{e}_2) = \alpha_2 + \Pr(x_2 = H|\mathbf{e}_2)\beta_2 H - e_2^i.$$

The equilibrium concept we employ is Pareto-undominated subgame perfect equilibrium. That is, the agents will play as the principal intends as long as doing so is a subgame perfect equilibrium and is not Pareto dominated by any other equilibrium in their subgame. Each agent can earn a reservation utility $\bar{U}$ in each period if he accepts employment elsewhere. Therefore, at the beginning of the first period, the contract must provide each agent with a total payoff across the two periods of at least $2\bar{U}$ on the equilibrium path. That is, playing (*work, work*) in both periods must satisfy $U_1(1,1) + U_2(1,1) \geq 2\bar{U}$, i.e.,

$$\alpha_1 + p_H(1-c)\beta_1 H + \alpha_2 + (p_H + p_H c)\beta_2 H - 2 \geq 2\bar{U}. \qquad \text{(Overall IR)}$$

The second period is the last period of the game. Therefore, the second-period contract (α_2, β_2) must ensure that the efforts $\mathrm{e}_2 = (1,1)$ constitute a stage-game Nash equilibrium (i.e., $U_2(1,1) \geq U_2(0,1)$) and is individually rational (i.e., $U_2(1,1) \geq \bar{U}$).[9] That is,

$$p_H \beta_2 H - 1 \geq p \beta_2 H, \qquad \text{(Period-2 Nash)}$$

and

$$\alpha_2 + p_H \beta_2 H - 1 \geq \bar{U}. \qquad \text{(Period-2 IR)}$$

2.1. Team incentives in the first period

The agents work closely enough that they observe each other's non-verifiable actions, while the principal observes only the verifiable accounting report y_t, which imperfectly captures the agents' actions. The repeated relationship creates room for the two agents to mutually monitor each other. The demand for mutual monitoring using implicit/relational contracts in our model is similar to Arya et al. (1997) and Che and Yoo (2001). The principal can relax the agents' Nash incentive constraints, which are based on the performance measures only, by instead using those performance measures to set the stage for the agents to mutually monitor each other.[10] In order for the agents to have incentives to mutually monitor each other, the principal needs to ensure that, from the agents' perspective, both working is preferred to both shirking in the first period: $U_1(1,1) \geq U_1(0,0)$. That is,

$$p_H(1-c)\beta_1 H + c p_H \beta_2^* H - 1 \geq p_L(1-c)\beta_1 H + c p_L \beta_2^* H. \qquad \text{(Pareto Dominance)}$$

We use the notation β_2^* to emphasize that, in designing the period-one contract, the principal takes the conjectured second-period optimal contract (α_2^*, β_2^*) as given.

The principal also needs to provide a means for the agents to punish each other in the second period if either agent unilaterally deviates from the (*work, work*) equilibrium play in the first period. Without loss of generality, we confine attention to a grim trigger strategy that, following any deviation (including a unilateral deviation), calls for the harshest punishment that is individually rational and can be sustained as a stage-game equilibrium in the second/last period. Denote by $V_2(\mathbf{e}_2, \mathbf{e}_1, y_1) = U_2(\mathbf{e}_2) + \beta_2^* \times E[x_1 - y_1|\mathbf{e}_1, y_1]$ agent i's second-period *continuation payoff* given the second-period efforts e_2, the first-period efforts e_1, and the reported performance y_1. Note that the continuation payoff V_2 depends on the expected accrual reversal, $x_1 - y_1$.

Let $\mathbf{e}_2^P$ be the punishment agent j imposes on agent i in the second period for unilaterally shirking in the first period (i.e., free-riding on agent j's effort). We characterized $\mathbf{e}_2^P$ later. The following condition ensures that the second-period punishment is sufficient to deter any agent from free-riding in the first period:

$$\Pr\left(V_2\left(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1\right) \geq \bar{U}\right)\left[U_2(1,1) - U_2\left(\mathbf{e}_2^P\right)\right] \geq U_1(0,1) - U_1(1,1). \qquad \text{(Monitoring)}$$

The right-hand side of (Monitoring) is agent i's benefit from unilateral deviating from (*work, work*) in the first period. The left-hand side is the cost of free-riding, which is the expected decrease in the second-period payoff by playing the punishment $\mathbf{e}_2^P$ rather than the on-equilibrium strategy (*work, work*). We multiply the cost of reneging by the probability $\Pr(V_2(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1) \geq \bar{U})$ in (Monitoring) because the agents will only carry out the punishment $\mathbf{e}_2^P$ if it is individually rational to do so. In the event that punishment $\mathbf{e}_2^P$ is not individually rational, the agents will continue to play the (*work, work*) equilibrium in period

[9] Stated more generally, the family of Period-2 IR constraints require $U_2(1,1) + \beta_2 E[x_1 - y_1|y_1, \mathbf{e}_1] \geq \bar{U}$ for any e_1 and report $y_1 \in \{H, L\}$, where $x_1 - y_1$ is the reversal of under-reported first period performance. Since the reversal $E[x_1 - y_1|y_1, \mathbf{e}_1] = 0$ when $y_1 = H$, the most demanding Period-2 IR constraint is $U_2(1,1) \geq \bar{U}$, as stated in (Period-2 IR).

[10] Following the literature on mutual monitoring in repeated team relationships (e.g., Arya et al., 1997; Che and Yoo, 2001), we assume communication from the agents to the principal is blocked.

two, in which case no punishment can be imposed. That is, rather than quit, the agents will accept the second-period contract if there is some equilibrium that satisfies their individual rationality constraints. Here, we take the typical view that individual rationality is a constraint on payoffs rather than modeling quitting as a means of punishment. In the online Appendix, we study *quitting* as an action that can be used as a punishment and obtain qualitatively similar results. In particular, whether the punishment is from quitting or from playing (*shirk*, *shirk*), the principal chooses a level of conservatism $c \in (0,1)$ that enables her to offer team incentives in the first period. The principal also obtains the same payoff under the two alternative means of punishment. In both cases, the role of conservatism is to create a wedge between the equilibrium and the punishment payoffs so that free-riding in the first period can be prevented.[11]

To determine the probability that the punishment is credible in (Monitoring), recall that the continuation payoff $V_2(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1) = U_2(\mathbf{e}_2^P) + \beta_2^* E[x_1 - y_1 | e_1^i \neq e_1^j, y_1]$ depends on the first-period accounting report y_1 via the expected reversal of accruals. The uncertainty about the reversal and, hence, whether the punishment will be individually rational arises because the accounting report y_1 is unknown ex ante. In particular, the probability that the punishment is credible is one if $V_2(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1) \geq \bar{U}$ holds for both $y_1 \in \{H, L\}$, is between zero and one if it holds for $y_1 = H$ or $y_1 = L$ (but not both), and is zero if it is never satisfied for any y_1. Formally, we express the probability as

$$\Pr\left(V_2\left(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1\right) \geq \bar{U}\right) = \sum_{y_1 \in \{H,L\}} \Pr\left(y_1 \middle| e_1^i \neq e_1^j, c\right) \text{ s.t. } V_2\left(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1\right) \geq \bar{U}. \tag{1}$$

As we will show in the next section, it is sometimes infeasible to provide team incentives. In this case, the principal must instead ensure that $e_1 = (1, 1)$ is a stage-game Nash equilibrium in the first period by ensuring $U_1(1, 1) \geq U_1(0, 1)$, or, equivalently,

$$(p_H - p)(1-c)\beta_1 H + (p_H - p)c\beta_2^* H \geq 1. \tag{Period-1 Nash}$$

3. Analysis

3.1. Principal's problem

We solve for the optimal contracts using backward induction. Since the contracting relationship ends after two periods, the second-period contracting problem is essentially a one-shot moral hazard problem. We summarize the principal's second-period optimization problem (for any reported performance y_1) as follows.

$$\begin{array}{lll} \textbf{Period}-\textbf{2 Program}: & \min\limits_{\alpha_2,\beta_2 \geq 0} & \alpha_2 + \beta_2 E(y_2|y_1) \\ s.t. & \text{Period}-2\text{ Nash} & \\ & \text{Period}-2\text{ IR} & \end{array} \tag{2}$$

If the (Period-2 IR) constraint does not bind, the solution to Period-2 Program is $\alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H - p)H}$, where the individual incentive rate β_2^* is solved from the binding constraint (Period-2 Nash). Even if (Period-2 IR) binds, there is a solution with $\alpha_2 = 0$ since the agent is risk neutral and the principal can substitute α_2 with β_2. To avoid the trivial case that the only role of compensation is to satisfy the agents' individual rationality constraints, we assume throughout the paper that, given $\alpha_2^* = 0$ and β_2^*, (Period-2 IR) is satisfied if both agents work. That is, $p_H \beta_2^* H - 1 \geq \bar{U}$, or, equivalently,

$$\bar{U} \leq \frac{p}{p_H - p}. \tag{3}$$

In the first period, the principal takes $\alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H - p)H}$ as given and designs the first-period salary α_1 and bonus rate β_1. The level of accounting conservatism $c \in [0, 1]$ is also a choice variable for the principal. The principal can choose to provide individual incentives, as in the second period, or instead to provide team incentives, i.e., to provide the agents with incentives to mutually monitor each other's effort in the first period.

As we discussed in the model setup, providing team incentives requires the optimal contract to ensure that the agents have a means of punishing each other in the second period if one of the agents shirks in the first period. The following lemma characterizes the punishment strategy $\mathbf{e}_2^P$.

Lemma 1. *The punishment has the agents playing the stage-game equilibrium (shirk, shirk) in the second period whenever it is individually rational, i.e.,* $\mathbf{e}_2^P = (0, 0)$.

[11] If the agents punish each other by quitting, (Monitoring) can be rewritten as $U_1(1,1) + U_2(1,1) \geq \alpha_1 + p(1-c)\beta_1 H + \bar{U}$. That is, each agent's equilibrium payoff across two periods is greater than the payoff he would receive from free-riding and triggering the quitting punishment. Quitting is credible by definition: if either agent quits at the end of the first period, both receive their reservation utilities in the second period.

Proof. All proofs are in Appendix A. □

Intuitively, the assumed productive complementarity $p_H - p > p - p_L$ ensures that neither agent has an incentive to unilaterally deviate from (*shirk, shirk*) in the second period, since his marginal productivity is lower when the other agent is shirking than when he is working. Therefore, playing (*shirk, shirk*) is a stage-game equilibrium in the second period and can be used as a punishment as long as it satisfies individual rationality.

Using the arguments developed so far, we can summarize the principal's first-period program as the following integer program. It is an integer program because the variable T takes a value of either zero or one: $T = 1(T = 0)$ means that the principal designs the contract to provide team incentives (individual incentives) in the first period.

$$\begin{aligned}
&\textbf{Period} - \textbf{1 Program}: && \min_{\alpha_1,\beta_1 \geq 0, c \in [0,1], T=\{0,1\}} \quad \alpha_1 + p_H(1-c)\beta_1 H + p_H c \beta_2^* H \\
&s.t. && (1-T) \times \text{Period} - 1 \text{ Nash} \\
& && T \times \text{Pareto Dominance} \\
& && T \times \text{Monitoring} \\
& && \text{Overall IR}
\end{aligned} \tag{4}$$

3.2. Optimal contract

The provision of team incentives depends on whether the agents can credibly punish each other in order to deter free-riding behavior. We start by analyzing a benchmark case in which the agents' reservation utility $\bar{U}$ is less than or equal to $\bar{U}_2(0,0) = \frac{p_L}{p_H - p}$ (using the optimal α_2^* and β_2^*). In this case, playing the (*shirk, shirk*) punishment is always credible, and there is no beneficial role for accounting conservatism.

Proposition 1. *For $\bar{U} \leq U_2(0,0)$, the optimal contract provides team incentives ($T = 1$), sets accounting conservatism $c^* = 0$, and sets $\alpha_1^* = \alpha_2^* = 0$, $\beta_1^* = \frac{1}{(p_H - p_L)H}$, and $\beta_2^* = \frac{1}{(p_H - p)H}$.*

For $\bar{U} > U_2(0,0)$, playing (*shirk, shirk*) in the second period to punish the free-riding agent is no longer credible under a neutral accounting system (i.e., $c = 0$). This is where conservatism (i.e., $c > 0$) comes in. A conservative system can make the (*shirk, shirk*) punishment individually rational when the first-period accounting report is low i.e., $y_1 = L$. Under conservatism, a low report in the first period makes the agent believe there is a chance that performance was underreported and that there will be a reversal of understated first-period performance in period two.

We assume $\bar{U} > U_2(0,0)$ throughout the remainder of the paper. In this case, playing the shirking punishment $\mathbf{e}_2^P = (0,0)$ is credible only if the agent expects a reversal of understated accruals in the second period, i.e., only if the first-period accounting report is $y_1 = L$. We can therefore state (Monitoring) in the principal's Period-1 Program equivalently as:

$$\Pr(y_1 = L | e_1^i \neq e_1^j)\left(\frac{p_H - p_L}{p_H - p} - 1\right) \geq (p - p_H)(1-c)\beta_1 H + (p - p_H)c\beta_2^* H + 1, \tag{Mutual Monitoring}$$

and require that, given $y_1 = L$, it is credible to punish the first period free-rider by playing $\mathbf{e}_2^P = (0,0)$ in period two:

$$U_2(0,0) + \Pr\left(x_1 = H \middle| e_1^i \neq e_1^j, y_1 = L\right)\beta_2^* H \geq \bar{U}. \tag{Credible Punishment}$$

The next lemma summarizes the optimal contract, taking the degree of accounting conservatism as given. The results highlight the non-monotonic relationship between conservatism and its ability to foster team incentives. The analysis provides a foundation to use in deriving the optimal level of conservatism.

Lemma 2. *Given an exogenous level of conservatism c and $\bar{U} > U_2(0,0)$, an optimal contract is ($\alpha_1 = \alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H - p)H}$ in all cases):*

i. *For $c < \underline{c} = \frac{(1-p)[\bar{U}(p_H - p) - p_L]}{p(pU - p_H U + p_L + 1)}$, the contract provides individual incentives with $\beta_1 = \beta_2^*$. The expected payment is $\frac{2p_H}{p_H - p}$ per agent.*
ii. *For $\underline{c} \leq c \leq \bar{c} = \frac{p_H - p}{p_H - p_L}$ and $\bar{U} \leq \frac{p}{2(p_H - p)}$, the contract provides team incentives with $\beta_1 = \frac{c(p_L - p_H) - p + p_H}{(c-1)H(p - p_H)(p_H - p_L)} < \beta_2^*$. The expected payment is $\frac{2p_H - p}{p_H - p}$ per agent, and $\frac{d\beta_1}{dc} < 0$.*
iii. *For $\bar{c} < c \leq 1$, the contract provides team incentives with $\beta_1 = 0$. The expected payment is increasing in c and equals the cost of individual incentives $\frac{2p_H}{p_H - p}$ at $c = 1$.*

The agents' risk-neutrality makes it costless for the principal to replace positive salaries with higher bonuses on the equilibrium path. The only potential role for a salary is to ensure that the (*shirk*, *shirk*) punishment is credible in the second period, i.e., individually rational. Since the second-period salary is set after the agents have taken their first-period actions, the principal has no incentive to offer a fixed salary to ensure (*shirk*, *shirk*) is credible in the second period.

Part (i) of the lemma shows that team incentives are infeasible when the level of conservatism is low, i.e., $c < \underline{c}$. As accounting conservatism increases from zero, the performance measures y_1 and y_2 reported in each of the two periods become increasingly intertwined because of the delayed recognition of early good news. Agents understand that a first-period low accounting report, $y_1 = L$, may be due to understated first-period high performance that will be reversed in the second period. A higher level of conservatism c increases the expected accrual reversal $E[x_1 - y_1 | y_1 = L]$ in period two, making the punishment $\mathbf{e}_2^P = (0, 0)$ more likely to be credible when the first-period report is $y_1 = L$.

At $c = \underline{c} = \frac{(1-p)[\bar{U}(p_H - p) - p_L]}{p(p\bar{U} - p_H\bar{U} + p_L + 1)}$, the expected reversal of accruals is just high enough to satisfy (Credible Punishment) as an equality. Having a credible punishment equilibrium in period two allows the principal to provide team incentives in the first period. The principal chooses the period-one bonus rate $\beta_1 = \frac{c(p_L - p_H) - p + p_H}{(c-1)H(p-p_H)(p_H - p_L)} < \beta_2^*$ so that the agents are indifferent between both working and both shirking in the first period. Since a higher conservatism c means that the agents' first-period efforts $\mathbf{e}_1 = (1, 1)$ are rewarded more often at a higher rate β_2^* in period two, the principal reduces the first-period bonus rate $\beta 1$ to save unnecessary rents, i.e., $\frac{d\beta_1}{dc} < 0$. At $c = \bar{c}$, the principal optimally sets $\beta_1 = 0$. The condition $\bar{U} \leq \frac{p}{2(p_H - p)}$ ensures that the contract satisfies the (Overall IR). We characterize the optimal contract for $\bar{U} > \frac{p}{2(p_H - p)}$ later in Proposition 2.

It may be tempting to think that a higher level of conservatism always increases contracting efficiency. However, Part (iii) of Lemma 2 shows that this is not the case. In fact, contracting efficiency strictly decreases as conservatism is increased above $\bar{c}$. Shifting high performance from period one to period two can be costly because the second-period (individual incentive) bonus rate β_2 is higher than the first-period (team incentive) bonus rate β_1. When the level of conservatism is not too high (i.e., $c < \bar{c}$), the principal can react to a higher c by lowering β_1 and avoid an overall increase in compensation cost. β_1 is reduced to zero at $c = \bar{c}$. Even greater conservatism would increase the compensation cost because more first-period performance would be delayed and, hence, paid out at the higher bonus rate β_2 (instead of β_1). In other words, increasing the level of conservatism beyond c essentially substitutes team incentives with individual incentives by moving performance from period one to period two and paying the agents based on the individual incentive rate β_2. At the maximum level of conservatism $c = 1$, all performance generated in the first period is deferred and paid out at the individual incentive rate β_2, making the incentive scheme equivalent to relying solely on individual incentives. Fig. 1 illustrates Lemma 2 using a numerical example with $p_H = 0.5$, $p = 0.2$, $p_L = 0$, and $\bar{U} = 0.3$.

Lemma 2 and Fig. 1 demonstrate the non-monotonicity of conservatism on contracting efficiency, measured as the expected compensation cost. Proposition 2 below endogenizes the optimal level of conservatism c*.

Proposition 2. *The optimal level of conservatism c* is:*

- *For $\bar{U} \in \left(0, \frac{p}{2(p_H - p)}\right]$, c* is any $c \in [\underline{c}, \bar{c}]$, where $0 < \underline{c} < \bar{c} < 1$ are characterized in Lemma 2. The bonus rates are $\beta_1^* = \frac{c(p_L - p_H) - p + p_H}{(c-1)H(p-p_H)(p_H - p_L)} < \beta_2^* = \frac{1}{(p_H - p)H}$, and the expected payment is $\frac{2p_H - p}{p_H - p}$ per agent.*
- *For $\bar{U} > \frac{p}{2(p_H - p)}$, $c^* = \frac{p_H(1 + 2\bar{U}) - 2p(1 + \bar{U})}{p_H}$ is increasing in $\bar{U}$ and equals one when $\bar{U} = \frac{p}{p_H - p}$. The bonus rates are $\beta_1^* = 0 < \beta_2^* = \frac{1}{(p_H - p)H}$, and the expected payment is $2(1 + \bar{U})$ per agent.*

Part (i) of the proposition shows that, as long as $\bar{U}$ is not too high, there is a range of accounting conservatism the principal can choose to ensure that the agents receive team incentives in period one and individual incentives in period two. The role of $c > 0$ is to make the punishment credible, creating a wedge between the equilibrium and punishment payoffs needed to deter

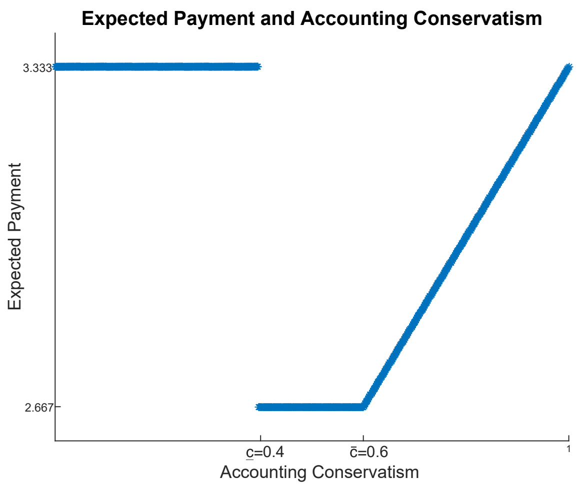

Fig. 1. Contracting Efficiency and Accounting Conservatism ($p_H = 0.5, p = 0.2, p_L = 0, \bar{U} = 0.3$).

free-riding. The optimal level of conservatism is non-unique: there is a range of (c, β_1) values that yield the same optimal compensation cost, with $\frac{d\beta_1}{dc} < 0$ (As will be shown in Section 4, the optimal level of conservatism is unique when we extend the analysis to include risk-averse agents.).

In Proposition 2 — Part (ii), $\bar{U}$ is so high that the only role of the optimal contract is to ensure that playing (*work, work*) in both periods is individually rational. To satisfy (Overall IR), the principal must either start using a first-period salary (while maintaining c at $\bar{c}$) or further increase the level of conservatism to defer more performance to the second period in which the higher bonus rate β_2 is employed. We characterize the second solution in the proposition.

We have assumed the principal offers a linear contract (α_t, β_t) sequentially at the beginning of each period $t = \{1, 2\}$. Suppose instead that the principal can commit to both periods' linear contracts (α_1, β_1) and (α_2, β_2) upfront (just after c is installed). Building on the numerical example used in Fig. 1, Fig. 2 below demonstrates how the compensation cost varies as a function of the level of conservatism. The only difference between Figs. 1 and 2 occurs for sufficiently low conservatism (i.e., $c < \underline{c}$), where team incentives are infeasible in Fig. 1. The ability to commit to the period-two contract (α_2, β_2) upfront allows the principal to provide partial team incentives for $c < \underline{c}$ in Fig. 2. The reason is that the principal can now commit to a positive fixed salary $\alpha_2 > 0$ to ensure that the (*shirk, shirk*) punishment is credible in period two. Nonetheless, both the optimal conservatism $c^* \in [\underline{c}, \bar{c}]$ and the expected payment under c^* are not affected by the principal's ability to commit to the short-term contract (α_t, β_t) upfront. In other words, our results are robust to an upfront commitment to the short-term contracts.

3.3. Conservatism vs. deferred compensation

In our model, conservatism fosters team incentives by *partially* deferring first-period high performance to the second period (and aggregating it with second-period performance). One may wonder if our conservatism-based mechanism can be replicated by a deferred compensation scheme (under unbiased measurement) in which the bonus for a high period-one performance $\beta_1 \times H$ is not paid out until period two.

Similar to a conservative accounting system, deferred compensation also shifts period-one pay to the second period, which has the potential benefit of making $\mathbf{e}_2^P = (0, 0)$ a credible punishment. However, the two schemes are qualitatively different in terms of the conditions under which each agent expects the deferral of payments. Under conservatism, the agents expect that some payments will be deferred to period two when the first-period accounting report is low, i.e., $y_1 = L$. Under the deferred compensation scheme coupled with unbiased accounting, the agents' payments are deferred from period one to period two only if $y_1 = H$. For deferred compensation, we need to restate (Mutual Monitoring) as follows to reflect the fact that playing the punishment $\mathbf{e}_2^P = (0, 0)$ is credible only if $y_1 = H$:[12]

$$\Pr(y_1 = H | e_1^i \neq e_1^j)\left(\frac{p_H - p_L}{p_H - p} - 1\right) \geq 1 - (p_H - p)\beta_1^D H. \qquad \text{(Monitoring under Deferred)}$$

This difference turns out to be important. We next show that an optimal conservatism-based scheme dominates the deferred compensation scheme in our model.

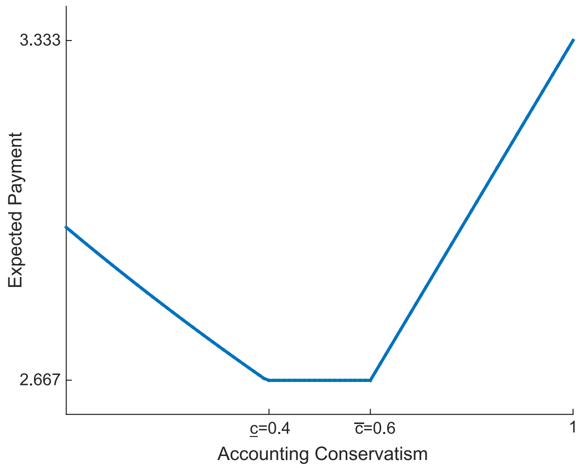

Fig. 2. Contracting Efficiency with Commitment ($p_H = 0.5, p = 0.2, p_L = 0, \bar{U} = 0.3$).

[12] β_1^D is the period-one bonus rate under deferred compensation and is derived in Appendix A.

Proposition 3. *The principal strictly prefers optimal accounting conservatism and the related optimal contracts to a deferred compensation scheme coupled with unbiased accounting.*

Intuitively, conservative accounting is preferred because the agents can punish the free-rider more often under conservatism than under a deferred compensation. Recall that conservatism makes the (*shirk, shirk*) punishment credible when the first-period reported performance is low, i.e., $y_1 = L$, while a deferred compensation makes the punishment credible when the reported performance is high, i.e., $y_1 = H$. Given the agents' complementary efforts, first-period performance is more likely to be reported as low under conservatism than as high under an unbiased system (and a deferred compensation scheme), given that one of the agents unilaterally shirked in the first period. The fact that a shirking agent is punished more often under the conservatism scheme makes it better suited to deterring free-riding and fostering team incentives.[13]

3.4. Long-term contracts

The main takeaway from our paper is that the inter-temporal aggregation of good news introduced by accounting conservatism can foster long-term, team-oriented incentives. So far, we have confined attention to short-term linear contracts (α_t, β_t). As we show in this subsection, if the principal can commit to a long-term and non-linear contract, she can achieve the first-best by choosing an information system with maximal conservatism ($c = 1$). The accounting system with $c = 1$ is equivalent to one that measures performance only at the end of the relationship ("ship accounting"), which is critical in shaping the agents' beliefs at the end of the first period.

Denote by $\mathrm{L} = \{S, w_L, w_H, w_{2H}\}$ the long-term contract, where $S \geq 0$ is a fixed salary and the bonuses (w_L, w_H, w_{2H}) depend only on the total output $x_1 + x_2 = \{L, H, 2H\}$ accumulated across the two periods. We place no restriction on the form of this bonus (e.g., linearity). This long-term contract L is coupled with maximally conservative reporting $c = 1$. Given the long-term contract L, the principal needs to ensure the following two conditions to motivate the agents to mutually monitor each other's effort in the first period:

$$U(\mathbf{e}_1 = (1,1), \mathbf{e}_2 = (1,1)) \geq U(\mathbf{e}_1 = (0,1), \mathbf{e}_2 = (0,0)), \qquad \text{(Mutual Monitoring LT)}$$

$$S + pp_L w_{2H} + [p(1-p_L) + (1-p)p_L]w_H + (1-p)(1-p_L)w_L \geq \bar{U}. \qquad \text{(Credible Punishment LT)}$$

(Mutual Monitoring LT) prevents the agent from unilaterally shirking in the first period and, hence, triggering the (*shirk, shirk*) punishment. (Credible Punishment LT) ensures that the punishment strategy is individually rational in period two. In addition, the principal needs to ensure that (*work, work*) is a stage-game equilibrium in the second period if the agents played (*work, work*) in the first period and that agents earn at least their reservation utilities $2\bar{U}$ across the two periods. The principal chooses the optimal long-term contract $\mathrm{L} = \{S, w_L, w_H, w_{2H}\}$ to minimize the cost of providing team incentives, $S + p_H^2 w_{2H} + 2p_H(1-p_H)w_H + (1-p_H)^2 w_L$, subject to (Mutual Monitoring LT), (Credible Punishment LT), (Period-2 Nash), and (Overall IR). The last two constraints are qualitatively similar to those in the main model, and, hence, are omitted for brevity.

Observation 1. *If the principal can commit to a long-term contract, it is optimal for her to set $w_H = w_L = 0, w_{2H} = \frac{2}{p_H^2}, S = 2\bar{U}$, and $c = 1$. The optimal long-term contract provides the principal with the first-best payoff.*

Here, conservatism plays a related but different role than it played in our main model. Maximal conservatism ($c = 1$) is equivalent to measuring the sum of first- and second-period performance only at the end of the game. Under long-term contracting, the role of conservatism is solely in hiding first-period bad performance (L) from the agent. In our main model, the role of conservatism includes both shaping the agents' beliefs and shifting rents from the first to the second period to create multiple equilibria the agents can use to punish each other. Here, the second-period equilibrium depends on the first-period play but is unique. In particular, playing (*shirk, shirk*) is the unique equilibrium in the second-period game if any agent deviated from *work* in the first period. So, the punishment here is not a choice to play the worst of multiple equilibria in the second period but rather to play the unique equilibrium that results from their diminished prospects of achieving high performance ($2H$) if (*work, work*) was not played in the first period.

We see the main model as the more natural one for studying conservatism because the co-mingling of performance across periods with periodic incentive rates that differ ($\beta_1 \neq \beta_2$) is the essential feature of conservatism we set out to study. Under long-term contracting, there is only a benefit to conservatism, i.e., there is no tradeoff. Under short-term contracting, a tradeoff arises in that conservatism becomes costly above a threshold level. Our approach is also in keeping with the view that first-best solutions are best seen as benchmarks.

Fig. 3 compares the long-term contracting benchmark to short-term contracting under conservative accounting and deferred compensation via an example. When the principal can commit to a long-term contract, she achieves the first-best by using maximum conservatism $c = 1$, and the compensation cost is $2(1 + \bar{U}) = 2.2$ per agent. Under the conservatism mechanism, the short-term contract bonus rate β_1 is chosen so that the agents are indifferent between both working and both shirking in the first period. The expected compensation cost, $\frac{2p_H - p}{p_H - p}$, is increasing in $p = \Pr(H|a^i \neq a^j)$ because a higher p

[13] $p_L = 0$ is a maintained assumption in our risk-neutral setup. If we relax that assumption, then $p \leq \frac{1}{2}$ is a sufficient condition for conservatism to be strictly preferred by the principal to deferred compensation.

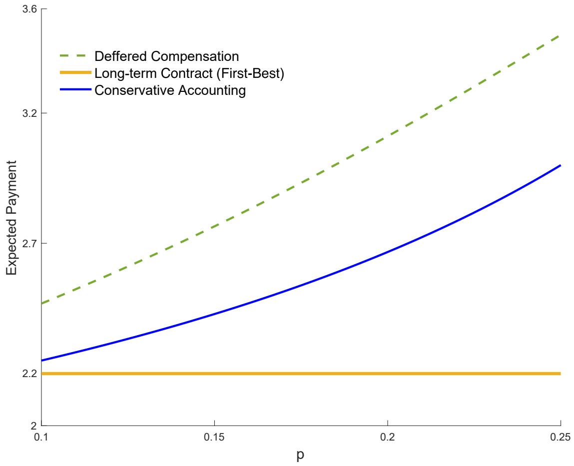

Fig. 3. Comparison among different mechanisms ($p_H = 0.5, p_L = 0, \bar{U} = 0.1$).

increases the cost of providing individual incentives in period two, i.e., a higher $\frac{p_H}{p_H - p}$. Compared to a conservative accounting system, deferred compensation is less efficient in providing team incentives in the first period because free riding is punished less often under deferred compensation.

4. Conservatism with risk-averse agents

This section extends our main result that conservatism fosters team incentives to a setting with risk-averse agents. The analysis also demonstrates a risk-related cost of increasing conservatism. We discuss how this risk-related cost affects the comparison between conservative accounting and deferred compensation.

The only difference from our main model is that contracting friction created by the limited liability constraint is now replaced by agent risk aversion. A risk-neutral owner contracts with two risk-averse managers and offers them a linear contract $w_t = \alpha_t + \beta_t \times y_t$ at the beginning of each period $t = \{1, 2\}$. As in Arya et al. (1997), we assume a constant absolute risk aversion (CARA) payoff $u^i(w_1, w_2, e_1^i, e_2^i) = -exp[-\rho(w_1 + w_2 - c(e_1^i) - c(e_2^i))]$, where $\rho > 0$ is the risk-aversion parameter and $c(e_t^i)$ is the cost of effort $e_t^i \in \{0, 1\}$ with $c(1) > c(0) = 0$. In addition to constant absolute risk aversion, this utility function is useful because the measurement properties that emerge are not driven by a demand for consumption smoothing. It is convenient to denote $F_t \equiv exp[-\rho\,\alpha_t]$, $t(s) \equiv exp[-\rho\, s]$, and $C[e_t^i] \equiv exp[\rho\, c(e_t^i)]$. We can substitute the linear wage w_t and rewrite $u^i(w_1, w_2, e_1^i, e_2^i) = -F_1 F_2\, t(\beta_1 y_1)\, t(\beta_2 R)\, t(\beta_2 x_2)\, C[e_1^i] C[e_2^i]$, where $R = x_1 - y_1$ is the reversal of the understated period-one performance due to conservatism.

Denote by $U(e_1^i, e_1^j, e_2^i, e_2^j)$ agent i's expected payoff across the two periods. We take the expectation of $u^i(w_1, w_2, e_1^i, e_2^i)$ over w_1 and w_2 to obtain

$$\begin{aligned} \mathrm{U}(e_1^i, e_1^j, e_2^i, e_2^j) &= \sum_{x_2} \left[\sum_{x_1, y_1} u^i(w_1, w_2, e_1^i, e_2^i) \cdot \Pr(x_1, y_1 | e_1^i, e_1^j) \right] \cdot \Pr(x_2 | e_2^i, e_2^j) \\ &= -F_1\, C[e_1^i]\, \mathbf{E}\left[t(\beta_1 y_1) \cdot t(\beta_2 R) | e_1^i, e_1^j \right] \times F_2\, C[e_2^i]\, \mathbf{E}[t(\beta_2 x_2) | e_2^i, e_2^j]. \end{aligned} \tag{5}$$

Let $U_2(e_2^i, e_2^j) = -F_2 C[e_2^i] \mathbf{E}[t(\beta_2 x_2) \big| e_2^i, e_2^j]$ be agent i's second-period payoff without the reversal of accruals. Arya et al. (1997) derive the optimal period-two contract. They show that α_2^* and β_2^* are chosen so that the (*work*, *work*) Nash incentive binds, and the (*work*, *work*) equilibrium sets each agent's payoff equal to the per-period reservation utility $\bar{U}$. That is, α_2^* and β_2^* are chosen to ensure $U_2(1,1) = U_2(0,1) = \bar{U}$. We next show that, given the productive complementarity assumption, (*shirk*, *shirk*) is also a Nash equilibrium and is Pareto-dominated by the (*work*, *work*) equilibrium. Therefore, (*shirk*, *shirk*) can be used as a punishment if anyone free rides in the first period.

Lemma 3. *Both (work, work) and (shirk, shirk) are Nash equilibria in period two. Further, (shirk, shirk) is Pareto dominated by (work, work), i.e.,* $U_2(0,0) < U_2(1,1) = \bar{U}$.

Lemma 3 shows that, for any reservation utility $\bar{U}$, playing the (*shirk*, *shirk*) punishment is *not* credible if the agents expect no reversal of accruals in the second period. This is because the second-period α_2^* and β_2^* are chosen so that, in the absence of an accrual reversal, the agents receive $\bar{U}$ in period two by playing the superior (*work*, *work*) equilibrium. Therefore, a necessary condition for the agents to play the inferior (*shirk*, *shirk*) equilibrium is that they expect a reversal (of understated performance) from the first period.

A conservative accounting system can help restore the credibility of the (*shirk*, *shirk*) punishment because of its delayed recognitions of good news and subsequent accrual reversal. Given a first-period low accounting report $y_1 = L$, playing (*shirk*, *shirk*) to punish the first-period free-rider is credible if the level of conservatism $c \geq \underline{c}^A$. The threshold $\underline{c}^A \leq 1$ is uniquely determined so that the agent's continuation payoff, $U_2(0,0) \times \mathbf{E}[t(\beta_2 R) \big| y_1 = L, e_1^i \neq e_1^j]$, which incorporates the expected accrual reversal, equals $\bar{U}$. That is, $c = \underline{c}^A$ sets:

$$U_2(0,0) \times \left[\frac{p\underline{c}^A}{p\underline{c}^A + 1 - p} t(\beta_2 H) + \frac{1-p}{p\underline{c}^A + 1 - p} t(0) \right] = \bar{U}. \tag{6}$$

Note that the reversal of accruals is compensated in period two at the rate of β_2, while the probability of having a reversal depends on period-one actions ($e_1^i \neq e_1^j$) and the level of conservatism $\underline{c}^A$.

The following proposition and corollary summarize the role of accounting conservatism in fostering team incentives under agent risk aversion.

Proposition 4. *With risk-averse agents, providing team incentives is feasible if and only if $c \geq \underline{c}^A$. For $c < \underline{c}^A$, it is optimal to provide individual incentives in both periods, i.e., $\alpha_1^* = \alpha_2^*$ and $\beta_1^* = \beta_2^*$. For $c \geq \underline{c}^A$, the first-period contract is lower-powered than the second-period contract: $\beta_1^* < \beta_2^*$.*

Corollary 1. *With risk-averse agents, it is uniquely optimal to set $c = \underline{c}^A$.*

Fig. 4 illustrates the results using a numerical example in which $p_H = 0.5, p = 0.2, p_L = 0.1, H = 1, \bar{U} = -0.1, \rho = 0.5$, and the cost of "work" is $c(1) = 0.1$. The optimal second-period contract is $\alpha_2^* = 4.54$ and $\beta_2^* = 0.34$. When there is no accrual reversal in period two, each agent's second-period payoff is $U_2(1,1) = -0.1 = \bar{U}$ and $U_2(0,0) = -0.102 < \bar{U}$. One can see that the (*shirk*, *shirk*) punishment is not credible because it is not individually rational.

Setting $c \geq \underline{c}^A = 0.45$ makes the (*shirk*, *shirk*) punishment credible when the first-period accounting report is low. For $c < \underline{c}^A = 0.45$, the (*shirk*, *shirk*) punishment is never credible, and the principal offers the individual incentive contract in both periods. As is shown in Fig. 4, increasing the level of conservatism over $0 < c < 0.45$ does not affect contracting efficiency because it does not matter when a good performance is reported if the contracts in both periods share the same bonus rates, i.e., $\beta_1^* = \beta_2^*$.

Team incentives are feasible for $c \geq \underline{c}^A = 0.45$, thanks to the presence of a credible punishment. At the optimal $\underline{c}^A$, the principal offers $\alpha_1^* = 4.58$ and $\beta_1^* = 0.19$ to implement team incentives in the first period. As in our main model, the second-period contract is higher-powered than the first period contract, i.e., $\beta_2^* = 0.34 > \beta_1^* = 0.19$, because the principal must provide individual (Nash) incentives in the second/last period. Conservatism delays some high first-period performance to the second period and, hence, imposes risk on the agents, since the second-period bonus rate is higher than the first-period bonus rate. This cost of conservatism was absent in our main model with risk-neutral agents, resulting in a range of conservatism levels that yield identical payoffs. With risk-averse agents, the additional risk premium created by conservatism means that the optimal level of conservatism is unique and equal to $c = \underline{c}^A$, as seen in Fig. 4.

Turning now to a comparison between conservatism and deferred compensation, deferred compensation has the advantage of not imposing additional risk on the agents. Under the utility function we have adopted, the agents are indifferent between being paid now and being paid that same amount later, but paying them later has the potential to make the punishment equilibrium individually rational in the second period. Conservatism has the same advantage over deferred compensation that it had in the main model: conservatism facilitates punishment when one of the agents free-rides in the first period. While deferred compensation makes the (*shirk*, *shirk*) equilibrium individually rational in the second period following high reported first-period performance, conservatism makes the (*shirk*, *shirk*) equilibrium individually rational following low reported first-period performance. This difference gives conservatism the advantage of allowing the agents to punish the unilateral "shirker" more often because first-period performance is more likely to be reported as low under

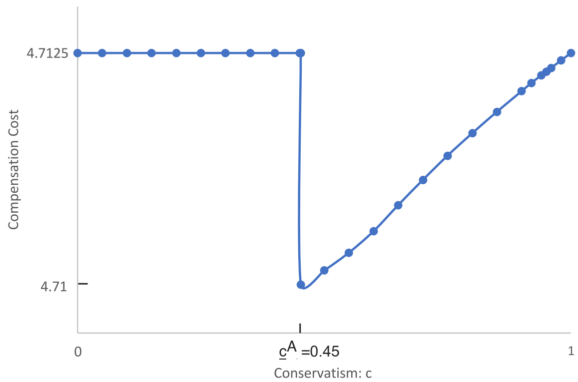

Fig. 4. Conservatism and compensation cost with risk-averse agents.

conservatism than as high under an unbiased system, given that one of the agents shirked in the first period. In short, conservatism has the advantage of making the punishment individually rational more often but comes with the cost of an increased risk premium. Because of the new risk-based cost of conservatism, deferred compensation is sometimes optimal.

The advantage of conservatism is more pronounced if the agents' productive technology exhibits a stronger complementarity, i.e., a smaller p given fixed values of p_H and p_L. To understand the result, note that, under a conservative system, playing (*shirk*, *shirk*) in period two is credible when $y_1 = L$, which occurs with probability $pc + 1 - p$ if an agent unilaterally shirks in period one. Under a deferred compensation scheme, the first-period "shirker" will be punished when $y_1 = H$ instead, which occurs with probability p. A stronger complementarity (i.e., a smaller p) favors conservatism because the "shirker" is punished more often under conservatism than under deferred compensation. We illustrate the importance of the degree of productive complementarity below using two examples. Table 1 – Part A uses the same numerical example as in Fig. 4, i.e., $p_H = 0.5$, $p = 0.2$, and $\rho = 0.5$. We increase p to 0.28 in Part B to capture a weaker complementarity (closer to productive independence $\frac{p_H+p_L}{2} = 0.3$). Conservatism is optimal under the parameters used in Part A, while deferred compensation is optimal under the parameters used in Part B. As one might expect, another way to make deferred compensation optimal is to increase the agent's risk aversion.

5. Implications for empirical researchers, regulators, and standard setters

We now discuss implications of our analysis for empirical researchers and regulators/standard setters. To the extent that some of these implications have been discussed by others, our model can be seen as providing a new theory for these predictions (and existing empirical results).

The role for conservatism we develop is an off-equilibrium role. Conservatism is valuable because it keeps relationships in check on the equilibrium path by making larger off-equilibrium threats credible. We should expect to be able to document the equilibrium role for conservatism (conservatism associated with stronger and more valuable relationships) rather than its off-equilibrium role (conservatism associated with larger punishments).

In our model, there is a connection between conservatism and corporate culture. In particular, conservative measurements are used to foster a team-based and long-run oriented culture rather than individualistic and myopic culture. Hence, one might expect conservatism to be associated with proxies for a team-based management culture such as low management turnover and the use of common performance measures in rewarding managers (e.g., Guay et al., 2019; Li, 2021). Applied to other relationships such as relationships between borrowers and lenders, buyers and suppliers, and sellers and customers, we should expect to see conservatism associated with lower relationship turnover in these settings.

If conservatism helps to foster long-term relationships and these relationships create unrecognized intangible assets that are valuable for shareholders, we should expect to see a greater gap between book value and market value for firms that adopt more conservative accounting, even after adjusting for the conservative measurement bias. To the extent that reporting on environmental, social, and governance (ESG) factors can be viewed as an attempt to report on relationships (e.g., with employees, suppliers, and customers) and conservatism fosters those relationships, we should expect to see conservative reporting associated with good ESG outcomes (e.g., low employee turnover and fair trading practices). In general, relational contracting seems to have much potential as a framework to use in understanding ESG reporting. Many ESG measurements seem to be designed to provide information about various relationships, including those with employees, suppliers, and customers.[14]

A common criticism of accounting conservatism is that it reinforces short-termism, inhibiting managers from engaging in long-term investments with positive NPVs.[15] In our model, conservatism fosters relationships, which can be seen as creating a long-term focus. By erring on the side of understatement when measuring uncertain future cash flows, accounting creates

Table 1

	c	α_1	β_1	Expected cost
Part A: conservatism dominates for a stronger complementarity ($p = 0.2$)				
Conservatism	0.45	4.581	0.188	4.710
Deferred compensation	0	4.552	0.320	4.712
Part B: deferred compensation dominates for a weaker complementarity ($p = 0.28$)				
Conservatism	0.58	4.546	0.159	4.715
Deferred compensation	0	4.533	0.361	4.713

14 Distelhorst and Shin (2022) documents a positive association between an ESG-type measure about the level of wages suppliers in developing countries pay their employees and the repeat business they receive from a large multinational garment retailer. This begs the question of why the retailer would want its supplier to pay higher wages. Perhaps, the retailer wants to promote stability of the workforce of the suppliers in order to obtain more reliably supply. That is, the buyer may be promising repeat business in exchange for suppliers promising to pay higher wages and, hence, provide more reliable supply.

15 See, for example, the hypothesis development in Clinch (1991) and survey evidence in Graham et al. (2005). Chy and Hope (2021) document evidence that conservatism reduces firms' long-term investments in innovation.

beliefs that support maintaining the relationship when it might otherwise be discontinued. If accounting conservatism fosters stability and enhances the value of relationships, firms for which relationships play a more crucial role should employ greater accounting conservatism.

The role of conservatism in fostering relationships may also provide an explanation for why we treat operating assets more conservatively than financial assets. Operating assets create value when combined with various intangible assets, including unrecognized intangible assets generated by relationships. Adopting conservative recognition and measurement rules for operating assets can be seen as fostering those relationship and, hence, the combined value of the recognized and unrecognized operating assets. In contrast, the value of financial assets is less reliant on relationships.

Cheng et al. (2016) provide evidence that real earnings management is negatively associated with a team-oriented culture. If conservatism fosters a team-based culture and a team-based culture dampens incentives for earnings management, conservatism should be associated with lower levels of earnings management. Introducing corporate culture as intermediate link between conservatism and earnings management provides a new mechanism for the common claim that conservatism combats earnings management. The usual explanation is that, by imposing a higher verification standard for the reporting of good news vs. bad news, accounting conservatism discourages the manager from making upward manipulations (e.g., Gao, 2013). We are not arguing that the direct link is unimportant. Instead, we are arguing that there might also be an indirect link involving corporate culture.

A novel feature of our analysis is that conservative measurements play an important role in shaping beliefs. Arguably, the focus of accounting regulators and standard setters (particularly the Financial Accounting Standard Board) is on providing decision-useful information, placing less emphasis on stewardship and contracting. One defense of this approach is that compensation committees are free to design their own performance measures to incorporate in contracts. However, even if measurements can be customized and contracted on for stewardship and other contracting purposes, financial reporting plays an important role in shaping the beliefs of some of the parties in those stewardship/contracting relationships. For example, it may be difficult for a board of directors to ignore poor financial accounting performance in making CEO retention/replacement decisions.

6. Conclusion

In this paper, we develop a role for accounting conservatism in fostering a team-based corporate culture. The key insight is that conservatism can be used to create beliefs that make an off-equilibrium punishment, needed to prevent free-riding, credible when it would otherwise not be.

The relational contracting framework seems to have a great deal of potential in studying the role of accounting conservatism in promoting trust in a variety of relationships. Adapting the arguments in Watts (2003), Hui et al. (2012) study the contracting role of conservatism in relationships firms have with their suppliers and customers, hypothesizing that suppliers and customers with significant bargaining power will require the firm to adopt conservative accounting policies in order to ensure that the firm will survive and relation-specific investments will be recovered. Perhaps, our theory can be extended to develop a broader role for accounting conservatism in promoting self-enforcing promises.

One limitation of our analysis is that we have relatively little to say about the cons of accounting conservatism. A natural downside of conservatism is that biased information can get in the way of good decision making. For example, if we introduce asymmetric information about the fit between the agent(s) and the firm and/or each other into our model, a conservative bias would presumably make assessing fit and deciding when to end vs. continue the relationship more difficult.

Partners in a relationship may be able to take actions to improve their fit (e.g., by acquiring skills that are valued by the other party). In a standard one-shot hold-up problem, partners underinvest in their relationships because the cost will be sunk and, hence, ignored when they bargain over the surplus created by their investments in the relationship. Relational contracting can mitigate this underinvestment problem. Agents can find it optimal to make themselves vulnerable so that the gap between the existing and a new relationship is expanded, which increases the punishment the agents can impose on each other by terminating the relationship (Halac, 2015). This increased penalty is valuable because it increases the agents' ability to enforce promises. Conservatism plays a similar role in our model. It may be interesting to extend our model to incorporate such relationship-specific investments to see if accounting conservatism is a substitute for or complement to these investments.

In general, the link between accounting and corporate culture seems an under-explored topic. Stepping back from our model, does a conservative management culture foster conservative accounting measurements? Do conservative measurements play a role in fostering/sustaining a conservative management culture? What would employees and others infer about new management and the culture they want to foster if they switched from a system of more conservative measurements to one of more aggressive measurements? What other properties of accounting systems play a role in shaping corporate culture?

Appendix B. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jacceco.2022.101571.

Appendix A

Proof of Lemma 1. We showed in the text that the solution to Period-2 Program is $\alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H-p)H}$, where β_2^* is solved from the binding constraint (Period-2 Nash). Substituting $\alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H-p)H}$, we express $U_2(0,0) = \frac{p_L}{p_H-p}$ and $U_2(1,0) = \frac{p}{p_H-p} - 1$. It is easy to show that (*shirk, shirk*) is a stage-game Nash equilibrium and hence self-enforcing:

$$\begin{aligned} U_2(1,0) - U_2(0,0) &= \frac{p}{p_H-p} - 1 - \frac{p_L}{p_H-p} \\ &= \frac{2p-(p_H+p_L)}{p_H-p} < 0, \end{aligned}$$

where the inequality follows from the productive complementarity $p_H - p > p - p_L$. Here, (*shirk, shirk*) is a punishment from the agents' point of view in that

$$U_2(0,0) = \frac{p_L}{p_H-p} < \frac{p}{p_H-p} = U_2(0,1) \le U_2(1,1),$$

where the last inequality follows from (Period-2 Nash). □

Proof of Proposition 1. For $\bar{U} \le U_2(0,0)$, the first period free-rider can always be punished in the second period because the punishment $\mathbf{e}_2^P = (0,0)$ is guaranteed to be individually rational. Given the second-period optimal contract $\alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H-p)H}$ and $c = 0$, one can derive $\beta_1 = \frac{1}{(p_H-p_L)H}$ by solving (Pareto Dominance) as a binding constraint. It is easy to verify that $\alpha_1^* = 0$ and $\beta_1^* = \frac{1}{(p_H-p_L)H}$ satisfy (Monitoring), which becomes the following because $\bar{U} \le U_2(0,0)$ implies $\Pr\left(V_2(\mathbf{e}_2^P, e_1^i \neq e_1^j, y_1) \ge \bar{U}\right) = 1$:

$$V_2(\mathbf{e}_2 = (1,1)) - V_2\left(\mathbf{e}_2^P\right) = U_2(1,1) - U_2(0,0) \ge U_1(0,1) - U_1(1,1).$$

The optimality of $\alpha_1^* = 0, \beta_1^* = \frac{1}{(p_H-p_L)H}$ and $c = 0$ follows by noting that β_1^* is lower powered than $\beta_2^* = \frac{1}{(p_H-p)H}$. □

Proof of Lemma 2. For Part (i), one can use Bayes' Rule to derive the left-hand side of (Credible Punishment) as

$$[\Pr(x_1 = H | e_1^i \neq e_1^j, y_1 = L) + p_L]\,\beta_2^* H = \left(\frac{pc}{pc+1-p} + p_L\right)\beta_2^* H.$$

Substituting $\beta_2^* = \frac{1}{(p_H-p)H}$, one can verify that $\left(\frac{pc}{pc+1-p} + p_L\right)\beta_2^* H$ equals $\bar{U}$ at $c = \underline{c} = \frac{(1-p)[\bar{U}(p_H-p)-p_L]}{p(pU-p_HU+p_L+1)}$. ($\underline{c} > 0$ is ensured under the maintained assumption $\bar{U} \le \frac{p}{p_H-p}$.) Since $\left(\frac{pc}{pc+1-p} + p_L\right)\beta_2^* H$ is monotonically increasing in the level of conservatism c, it follows that (Credible Punishment) is violated for any $c < \underline{c}$, in which case playing the punishment strategy $\mathbf{e}_2^P = (0,0)$ is not individually rational. Without a credible punishment in the second period, the principal cannot implement team incentives in the first period. As a result, the principal offers the individual incentive contract $\alpha_t = 0$ and $\beta_t = \frac{1}{(p_H-p)H}$ in both periods $t = 1, 2$. The expected payment across the two periods is $\frac{2p_H}{(p_H-p)}$ for each agent.

For Parts (ii) and (iii) of the lemma, we first solve the optimal contract of a relaxed program in which we drop the (Mutual Monitoring) constraint. We then verify that the optimal solution derived from the relaxed program satisfies (Mutual Monitoring). Let L be the Lagrangian of the relaxed program.

$$\begin{aligned} \mathbf{L} = \quad & \alpha_1 + p_H(1-c)\beta_1 H + p_H c \beta_2^* H - \lambda_{pareto} \times \text{Pareto Dominance} \\ & -\lambda_{credible} \times \text{Credible Punishment} - \lambda_{IR} \times \text{Overall IR} - \mu_\alpha \times \alpha_1 - \mu_\beta \times \beta_1, \end{aligned}$$

where $\beta_2^* = \frac{1}{(p_H-p)H}$ is derived from Period-2 Program and λ and μ are the Lagrangian multipliers of the corresponding constraints.

For $c \in [\underline{c}, \bar{c}]$, the two binding constraints are (Pareto Dominance) and the non-negativity constraint on α_1, from which we obtain the optimal solution

$$\alpha_1 = 0 \text{ and } \beta_1 = \frac{-cp_H + cp_L - p + p_H}{(c-1)H(p-p_H)(p_H-p_L)}.$$

The only non-zero Lagrangian multipliers are

$$\lambda_{pareto} = \frac{p_H}{p_H - p_L} \text{ and } \mu_\alpha = 1.$$

The (Overall IR) requires $\bar{U} \leq \frac{p}{2(p_H-p)}$. It is easy to show that $\frac{d\beta_1}{dc} < 0$ and $\beta_1 = 0$ as c incases to $\bar{c} = \frac{p_H-p}{p_H-p_L}$. One can verify that the solution α_1 and β_1 satisfy (Mutual Monitoring)—the constraint that is ignored in the relaxed program. This completes the proof of Part (ii).

For $c > \bar{c}$, setting $\alpha_1 = \beta_1 = 0$ satisfies all the constraints. This is clearly the solution that minimizes the expected payment, since $\alpha_2^* = 0$ and $\beta_2^* = \frac{1}{(p_H-p)H}$ are independent of the choice of β_1. The expected payment $\pi(c) = (p_H c + p_H)\beta_2^* H = \frac{p_H c + p_H}{p_H - p}$ increases in c, and it is easy to verify that $\pi(c=1) = \frac{2p_H}{p_H-p}$. In the last step, we substitute the optimal contract derived from the relaxed program and verify that (Mutual Monitoring) is satisfied for $c > \bar{c}$. □

Proof of Proposition 2. Part (i) of the proposition follows Lemma 2. We know that each agent's expected payment is a function of c as follows:

$$\pi(c) = \begin{cases} \dfrac{2p_H}{p_H - p}, & c < \underline{c}, \\ \dfrac{2p_H - p}{p_H - p}, & c \in \left[\underline{c}, \bar{c}\right], \\ \dfrac{p_H c + p_H}{p_H - p}, & c > \bar{c}, \end{cases}$$

where $\underline{c} = \frac{(1-p)[\bar{U}(p_H-p)-p_L]}{p(p\bar{U}-p_H\bar{U}+p_L+1)}$ and $\bar{c} = \frac{p_H-p}{p_H-p_L}$ are derived in Lemma 2. Straightforward algebra shows that $c \in [\underline{c}, \bar{c}]$ is optimal, and the expected payment is $1 + \frac{p_H}{p_H-p}$ for each agent.

For $\bar{U} > \frac{p}{2(p_H-p)}$, the contract specified in Part (i) is infeasible because it violates (Overall IR). In this case, the optimal $c^* = \frac{p_H(1+2\bar{U})-2p(1+\bar{U})}{p_H}$ is solved from the binding constraint (Overall IR). It is easy to verify that $c^* \in (0, 1]$ under the relevant range of $\bar{U}$ (recall $\bar{U} \leq \frac{p}{p_H-p}$ in (3)). The solution is optimal because the expected payment is $2(1+\bar{U})$ per agent, which is the sum of the agent's cost of effort and the reservation utility. □

Proof of Proposition 3. We have shown previously that team incentives $T = 1$ is strictly preferred by the principal to individual incentives. If the principal wants to implement team incentives using a deferred compensation coupled with unbiased accounting, she faces the same Period-2 Program and a similar but not identical Period-1 Program as those studied in the main model. The only difference in the Period-1 Program is that we need to restate (Mutual Monitoring) and (Credible Punishment) as follows:

$$\Pr(y_1 = H | e_1^i \neq e_1^j)\left(\frac{p_H - p_L}{p_H - p} - 1\right) \geq 1 - (p_H - p)\beta_1^D H, \qquad \text{(Monitoring under Deferred)}$$

and

$$\beta_1^D H + p_L \beta_2^* H \geq \bar{U}, \qquad \text{(Credible Punishment under Deferred)}$$

where β_1^D is the period-one bonus rate under the deferred compensation scheme.

It is without loss of generality to confine the analysis of deferred compensation to the case of $\bar{U} \leq \frac{p}{2(p_H-p)}$, because we show in Proposition 2 that the first best is achieved under conservatism for $\bar{U} > \frac{p}{2(p_H-p)}$. Given $\bar{U} \leq \frac{p}{2(p_H-p)}$, the optimal deferred compensation scheme is $\alpha_1 = 0$ and $\beta_1^D = \frac{p_H-p^2-p(1-p_L)}{H(p_H-p)^2}$. The solution is obtained from the binding constraints (Monitoring under Deferred) whose Lagrangian multiplier is $\frac{p_H}{p_H-p}$ and the non-negativity constraint on α_1 whose Lagrangian multiplier is 1. The expected compensation cost is $\frac{p_H(2p_H-p(2+p))}{(p_H-p)^2}$ per agent. Proposition 2 shows that the expected payment under conservatism is $1 + \frac{p_H}{p_H-p}$. One can see that the expected payment is lower under conservatism given the complementarity assumption $p_H - p > p - p_L$ and the normalization $p_L = 0$. □

Proof of Observation 1. Setting (Mutual Monitoring LT) and (Overall IR) as equalities and $w_H = w_L = 0$, one can solve for $w_{2H} = \frac{2}{p_H^2 - pp_L}$ and $S = 2\left(\bar{U} - \frac{pp_L}{p_H^2 - pp_L}\right)$. It is straightforward to verify that (Credible Punishment LT) is slack under the contract and that (Period-2 Nash) below is satisfied if and only if $p \leq \frac{p_H^2}{2p_H - p_L}$.

$$U_2(\mathbf{e}_2 = (1,1)|\mathbf{e}_1 = (1,1)) \geq U_2(\mathbf{e}_2 = (0,1)|\mathbf{e}_1 = (1,1)). \tag{7}$$

The condition $p \leq \frac{p_H^2}{2p_H - p_L}$ is implied by the complementarity of the team production technology $p < \frac{p_H + p_L}{2}$ and our normalization $p_L = 0$. The optimality follows because the expected payment under the solution is the first-best level $2(1+\bar{U})$, which only reimburses each agent for his cost of effort 1 and reservation utility $\bar{U}$ in both periods. □

Proof of Lemma 3. The agents' CARA utility function is $u^i(w_1, w_2, e_1^i, e_2^i) = -exp[-\rho(w_1 + w_2 - c(e_1^i) - c(e_2^i))]$, and the contract is $w_t = \alpha_t + \beta_t \times y_t$ for $t \in \{1, 2\}$. It is convenient to denote

$$F_t \equiv \exp[-\rho\,\alpha_t], \quad t(s) \equiv \exp[-\rho\,s], \text{ and } C[e_t^i] \equiv exp[\rho\,c(e_t^i)].$$

We can rewrite the utility function u^i as $u^i(w_1, w_2, e_1^i, e_2^i) = -F_1 F_2\, t(\beta_1 y_1)\, t(\beta_2 R)\, t(\beta_2 x_2)\, C[e_1^i] C[e_2^i]$, where $R = x_1 - y_1$ is the accrual reversal. Taking expectations of $u^i(w_1, w_2, e_1^i, e_2^i)$ over the realizations of x_1, y_1 and x_2, we obtain agent i's ex ante expected payoff across two periods as

$$\begin{aligned} U\left(e_1^i, e_1^j, e_2^i, e_2^j\right) &= \sum_{x_2}\left[\sum_{x_1, y_1} u^i\left(w_1, w_2, e_1^i, e_2^i\right) \cdot \Pr\left(x_1, y_1 \middle| e_1^i, e_1^j\right)\right] \cdot \Pr\left(x_2 \middle| e_2^i, e_2^j\right) \\ &= -F_1\, C\left[e_1^i\right] \underbrace{\mathbf{E}\left[t(\beta_1 y_1) \cdot t(\beta_2 R) \middle| e_1^i, e_1^j\right]}_{\Phi(e_1^i, e_1^j)} \times F_2\, C\left[e_2^i\right] \underbrace{\mathbf{E}\left[t(\beta_2 x_2) \middle| e_2^i, e_2^j\right]}_{\Gamma(e_2^i, e_2^j)}. \end{aligned} \tag{8}$$

Let $\Phi(e_1^i, e_1^j) \equiv \mathbf{E}\left[t(\beta_1 y_1) \cdot t(\beta_2 R) | e_1^i, e_1^j\right]$ and $\Gamma(e_2^i, e_2^j) \equiv \mathbf{E}[t(\beta_2 x_2) | e_2^i, e_2^j]$. That is,

$$\begin{aligned} \Phi(e_1^i, e_1^j) = {} & \Pr(x_1 = H | e_1^i, e_1^j)(1-c)\, t(\beta_1 H)\, t(\beta_2 L) + \Pr(x_1 = H | e_1^i, e_1^j)\, c\, t(\beta_1 L)\, t(\beta_2 H) \\ & + \Pr(x_1 = L | e_1^i, e_1^j)\, t(\beta_1 L)\, t(\beta_2 L), \end{aligned} \tag{9}$$

$$\Gamma(e_2^i, e_2^j) = \Pr(x_2 = H | e_2^i, e_2^j)\, t(\beta_2 H) + \Pr(x_2 = L | e_2^i, e_2^j)\, t(\beta_2 L). \tag{10}$$

Let $U_2(e_2^i, e_2^j) = -F_2 C[e_2^i] \Gamma(e_2^i, e_2^j)$ be Agent i's incremental payoff in the second period. Arya et al. (1997) show that the optimal period-two contract α_2^* and β_2^* are chosen so that the (*work*, *work*) Nash incentive binds, and the incremental payoff the agents earn in the "work" equilibrium equals the per-period reservation utility $\bar{U}$. That is, α_2^* and β_2^* are derived from setting $U_2(1,1) = U_2(0,1) = \bar{U}$, or, equivalently,

$$-F_2 C[1]\, \Gamma(1,1) = -F_2 C[0]\, \Gamma(0,1) = \bar{U}. \tag{11}$$

The proof of Lemma 3 uses condition (11). The claim that (*shirk*, *shirk*) is a Nash equilibrium means $U_2(0, 0) \geq U_2(1, 0)$. Recall $U_2(e_2^i, e_2^j) = -F_2 C[e_2^i] \Gamma(e_2^i, e_2^j)$. The Nash condition is equivalent to $C[0]\Gamma(0, 0) \leq C[1]\Gamma(1, 0)$. We conclude from (11) that $C[0] = C[1] \frac{\Gamma(1,1)}{\Gamma(0,1)} = C[1] \frac{\Gamma(1,1)}{\Gamma(1,0)}$, where the last equality uses the observation $\Gamma(1, 0) = \Gamma(0, 1)$ obtained from the definition of Γ in (10). Substituting $C[0] = C[1] \frac{\Gamma(1,1)}{\Gamma(1,0)}$, we show that the Nash condition $C[0]\Gamma(0, 0) \leq C[1]\Gamma(1, 0)$ is equivalent to $\Gamma(1, 1)\Gamma(0, 0) \leq \Gamma^2(1, 0)$, which can be shown to hold under the productive complementary assumption $p < \frac{p_H + p_L}{2}$.

Similarly, showing that (*shirk*, *shirk*) is Pareto dominated by (*work*, *work*) means $U_2(0, 0) < U_2(1, 1)$, or, equivalently, $C[1]\Gamma(1, 1) < C[0]\Gamma(0, 0)$. The condition can be further simplified as $\Gamma(1, 0) < \Gamma(0, 0)$ after substituting $C[0] = C[1] \frac{\Gamma(1,1)}{\Gamma(1,0)}$. It remains to note from the definition of Γ in (10) that $\Gamma(1, 0) < \Gamma(0, 0)$ holds for any $p > p_L$. □

Proof of Proposition 4. Agent i's continuation payoff in period two, V_2, is

$$V_2\left(e_2^i, e_2^j, \mathbf{e}_1, y_1\right) = U_2\left(e_2^i, e_2^j\right) \times \mathbf{E}[t(\beta_2 R) | y_1, \mathbf{e}_1], \tag{12}$$

where $E[t(\beta_2 R)|y_1, e_1] \leq 1$ is due to the accrual reversal. Following $y_1 = L$, playing (*shirk*, *shirk*) is individually rational if and only if the conservatism $c \geq \underline{c}^A$, where $\underline{c}^A \in (0, 1]$ is uniquely determined by $V_2(\mathbf{e}_2 = (0,0), \mathbf{e}_1 = (0,1), y_1 = L) = \bar{U}$, i.e.,

$$-F_2\, C[0]\, \Gamma(0,0) \times \left[\frac{p\underline{c}^A}{p\underline{c}^A + 1 - p} t(\beta_2 H) + \frac{1-p}{p\underline{c}^A + 1 - p} t(0)\right] = \bar{U}. \tag{13}$$

For $c < \underline{c}^A$, there is no credible punishment, and it is optimal for the principal to offer the same individual incentive contract in the first period, i.e., $\alpha_1^* = \alpha_2^*$ and $\beta_1^* = \beta_2^*$.

For $c \geq \underline{c}^A$, playing the (*shirk*, *shirk*) punishment is credible if $y_1 = L$. The following condition prevents the agents from free-riding in the first period:

$$\begin{aligned} \mathrm{U}(e_1^i = e_1^j = e_2^i = e_2^j = 1) &\geq \Pr(y_1 = L | e_1^i \neq e_1^j) \cdot \bar{\mathrm{U}}(e_1^i = 0, e_1^j = 1, e_2^i = e_2^j = 0) \\ &+ \Pr(y_1 = H | e_1^i \neq e_1^j) \cdot \bar{\mathrm{U}}(e_1^i = 0, e_1^j = 1, e_2^i = e_2^j = 1). \end{aligned} \tag{14}$$

In addition to preventing a unilateral deviation (14), the contract must ensure that, from the agents' point of view, playing (*work*, *work*) in both periods is not Pareto dominated by any other equilibrium in their subgame. Given Lemma 3, this is equivalent to ensuring that working in both periods Pareto dominates joint shirking in the first-period and returning to the stage equilibrium (*work*, *work*) in the second period:

$$U\left(e_1^i = e_1^j = e_2^i = e_2^j = 1\right) \geq U\left(e_1^i = e_1^j = 0, e_2^i = e_2^j = 1\right). \tag{15}$$

The period-one team incentive contract (α_1, β_1) also needs to ensure that the agents receive their overall reservation utilities across the two periods, i.e.,

$$U\left(e_1^i = e_1^j = e_2^i = e_2^j = 1\right) \geq -\bar{U}^2. \tag{16}$$

Fixing the level of conservatism $c \geq \underline{c}^A$, the optimal team incentives contract (α_1^*, β_1^*) is a solution to the following program:

$$\begin{aligned} \min_{\alpha_1,\beta_1} \quad & \alpha_1 + p_H(1-c)\beta_1 H + \alpha_2^* + (p_H c + p_H)\beta_2^* H \\ s.t. \quad & \text{Monitoring } (14) \\ & \text{Pareto } (15) \\ & \text{Overall IR } (16) \end{aligned}$$

The principal takes α_2^* and β_2^* as given in the first period. The lemma below is useful in proving $\beta_1^* < \beta_2^*$.

Lemma 4. The Overall IR constraint (16) binds. Therefore, a decrease in β_1 in the optimal contract is accompanied by an increase in α_1,

$$\frac{d\alpha_1}{d\beta_1} = -p_H(1-c)H\frac{t(\beta_1 H)}{\Phi(1,1)}. \tag{17}$$

Proof. The Overall IR constraint binds because, otherwise, the principal would lower α_1, which does not affect the other two constraints (14) and (15) and strictly benefits the principal. One can therefore apply the implicit function theorem to the binding constraint (16) to obtain $\frac{d\alpha_1}{d\beta_1} = -p_H(1-c)H\frac{\exp(-\rho\beta_1 H)}{\Phi(1,1)} < 0$. □

The proof that $\beta_1^* < \beta_2^*$ is built on Lemmas 3 and 4. We prove the claim by showing that constraints (14) and (15) are slack at $\beta_1 = \beta_2^*$, and that lowering β_1 from β_2^* (while increasing α_1 in the rate specified in Lemma 4) decreases the expected payments. The same argument shows that increasing $\beta_1 > \beta_2^*$ makes the principal worse off. We start by expressing the monitoring constraint (14) as $-C[1]\Phi(1,1)C[1]\Gamma(1,1) \geq -C[0]\Phi(0,1)[lC[0]\Gamma(0,0) + (1-l)C[1]\Gamma(1,1)]$, which is equivalent to

$$\frac{C[1]\Phi(1,1)}{C[0]\Phi(0,1)} \leq \left[l\frac{C[0]\Gamma(0,0)}{C[1]\Gamma(1,1)} + (1-l)\right], \tag{18}$$

where $l = \Pr(y_1 = L | e_1^i \neq e_1^j)$. Similarly, the Pareto dominance constraint (15) can be written as

$$C[1]\Phi(1,1) \leq C[0]\Phi(0,0). \tag{19}$$

If $\beta_1 = \beta_2^*$, it follows from the definitions (9) and (10) that $\Phi(e_1^i, e_1^j) = \Gamma(e_2^i, e_2^j)$ whenever $(e_1^i, e_1^j) = (e_2^i, e_2^j)$. It is shown below that the Pareto constraint (19) is slack at $\beta_1 = \beta_2^*$:

$$C[1]\Phi(1,1) = C[1]\Gamma(1,1) = C[0]\Gamma(0,1) < C[0]\Gamma(0,0) = C[0]\Phi(0,0). \tag{20}$$

The second equality $C[1]\Gamma(1,1) = C[0]\Gamma(0,1)$ is the binding Nash incentive in period two as shown in (11), while the inequality $C[0]\Gamma(0,1) < C[0]\Gamma(0,0)$ uses the fact that $\Gamma(0,1) < \Gamma(0,0)$, which follows from the definition of Γ in (10).

To see that the monitoring constraint (18) is also slack at $\beta_1 = \beta_2^*$, one can apply the argument below (20) to show that the left-hand side of (18) is $\frac{C[1]\Phi(1,1)}{C[0]\Phi(0,1)} = \frac{C[1]\Gamma(1,1)}{C[0]\Gamma(0,1)} = 1$. Recall from Lemma 3 that the period-two contract ensures $U_2(0,0) < U_2(1,1)$, which means $C[0]\Gamma(0,0) > C[1]\Gamma(1,1)$. Substituting $\frac{C[0]\Gamma(0,0)}{C[1]\Gamma(1,1)} > 1$ into (18), one can see its right-hand side is greater than one, and, therefore, the constraint is slack at $\beta_1 = \beta_2^*$.

Having shown that both (14) and (15) constraints are slack at $\beta_1 = \beta_2^*$, we can reduce β_1 so that the two constraints are still satisfied (the two constraints are independent of α_1). Meanwhile, we increase α_1 from α_2^* according to the rate specified in Lemma 4. To see that the lower-powered contract decreases the expected payments, note that the expected payments are unchanged if a unit decrease in β_1 is accompanied by $p_H(1-c)H$ units increase in α_1. We know from Lemma 4 that α_1 is increased at the rate of $p_H(1-c)H\frac{t(\beta_1 H)}{\Phi(1,1)}$. It is easy to verify that, at $\beta_1 = \beta_2^*$, $\frac{t(\beta_1 H)}{\Phi(1,1)} = \frac{\exp(-\rho\beta_1 H)}{p_H \exp(-\rho\beta_1 H)+(1-p_H)} < 1$. Therefore, the constructed (lower-powered) contract strictly decreases the expected payments. □

Proof of Corollary 1. Let (α_1, β_1) be the optimal solution for a given $c \geq \underline{c}^A$. It is easy to see that a higher c relaxes all three constraints. Because (Overall IR) binds under an optimal contract (see Lemma 4), we know that the principal will reduce β_1 or/and α_1 to exhaust the slack in (Overall IR). We prove the corollary by showing that the expected payments increases in $c \geq \underline{c}^A$. We first prove the following lemma.

Lemma 5. $\frac{\Phi(1,1)}{t(\beta_1 H)} \geq 1$ in any optimal contract.

Proof. Suppose, by contradiction, that $\frac{\Phi(1,1)}{t(\beta_1 H)} < 1$ under an optimal contract. One can increase β_1 and lower α_1 according to Lemma 4 so that (Overall IR) is maintained as an equality. Such a change is feasible because a higher β_1 relaxes (Monitoring) and (Pareto) and both constraints are independent of α_1. Given $\frac{\Phi(1,1)}{t(\beta_1 H)} < 1$, one can use the argument developed at the end of the previous proof to show that the expected payments are lower after the change, violating the assumption that the original contract is optimal. □

Having proved $\frac{\Phi(1,1)}{t(\beta_1 H)} \geq 1$, consider the case where $\frac{\Phi(1,1)}{t(\beta_1 H)} > 1$ holds as strict inequality under the optimal contract (α_1, β_1) prior to an increase in c. In this case, one can use the argument at the end of the previous proof to show that the optimal way to exhaust slack in (Overall IR) is to reduce β_1 while holding α_1 unchanged. (If the principal has to lower α_1 to exhaust the slack in (Overall IR) because other constraints prevent further reduction in β_1, the analysis is similar to what we show in the next paragraph.) We apply the implicit function theorem to (Overall IR) and obtain $\frac{d\beta_1}{dc} = \frac{t((\beta_2-\beta_1)H)-1}{(1-c)\rho H} < 0$. That is, β_1 will decrease by $\frac{1-t((\beta_2-\beta_1)H)}{(1-c)\rho H}$ units to exhaust the slack caused by one unit increase in c. In order to keep the expected payments unchanged, a unit increase in c must be accompanied by a decrease of $\frac{\beta_2-\beta_1}{1-c}$ units of β_1. To show that a higher c results in higher payments, it is sufficient to show $\frac{\beta_2-\beta_1}{1-c} > \frac{1-t((\beta_2-\beta_1)H)}{(1-c)\rho H}$, which is equivalent to

$$\rho(\beta_2-\beta_1)H > 1 - exp[-\rho(\beta_2-\beta_1)H]. \tag{21}$$

Recall $\beta_2 > \beta_1$ from Proposition 4. Hence, (21) follows by verifying that $\rho(\beta_2-\beta_1)H-(1-exp[-\rho(\beta_2-\beta_1)H])$ is increasing in $(\beta_2-\beta_1)$ and equals zero at $\beta_2 = \beta_1$.

Now, suppose $\frac{\Phi(1,1)}{t(\beta_1 H)} = 1$ under the optimal contract (α_1, β_1) prior to an increase in c. Because a higher c reduces $\frac{\Phi(1,1)}{t(\beta_1 H)}$, we know from Lemma 5 and the discussion above that the principal will increase β_1 to ensure $\frac{\Phi(1,1)}{t(\beta_1 H)} = 1$ and lower α_1 to exhaust the slack in (Overall IR). (Note that $\frac{\Phi(1,1)}{t(\beta_1 H)}$ is independent of α_1 and increases in β_1.). Suppose for now that α_1 is lowered according to (17) and let the resulting contract for a higher c be (α_1', β_1') with $\beta_1' > \beta_1$ and $\alpha_1' < \alpha_1$. Because $\frac{\Phi(1,1)}{t(\beta_1 H)} = 1$, substituting α_1 with β_1 according to (17) does not change expected payments. Therefore, in calculating the effects of moving from (α_1, β_1) to (α_1', β_1') on the expected payments and (Overall IR), we can focus on the direct effect of a higher c in increasing the payments and relaxing the constraint. The principal will further reduce α_1' to exhaust the slack in (Overall IR). We apply the implicit function theorem to (Overall IR) and obtain $\frac{d\alpha_1}{dc} = \frac{p_H[t(\beta_2 H)-t(\beta_1 H)]}{\rho\Phi(1,1)} < 0$. That is, the slack caused by a unit increase in c allows the principal to decrease α_1 by $\frac{p_H[t(\beta_1 H)-t(\beta_2 H)]}{\rho\Phi(1,1)}$ units. In comparison, a unit increase in c must be accompanied by a decrease of $p_H(\beta_2-\beta_1)H$ units of α_1 to keep expected payments unchanged. We show below $p_H(\beta_2-\beta_1)H > \frac{p_H[t(\beta_1 H)-t(\beta_2 H)]}{\rho\Phi(1,1)}$, which proves that expected payments are increasing in $c \geq \underline{c}^A$. Note that $p_H(\beta_2-\beta_1)H > \frac{p_H[t(\beta_1 H)-t(\beta_2 H)]}{\rho\Phi(1,1)}$ is equivalent to $\rho(\beta_2-\beta_1)H > \frac{1-t((\beta_2-\beta_1)H)}{\Phi(1,1)/t(\beta_1 H)}$, and the latter follows from

$$\rho(\beta_2-\beta_1)H > 1 - exp[-\rho(\beta_2-\beta_1)H] = 1 - t((\beta_2-\beta_1)H) \geq \frac{1-t((\beta_2-\beta_1)H)}{\Phi(1,1)/t(\beta_1 H)}.$$

The first inequality is shown in (21) and the last inequality uses the fact $\Phi(1,1)/t(\beta_1 H) \geq 1$ in Lemma 5. □

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