Performance-Based Contracts, Monitoring and Fraud

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Abstract

We characterize the optimal contract between the risk-neutral owner of a firm and a manager, whose effort affects firm’s (long-term) performance, and who can also manipulate short-term earnings reports to influence the stock price. We show that if the owner cannot commit to a contract or an auditing policy (which are interim suboptimal), the efficient contract involves a fixed wage for the manager and a grant of options and stock shares with a long vesting period. Misreporting and thus short-term stock price manipulation happens with positive probability at the equilibrium.

Keywords: Optimal contracts, Performance-based pay, Financial reporting, Auditing, Fraud

1 Introduction

Performance-based pay has become a popular compensation scheme intended to alleviate the moral hazard problem and align the incentives of top management with those of the rest of shareholders. Following the recent accounting scandals at Enron, WorldCom and other corporations, the practice

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has been heavily criticized for encouraging managers to manipulate information. Starting with (Healy 1985) and followed by more recent work by (Bergstresser and Philippou 2006), (Burns and Kedia 2006), (Johnson, Ryan, and Tian 2009), and (Kedia and Philippou 2009) the empirical research indicates that this is indeed a double-edged sword, as the stock-based executive compensation appears to be associated with earnings management, misreporting and restatements of financial reports. Ke (2001) shows that the CEO-s of firms with relatively high amounts of equity incentives are more likely to engage in earnings management by reporting small earnings increases more often than decreases. Gao and Shrieves (202) show that earnings management intensity, as measured by the absolute value of discretionary accruals, is increasing in the amount of options and bonuses, and decreasing in salaries. Cheng and Warfield (2005) find an association between the extent of stock-based compensation and the magnitude of abnormal accruals. Bruner, McKee, and Santore (2008) run an experimental study which shows that the amount of fraud is positively correlated with the amount of equity-based compensation and negatively correlated with the probability of detection and the subjects’ risk aversion.

Our paper investigates the benefits of a more sophisticated performance-based pay that involves random internal auditing as well as long- and short-term incentive-pay schemes in the context of a principal-agent problem with both hidden actions and hidden information. We consider the contracting problem between a manager and a firm, when the manager’s actions affect the value of the firm but they are not fully verifiable by the firm’s owners. In addition, in the short-run, the manager has superior information about the true value of the firm, which he can either reveal truthfully, or strategically hide from the owners by issuing a misleading report, in a attempt to manipulate the stock market price.

Since the stock market price can be manipulated in the short-run, the “informativeness principle” would suggest that the compensation package for the manager should be tied to long-term firm performance indicators. However, if the manager is risk-averse or more impatient than the owner, deferring payments later in the future is costly for the owner. In addition, a contract involving long-term payments may not be stable to renegotiation and thus it may not be credible.

On the other hand, making the manager’s short-term reporting more informative via auditing carries its own cost. In addition, to be effective, the auditing policy has to be communicated to the agent before the reporting
decision is taken. On the other hand, the actual auditing is carried on after the report is issued. This lag between the moment the policy is designed and the moment it is implemented creates a time-inconsistency problem. If a particular auditing policy is successful in deterring fraud, then from an ex-post perspective the principal has no incentives to audit. On the other hand, to serve as a deterrent, it must be credible that the policy will be implemented. Much of the literature on auditing bypasses this time-inconsistency problem by assuming that the principal can commit to an auditing policy and thus the policy will be implemented even when it is not ex-post optimal. However, commitment of this sort seems unrealistic. In particular, if the stated ex-ante audit probability is positive but not equal to 1, it is hard to monitor whether the principal is actually adhering to the contract or not.

Without commitment, an auditing policy is credible (and can serve as a deterrent) only if implementing it is interim incentive compatible for the principal. Here we assume, as in (Khalil 1997), that the auditor cannot commit to an auditing policy and thus the policy has to be ex-post incentive compatible. This restricts the class of auditing policies that can be implemented.

We analyze the implications of this restriction on the design and performance of the optimal compensation packages, as well as the incentives for fraud and misreporting of a manager, and contrast the cost of monitoring to the cost of offering long-term contracts.

There are two types of fraud that the manager can commit. One is simply “cooking the books” by inflating the firm’s earnings, with the sole purpose of manipulating the investors’ perception of the firm and thus increase the stock price and the received bonus. In our model, this type of fraud is captured by the manager not reporting truthfully the realization of the signal he observed. The second type of fraud typically involves making suboptimal investments or stealing. In our model this type of fraud is stylized as the manager not exerting the highest level of effort. Since lack of effort increases the probability of a bad outcome and also increases the manager’s utility, it can be interpreted either as making bad investments or as appropriating firm’s resources. To induce the manager to report truthfully, the firm offers him a contract that specifies a certain level of (internal) auditing, in addition to a compensation package that is tied to the performance of the firm via a combination of short- and long-term payments. We show that monitoring cannot eliminate the incentives to manipulate earnings generated by the short-term compensation, and that the ex-ante optimal contract should
consist of a fixed wage and grants of options and stocks with a long vesting period.

2 The Model

We consider a hidden-action and hidden-information model with costly state verification, in which a firm owner (the principal) is contracting with a manager (the agent) for a one-time project. There are three time periods, \( t = 0, 1, 2 \). The contract between the owner and the manager is initiated at date 0 and the project pays off at date 2. The project’s payoff depends in part on the effort level exerted by the manager. Let \( \pi \) denote the project’s payoff and let \( e \) denote the manager’s effort choice. We start with a very simple model in which there are only two effort levels, \( e \in \{0, 1\} \), and two possible payoffs, \( \pi \in \{y, 0\} \), with \( y > 0 \). If the manager exerts effort at \( t = 0 \) then the probability of obtaining a positive project payoff at \( t = 2 \) is \( \rho > 0 \). If the manager exerts no effort, then the project’s payoff at date \( t = 2 \) will be 0 with certainty. That is \( \text{Prob}(\pi = y|e = 1) = p > 0 \), \( \text{Prob}(\pi = y|e = 0) = 0 \).

Consumption takes place at dates 1 and 2. We assume that both the manager and firm’s owner are expected utility maximizers and they are both risk-neutral, but the manager is more impatient than the owner. The manager’s discount factor is \( \beta \in (0, 1) \), while the owner’s discount factor is 1. Manager’s utility over consumption (at dates 1 and 2) and effort is given by \( U(c_1, c_2, e) := E_0(c_1) + \beta E_0(c_2) - \Phi(e) \), where \( \Phi(1) = \phi > 0 \), while \( \Phi(0) = 0 \) (that is, effort reduces the manager’s utility). For simplicity, we also assume that manager’s reservation utility is 0. All this is common knowledge.

At \( t = 0 \), the owner offers the manager a take-it-or-leave-it contract which will be specified below. If accepted, the manager then has to decide on an effort level \( e \), which is exerted between periods 0 and 1 and it is not observed by the owner. At \( t = 1 \) the manager receives an early signal about the project’s payoff, \( m \in \{H, L\} \) and may issue a report \( R \) to the owner declaring the observed realization. The signal is imperfect, in the sense that it reveals the true payoff with probability \( \delta \in \left[\frac{1}{2}, 1\right] \). That is, \( \text{Prob}(m = H|\pi = y) = \text{Prob}(m = L|\pi = 0) = \delta \). The role of the parameter \( \delta \) is to capture the degree of manipulation uncertainty that is characteristic to some industries, for which there is more scope for different interpretations of the facts. For example, the message is more likely to be noisier (that is, \( \delta \) is lower) in high-growth, high-tech industries with more intangible assets (such
as patents) which are harder to value. The ex-ante informativeness of the signal is public knowledge (that is, $\delta$ is known to everyone), but the actual realization of the signal is observed only by the manager. Following the manager’s report, $R$, the market price of the stock adjusts to its equilibrium value, $p(R)$, and the manager is paid according to the agreed upon contract. At $t = 2$ (which is understood as the long-run) the payoff of the project becomes public knowledge.

Since neither the effort nor the realization of the date-1 signal are observable to the owner, the manager may choose to exert a low effort level and manipulate the report to his/her advantage. The owner thus attempts to design an employment contract to avoid or reduce such moral hazard by tying the compensation to the performance of the firm and penalizing the manager upon the discovery of misreporting. We assume that the owner has access to a monitoring technology (internal auditing) which allows him to verify the accuracy of manager’s date-1 report at a cost $\tilde{C}$. If misreporting is detected, the manager has to pay a penalty which will be specified later.

The contract for the manager can be designed to have short- and long-term payments, and it can also specify a monitoring intensity (in the form of a probability of auditing). Date-1 transfers and intensity of monitoring can be made contingent on the report issued by the manager (or, alternatively the stock price); date-2 payments are contingent on the realized, observable payoff of the project and, possibly, the report at date 1.

Note first that if there are no asymmetries of information, the manager has to be paid only at date 1 a wage of $\hat{w} = \hat{\phi}$ and required to exert the high level of effort. Throughout the paper we maintain the assumption that the disutility of effort is low enough, $0 < \hat{\phi} < \rho \cdot y$, so that exerting high effort is optimal in the absence of asymmetric information.

3 Optimal contract without monitoring

When managers have some preference for early consumption (because of a lower discount factor or risk-aversion), it is hard to commit to long-term contracts even when they are ex-ante optimal. After a manager has exerted effort

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1 Auditing, when performed, reveals the signal that the manager received, not the true state of the world. We also assume, for simplicity, that the success rate of detecting misreporting, when it happened, is 100%. Relaxing this assumption does not change the results in a substantive way.
the effort induced by a long-term contract, the contract no longer serves any incentives purpose. If the manager is more impatient (or more risk-averse) than the owner, it is in the interest of both to advance payments. If the manager cannot manipulate the short-term signal (that is, the owner observes the signal as well), no long-term contract is renegotiation-proof, so all contracts must be short-term in this case.

If the manager can manipulate the short-term signal, this has two effects on the optimal contract. On the one hand, it is harder to provide incentives to the manager to exert high effort with a short-term contract. On the other hand, the manipulation creates a lemons problem at the renegotiation stage, which makes the long-term contracts more likely to be stable to renegotiation.

In this section we identify conditions under which optimal renegotiation-proof contracts exit in this framework. Most of these results are taken from (Axelson and Baliga 2009) and reproduced here for completeness.

We assume, for now, that monitoring is not possible. Thus, a contract has to specify only date-1 and date-2 transfers \( t_1, t_2 \), where date-1 transfers can depend on the report issued by the manager, and date-2 transfers can depend on both the date-1 report and the observed realization of the projects’ payoff. Therefore, a contract is \( (t_1(R), t_2(R, \pi))_{R \in \{H, L\}, \pi \in \{0, y\}} \).

The contract is designed such that it minimizes the cost to the owner while inducing the manager to report truthfully at date 1 and exert the high level of effort at date 0. Ignoring for now the renegotiation-proofness constraint, standard arguments imply that, at such a contract, the following must be true:

\[
t_2(L, 0) = t_2(H, 0) = t_2(L, y) = t_1(H) = 0.
\]

Hence, the contract consists of offering the manager a menu of two contracts: \( \{(t_1, 0), (0, t_2)\} \), with the first one intended for the manager who receives the low signal, \( L \), at date 1 and the second for the manager who receives the high signal, with the payment \( t_2 \) being made contingent on the observation of the positive payoff realization for the project.

Thus, the contract must solve the following optimization problem:
\[
\min_{t_1,t_2 \geq 0} \{ P(L|1)t_1 + P(H|1)P(y|H)t_2 \}
\]

\[ t_1 \geq \beta P(y|L) \cdot t_2, \]  \hspace{1cm} (1)

\[ \beta P(y|H)t_2 \geq t_1, \]  \hspace{1cm} (2)

\[ P(L|1)t_1 + \beta P(H|1)P(y|H)t_2 - \phi \geq t_1. \]  \hspace{1cm} (3)

The unique solution of this problem is

\[
\frac{t_1}{t_1} = \frac{\phi P(y|L)}{P(H|1)[P(y|H) - P(y|L)]} = \frac{\phi(1-\delta)}{2\delta(1-\rho)}, \]  \hspace{1cm} (4)

\[
\frac{t_2}{t_2} = \frac{\phi}{\beta P(H|1)[P(y|H) - P(y|L)]} = \frac{\phi}{2\beta\rho} \left( 1 + \frac{1-\delta}{\delta} \cdot \frac{\rho}{1-\rho} \right), \]  \hspace{1cm} (5)

which costs the owner

\[
c = \frac{\phi}{P(y|H) - P(y|L)} \cdot \left( \frac{P(L|1) \cdot P(y|L)}{P(H|1)} + \frac{P(y|H)}{\beta} \right). \]  \hspace{1cm} (6)

Note that as \( \beta \) increases, the cost to the owner decreases. Thus, dealing with an impatient manager is costlier to the owner. Moreover, if \( \beta \) is large enough, this contract is renegotiation-proof. Precisely, if \( \beta \) satisfies

\[
\frac{1-\beta}{\beta} \leq \frac{P(L|1)}{P(H|1)} \left( 1 - \frac{P(y|L)}{P(y|H)} \right), \]  \hspace{1cm} (7)

there is no mutually beneficial renegotiation at date 1.

Let \( \bar{\beta} \) be the lowest value of \( \beta \) that satisfies (7). It can be shown that an optimal renegotiation-proof contract exists if and only if \( \beta \geq \bar{\beta} \) (see Proposition 2 in (Axelson and Baliga 2009)). Thus, for an impatient manager (whose discount factor \( \beta < \bar{\beta} \) violates (7)), every contract with a long-term component will be subject to renegotiation at date 1 and thus, without commitment, such contracts are not credible as of date 0. On the other hand, since the signal is not observable by the owner at date 1, it is impossible to induce high effort with a short-term contract.

We analyze next to what extent auditing, performed at date 1, can alleviate this non-existence problem.
4 Short-term contract with auditing

In this section we assume that long-term compensation is not allowed and thus \( t_2 \equiv 0 \). In particular, this implies that equity grants (with a long vesting period) cannot be part of the manager’s contract.

Thus, the contract offered to the manager has to specify three things: (1) the transfers he would receive, contingent on his report, \( (t_H, t_L) \), (2) the probability of being audited, which may also depend on the issued report, \( (\gamma_H, \gamma_L) \), and the penalty incurred if misreporting is detected.

We assume, as in (Khalil 1997), that the owner cannot commit to an auditing policy and thus the policy has to be ex-post incentive compatible. This restricts the class of auditing policies that can be implemented. The probability of auditing is endogenously determined and it is tied to the reporting strategy of the manager. For example, if the manager reports truthfully, the owner does not have an incentive to audit.

Note that to provide incentives for high effort, the contract must have \( t_H > t_L \). This in turn implies that if the manager issues the report \( R = L \), then he must be telling the truth, because he would have no incentive to misreport if the message was \( H \). Since the monitoring has to be ex-post incentive compatible for the owner, it must be the case that, the owner never uses the auditing technology upon receiving the report \( R = L \), and thus the optimal contract must have \( \gamma_L = 0 \). To save on notation we will thus omit \( \gamma_L \) from the specification of the contract and let \( \gamma_H = \gamma \).

4.1 Transfer-independent penalties

Assume first that the penalty for misreporting is a fixed fine \( F \), which is independent of the transfer the manager received that period. We also assume that there is some limited liability clause which imposes an upper bound, \( \bar{F} \) on the fine that the manager can be charged.\(^2\)

Hence, the contract offered to the manager in this case is of the form \( (t_H, t_L, \gamma, F) \), with \( t_H, t_L \geq 0 \), \( \gamma \in [0, 1] \) and \( 0 \leq F \leq \bar{F} \). The contract is designed by the owner to induce a high level of effort. At date \( t = 1 \), after observing the early signal, the manager issues a report \( R \). As discussed above, if the signal is \( H \), the manager will report truthfully. If the signal is \( L \), the

\(^2\)Note that the form of limited liability used here allows a negative net transfer to the manager.
manager has an incentive to report truthfully only if \( t_L \geq t_H - \gamma F \). For \( \gamma > 0 \) to be part of the optimal contract, it must be ex-post incentive compatible for the owner to monitor, and therefore it must be that the manager uses a mixed strategy for his report upon observing \( L \). Thus he must be indifferent between reporting truthfully or not, which implies that:

\[
t_L = t_H - \gamma F.
\]  
(8)

The owner’s net expected benefit from using the monitoring technology with probability \( \gamma \) upon receiving the report \( R = H \) is \( \gamma (F \cdot P(L|R = H) - C) \), and thus the owner chooses \( \gamma > 0 \) if and only if \( F \cdot P(L|R = H) \geq C \).

The auditing policy \( \gamma \) is ex-post incentive compatible for the owner if and only if

\[
\gamma \in \arg\max_{\gamma' \in (0, 1]} \gamma' \cdot (F \cdot P(L|R = H) - C).
\]  
(9)

To induce the high effort, the contract must satisfy:

\[
P(L|1)t_L + P(H|1)t_H - \phi \geq P(L|0)t_L + P(H|0)t_H,
\]
which is equivalent to \( (P(H|1) - P(H|0))(t_H - t_L) \geq \phi \) or, using (8),

\[
\gamma F \cdot (P(H|1) - P(H|0)) \geq \phi.
\]  
(10)

Let \( \sigma_e \in (0, 1) \) denote the probability that the manager reports truthfully after observing \( L \), when the previous period choice of effort was \( e \in \{0, 1\} \).

We find first the contract that minimizes owner’s costs while inducing a given probability of truthful reporting, \( \sigma_1 \), and then determine the optimal probability \( \sigma_1 \).

Note that if the manager’s strategy is to report truthfully with probability \( \sigma_1 \), then (9) implies

\[
1 - \sigma_1 \geq \frac{C}{F - C} \cdot \frac{P(H|1)}{P(L|1)}.
\]  
(11)

If the maximum permissible fine \( \bar{F} \) violates inequality (11), then the strategy \( \sigma_1 \) cannot be implemented via an incentive compatible auditing policy. If \( \bar{F} \) is low enough so that \( \frac{C}{F - C} \cdot \frac{P(H|1)}{P(L|1)} \geq 1 \), then no \( \sigma_1 > 0 \) can be implemented.

In the sequel we assume that \( \frac{C}{F - C} \cdot \frac{P(H|1)}{P(L|1)} < 1 \) and let \( \bar{\sigma} \) be the highest value of \( \sigma_1 \) for which \( \bar{F} \) satisfies (11). Thus, given the upper bound on the fine
that the manager may be required to pay when misreporting, only strategies \( \sigma_1 \leq \bar{\sigma} \) can be implemented.

The optimal contract designed by the owner must maximize the firm’s expected profit, subject to constraints (8), (10) and (9), which is equivalent to minimizing the firm’s costs subject to those constraints. Thus, the owner’s problem is:

\[
\min \{ P(R = H|1) t_H + P(R = L|1) \cdot t_L + \gamma P(R = H|1) [C - F \cdot P(L|R = H)] \}
\]

\[
t_L = t_H - \gamma F, \quad \gamma F \cdot [P(H|1) - P(H|0)] \geq \phi, \quad \gamma \in \arg\max_{\gamma \in (0,1]} \gamma' \cdot (F \cdot P(L|R = H) - C).
\]

For \( \sigma_1 \leq \bar{\sigma} \), the solution of the above problem is:

\[
t_L = 0, \quad t_H = \frac{\phi}{P(H|1) - P(H|0)}, \quad F = C \left( 1 + (1 - \sigma_1) \frac{P(H|1)}{P(L|1)} \right), \quad \gamma = \frac{\phi}{F(P(H|1) - P(H|0))}.
\]

The cost to the owner is \( \frac{\phi P(R = H)}{P(H|1) - P(H|0)} \), which is decreasing in \( \sigma_1 \) and thus it is optimal for the owner to set \( \sigma_1 = \bar{\sigma} = 1 - \frac{C}{F - C} \cdot \frac{P(H|1)}{P(L|1)} \). Using that \( P(H|1) = \rho \delta + (1 - \rho)(1 - \delta) \), \( P(H|0) = 1 - \delta \) and \( P(R = H) = P(H|1) + (1 - \sigma_1) P(L|1) \), the optimal contract and cost to the owner can be written as follows:

\[
t_H = \frac{\phi}{\rho(2\delta - 1)}, \quad \sigma_1 = 1 - \frac{C}{F - C} \cdot \frac{\rho \delta + (1 - \rho)(1 - \delta)}{\rho(1 - \delta) + (1 - \rho)\delta}, \quad \gamma = \frac{\phi}{\rho F(2\delta - 1)}, \quad c = \frac{\bar{F}}{F - C} \cdot (\rho \delta + (1 - \rho)(1 - \delta)) \cdot \frac{\phi}{\rho(2\delta - 1)}.
\]

This shows that without the ability to commit to a particular monitoring intensity, misreporting cannot be eliminated completely, even when the monitoring technology has a 100% fraud detection rate. If monitoring intensity
has to be ex-post incentive compatible, then misreporting will happen with a positive probability that is decreasing in the severity of the punishment, $\bar{F}$ and increasing in the cost of monitoring, $C$. On the other hand, the intensity of monitoring, $\gamma$ increases when it is more costly for the manager to exert high effort (that is, when disutility of effort, $\phi$, increases) and decreases with the severity of the punishment.

Interestingly, the intensity of monitoring is not affected by the cost of using the technology. This means that if the cost of monitoring decreases, one should expect an increase in the compliance rate without a change in the monitoring intensity. If the monitoring costs decrease, the owner will, ceteris paribus, have an incentive to increase the monitoring intensity. The results highlight the fact that this incentive alone serves as an effective fraud deterrent. The compliance rate increases simply because the manager tries to avoid an increase in the intensity of monitoring.

By contrast, an increase in the maximum allowable punishment for fraud triggers a higher compliance rate and a lower monitoring intensity. The severity of the punishment directly affects the manager’s decision to report truthfully. Without a change in the intensity of monitoring, an increase in the punishment will lead to full compliance, but then monitoring will no longer be ex-post incentive compatible. Knowing that a higher punishment triggers higher compliance the owner will have an incentive to reduce the monitoring intensity.

The degree of uncertainty in the industry (that is, the magnitude of $\delta$ has a significant effect on all variables. As $\delta$ increases (that is, the signal becomes more precise and it is thus easier to separate misreporting from inherent industry uncertainty), $t_H$ decreases. That is, the incentive pay has to be larger in more uncertain industries.

On the other hand, $1 - \sigma$ is higher if $\delta$ is higher, which means that the manager has higher incentives to misreport if the firm is part of an industry with a higher degree of uncertainty (in which past performance is a poor predictor of future performance). Interestingly, the intensity of monitoring decreases as $\delta$ increases. This may seem surprising; however, $\sigma$ is the probability of truthful reporting contingent on receiving the low signal. This is not the frequency with which a positive report turns out to be false. That probability is $\text{Prob}(L|R = H)$, which is decreasing in $\delta$. Thus, as the signal becomes more precise, both the frequency of false positive reports and the monitoring intensity decrease.

The cost to the owner is decreasing in $\delta$ and $\bar{F}$ and increasing in the
auditing cost $C$ and the disutility of effort $\phi$. Note also that the manager receives the same transfers here as in the case of full transparency with respect to the early signal. However, because of the asymmetric information and the fact that misreporting happens with positive probability, the cost to the owner is higher (amplified by a factor of $\frac{\bar{F}}{\bar{F} - C}$).

4.2 Transfer-dependent penalty

Assume now that the limited liability clause prevents the owner to extract money from the manager and thus the maximum penalty for non-compliance is the retention of the transfer. Hence, the contract offered to the manager in this case is of the form $(t_H, t_L, \gamma)$, with $t_H, t_L \geq 0$, $\gamma \in [0, 1]$

The manager who receives the low signal at date 1 is indifferent between reporting truthfully or not if

$$t_L = (1 - \gamma)t_H. \quad (12)$$

To induce the high effort, the contract must satisfy, as before:

$$P(L|1)t_L + P(H|1)t_H - \phi \geq P(L|0)t_L + P(H|0)t_H,$$

which is equivalent to $(P(H|1) - P(H|0))(t_H - t_L) \geq \phi$ or, using $t_L = (1 - \gamma)t_H$,

$$\gamma t_H (P(H|1) - P(H|0)) \geq \phi. \quad (13)$$

The auditing policy $\gamma$ is ex-post incentive compatible for the owner if and only if

$$\gamma \in \arg\max_{\gamma' \in (0, 1]} \gamma' \cdot (t_H \cdot P(L|R = H) - C). \quad (14)$$

The owner’s problem is:

$$\min \{P(R = H|1)t_H + P(R = L|1) \cdot t_L + \gamma P(R = H|1) \cdot [C - t_H \cdot P(L|R = H)]\}$$

$$t_L = (1 - \gamma)t_H,$$

$$\gamma t_H \cdot [P(H|1) - P(H|0)] \geq \phi,$$

$$\gamma \in \arg\max_{\gamma' \in (0, 1]} \gamma' \cdot (t_H \cdot P(l|r = h) - C).$$

Standard arguments imply that the second inequality must be binding at the optimum, and thus $t_H = \frac{\phi}{\gamma\rho(2\delta - 1)}$, and $t_L = \frac{\phi(1 - \gamma)}{\gamma\rho(2\delta - 1)}$.

If $\frac{\phi}{\rho(2\delta - 1)} \geq \frac{C}{P(l|r = h)}$, then (14) implies that $\gamma = 1$ and thus $t_L = 0$ and

$$t_H = \frac{\phi}{\rho(2\delta - 1)}. \quad \text{If } \bar{\sigma} \in [0, 1] \text{ is the solution of } \frac{\phi}{\rho(2\delta - 1)} = \frac{C}{P(L|R = H)}, \text{ then, to}$$
implement any \( \sigma_1 < \bar{\sigma} \), auditing has to happen with certainty. In this case the cost to the owner is
\[
P(R = H) \left( C + \frac{\phi}{\rho(2\delta - 1)} P(H|R = H) \right) = C \cdot P(R = H) + \frac{\phi}{\rho(2\delta - 1)} P(H),
\]
which is decreasing in \( \sigma_1 \) and thus the owner would want to induce strategy \( \bar{\sigma} \) on this domain.

If \( \sigma_1 > \bar{\sigma} \), then auditing has to happen with probability
\[
\gamma = \frac{\phi}{\rho(2\delta - 1)} \cdot \frac{P(L|R = H)}{C} < 1,
\]
and therefore
\[
t_H = \frac{C}{P(L|R = H)},
\]
\[
t_L = \frac{C}{P(L|R = H)} - \frac{\phi}{\rho(2\delta - 1)}.
\]

In this case, the cost to the owner is \( \frac{C}{P(L|R = H)} - P(R = L) \cdot \frac{\phi}{\rho(2\delta - 1)} \), which is increasing in \( \sigma_1 \).

Hence, the owner would want to induce the strategy \( \bar{\sigma} \), by auditing with probability 1 and offering transfers \( t_L = 0 \) and \( t_H = \frac{\rho}{\rho(2\delta - 1)} \). Compared to the case of full transparency of the signal, the cost to the owner is increased by \( \phi(1 - \bar{\sigma}) \cdot P(L) \).

The above results show that, if the manager is sufficiently patient (\( \beta \) is high enough), none of these contracts can improve upon the long-term contract by increasing transparency at date 1.

5 Long-term contracts with auditing

As shown in Section 3, a renegotiation-proof long-term contract exists if the manager is sufficiently patient. The results of the previous section have shown that a short-term contract enhanced by monitoring cannot dominate the long-term renegotiation-proof contract. We investigate next if auditing while still maintaining the long-term component of the contract improves efficiency.

To understand why auditing at date 1 might improve efficiency, consider the following simple exercise. Assume there is an exogenous probability \( \gamma \) of
auditing at \( t = 1 \). If misreporting is detected upon auditing, then the entire transfer is retained. As in Section 3, the manager is offered a menu of two contracts. For each of them, the transfers are contingent on receiving a high value report from the manager. The first contract promises a transfer \( t_1 \) at date 1 and nothing at date 2, while the second promises nothing at date 1 and a transfer \( t_2 \) at date 2 contingent on the realization of the high payoff value. As before, the first contract is intended for the manager who receives the low signal, while the second is intended for the one who receives the high signal.

Clearly, under this contract, the manager will issue a high-value report irrespective of the signal received. The manager who receives the low signal prefers the short-term contract if

\[
(1 - \gamma)P(L|1) = (1 - \gamma)\beta P(y|L) \cdot t_2 \geq (1 - \gamma)P(L|0)t_1 + P(H|0)t_1,
\]

which is equivalent to

\[
\beta P(H|1)P(y|H)t_2 \geq \phi + t_1 [(1 - \gamma)P(H|1) + \gamma P(H|0)].
\] (16)

For a given \( \gamma \in [0, 1] \), the contract that minimizes owner’s costs is:

\[
t_1(\gamma) = \phi \frac{P(y|L)}{P(H|1)} \cdot \frac{1}{P(y|H) - P(y|L) \left[ 1 - \gamma + \gamma \frac{P(H|0)}{P(H|1)} \right]},
\] (17)

\[
t_2(\gamma) = \phi \frac{1}{\beta P(H|1)} \cdot \frac{1}{P(y|H) - P(y|L) \left[ 1 - \gamma + \gamma \frac{P(H|0)}{P(H|1)} \right]},
\] (18)

The cost to the owner is

\[
c(\gamma) = (1 - \gamma)P(L|1)t_1(\gamma) + P(H|1)P(y|H)t_2(\gamma).\]

Note that if \( \gamma = 0 \), the model is equivalent to the one described in Section 3 in which full manipulation of the signal is possible. Also, the transfers are decreasing in \( \gamma \). That is because as \( \gamma \) increases, the likelihood that a manager
who received the low signal will be paid decreases. Since the chances of getting the low signal are higher under low effort, this effectively serves as an additional deterrent against low effort and makes the incentive constraint for exerting high effort easier to be satisfied. Clearly, since the transfers decrease with \( \gamma \), the cost is also decreasing in \( \gamma \). Hence, the owner should select the highest value of \( \gamma \) for which the renegotiation-proof condition is still satisfied, that is,

\[
\frac{1 - \beta}{\beta} \leq (1 - \gamma) \frac{P(L|1)}{P(H|1)} \left( 1 - \frac{P(y|L)}{P(y|H)} \right).
\]  

(21)

This suggests that, in principle, monitoring at date 1 could improve the efficiency of the contract. We investigate next if this outcome can indeed be implemented via an auditing policy that is ex-post efficient for the owner.

For every \( \beta \geq \bar{\beta} \), let \( \gamma^*(\beta) \) be the highest value of \( \gamma \) that satisfies inequality (21). Clearly, \( \gamma^*(\bar{\beta}) = 0 \). The contract described above can be supported via an ex-post efficient policy in which the manager is audited with probability \( \gamma^*(\beta) \) if and only if

\[
C \leq P(L|1) \cdot t_1(\gamma^*(\beta)).
\]

6 Replicating the contract with stock and options

In this section we show that the contracts described before can be replicated via a compensation package consisting of stocks and options.

The manager’s payments consisting of transfers \((t_1, t_2)\) can be made contingent on the realization of the market stock price at that date. As before, the contract also specifies a probability of monitoring, \( \gamma \), which is carried on if the stock price reaches a certain level.

We start by analyzing how the manager’s reporting at date 1 affects the stock price. We assume that a non-negligible segment of the market consists of risk-neutral investors with a time discount factor of 1 (that is, the risk-free gross interest rate is 1). Then, the market price of any asset must be equal to the discounted expected value of its payoff. Hence, the stock price following the report \( R \in \{H, L\} \) is

\[
p(R) := P(y|R)y.
\]  

(22)
where $P(y|R)$ is market’s updated belief that the value is high, upon observing the manager’s report $R$. At equilibrium, these beliefs have to be consistent with the manager’s reporting strategy. If $\sigma$ is the probability with which the manager reports truthfully upon observing the low signal, then the market beliefs can be computed as follows using Bayes’ rule:

\begin{align*}
P(y|H) &= \frac{\rho(1 - \sigma(1 - \delta))}{1 - \sigma P(L|L)}, \quad (23) \\
P(y|L) &= \frac{\rho(1 - \delta)}{P(L|L)}. \quad (24)
\end{align*}

As these formulas suggest, the owner can induce a particular reporting strategy by setting a specific target for the stock price and conditioning transfers on that price. Thus the contract would specify a target stock price level and transfers contingent on the target being reached.

References


