Organizational reputation and agency

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Abstract

We model a professionally managed firm with a single asset — its organizational reputation. In contrast to classic reputation models under incomplete information, (1) the firm’s owner and manager are distinct agents with conflicting interests, (2) reputation adheres to the firm through its “oversight system,” a feature of the firm’s organization that restricts the manager’s ability to act in his own interests, and not its manager’s “type.” These realistic features of modern corporations dramatically affect the conditions for reputation formation: Firm reputation depends on outsiders’ perceptions about the viability of its oversight system. Not only can the firm maintain a reputation when outsiders believe it is highly likely to be the “bad type” with a relatively ineffective oversight system, but its reputation can be highest under these circumstances.

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Whose reputation is at risk: the organization, or the managers who run them? Are their interests aligned? This is the classic double agency dilemma—when things go well, management and the organization are rewarded via share premiums, compensation, and the like. When things go badly, it is the organization which is jeopardized by reputation risk, even though, too often, management does very well indeed. Moral hazard is real.

–McMillan (2011)

1 Introduction

McMillan’s quote highlights two characteristics that are widely acknowledged to be central to corporate reputations, which are arguably corporations’ most valuable asset (e.g., Gaines-Ross, 2008; Nakamura, 2009; Economist, 2018). First, like brand value with customers, a corporate reputation is an intangible asset that adheres to the firm itself (e.g., Burke, 2011; Davies, 2011; Barnett and Pollock, 2012). This “organizational reputation” is distinct from “managerial reputation,” which depends on characteristics of firm employees rather than the firm itself (e.g., Hodges, 2011; Macey, 2013). Second, corporate reputations are threatened by the agency problem arising from the separation of firm ownership and management: While managers’ actions influence firm reputation, managers do not enjoy the full benefit or cost of firm reputation since these flow primarily to firm owners. Frequent incidents of corporate reputation damage that have arisen from the actions of managers and been extremely costly for firm owners provide ample evidence of this agency conflict and its significant consequences.

While there are many models of the owner/manager agency conflict, the models do not account for the conflict’s effect on outsider perceptions of the firm, which is the basis for firm reputation. Hence, these agency models cannot speak to firm reputation when owner and manager are in conflict. Economists have also developed many models to explain why firm reputations are valuable and how the reputations are maintained. However, these reputation models do not distinguish between owners and managers and thus do not account for the agency conflict. Most also do not distinguish between organizational reputation and managerial reputation. Thus, while models of firm reputation may be well suited to capture reputations of entrepreneurial firms and partnerships, they are not particularly suited to capture reputations of modern corporations, which tend to have “distant” owners and relatively anonymous and “reputationless” managers.

In this paper, we adapt the classic asymmetric information-based reputation framework of Kreps and Wilson (1982b) and Milgrom and Roberts (1982) to examine corporate reputations that are founded on distinctive features of organizational structures and are threatened by agency conflicts. To introduce reputation founded on organizational structure, we allow the firm’s “oversight system,” a part of its organizational

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1Economist (2018) discusses recent incidents of damage to corporate reputations and the large toll they have extracted on firm values. Prominent examples of oversight system failures that have damaged firm reputations include Facebook (privacy controls), Kobe Steel (falsifying quality), Wells Fargo (fake accounts), Lululemon (too-sheer pants), Barclays (manipulating LIBOR rates), J. P. Morgan (rogue trading), Toyota (uncontrolled acceleration), and Volkswagen (falsifying emissions tests).

2See Bar-Isaac and Tadelis (2008) for an extensive survey of reputation models.

3Exceptions include Kreps (1996) and Levin and Tadelis (2005).
structure, to determine the firm’s “type”.

The oversight system represents organizational features that are intended to restrict the manager’s ability to act in his own interest at the expense of the organization. Therefore, in accordance with Weigelt and Camerer’s (1988, p. 443) definition: “A corporate reputation is a set of attributes ascribed to a firm, inferred from the firm’s past actions.” As in the classic models, the firm can either be a “good type” (with a completely effective oversight system) or a “bad type” (with an ineffective system), and the firm’s type is privately known to the manager but not to outsiders. To completely break the link between the firm’s reputation and that of its manager, we assume that all managers share the same commonly known characteristics. Similarly, the owner’s characteristics are common knowledge. Since there is no private information about either the owner’s or manager’s characteristics, consistent with the views of March and Weil (2005), no reputation can arise from their characteristics.

To introduce the agency conflict, we assume that the firm’s owner and manager are distinct agents. The manager is self-interested. He operates the firm, and managerial self-dealing jeopardizes its reputation by stochastically precipitating a drop in product quality. The manager poses a real threat to the firm’s reputation because, while he benefits from self-dealing, he is not endowed with an ownership claim on the firm’s reputational rents to offset his destructive impulses. These rents belong to the owner and residual claimant, who shoulders the reputation risk of the manager’s self-dealing. The agency conflict is further exacerbated because the owner, like consumers, is uninformed about the firm’s type and can only learn it from the manager’s actions. To align the manager’s interests, the owner can offer the manager incentive compensation and choose when to terminate the manager.

In our model, the firm operates profitably and earns reputation rents only so long as the manager’s actions do not “reveal” it to be a bad type to outsiders. This revelation can only occur when the quality of the firm’s output drops, since low quality is only possible when the oversight-system is ineffective and permits managerial-self dealing. Once the firm is revealed to be the bad type, as in the KWMR framework, “unraveling” by backward induction ensures that the firm becomes economically unviable.

To assure outsiders that the oversight system is at least partially effective, the manager must act “reputably” by eschewing self-dealing. If the oversight system is effective, it alone can ensure that the manager acts reputably. If the oversight system is ineffective, only incentive compensation can curb managerial self-dealing. The owner’s and outsiders’ shared beliefs about the oversight system play a key and complex role

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4In the KWMR framework, the firm’s type is determined solely by its manager’s privately observed characteristics. Its reputation is wholly founded on uninformed outsiders’ beliefs about the manager’s hidden characteristics. Tirole (1996) develops a model in which firm reputation is based on the average characteristics of a team.

5The oversight system may take the form of one or more of the following: governance systems (e.g., McMillan, 2011); accounting, reporting and other management control systems (e.g., Chenhall, 2003), risk management systems (e.g., Protiviti Consulting, 2016), human resources systems (e.g., Martin et al., 2011), organizational initiatives to foster “corporate culture” aimed at inducing “pro-social” preferences in firm employees (Bénabou and Tirole, 2006) and discouraging opportunistic actions (e.g., Toyota’s program to instill the “Toyota Way” culture (Liker, 2004)).

6In the KWMR framework, while the manager’s interests conflict with those of firm outsiders, the agency conflict with the owner is completely suppressed because the manager is also the firm’s sole owner and thus claims all of the firm’s reputation rents. Managers attempting to circumvent oversight systems are likely to learn more about the actual effectiveness of these systems than firm owners. For example, managers at Volkswagen identified and exploited flaws in its oversight system for a considerable period. Judging from its stock price reaction to the revelation of emissions cheating, shareholders were surprised to learn that the firm’s oversight systems had been circumvented. This perspective on the inherent information superiority of managers over owners with regard to the actual workings of the firm reflects the general view, succinctly stated by Peter Drucker (1998) that “knowledge workers must know more about their job than their boss does—or what good are they?”

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in the owner’s decision to award incentive compensation. First, only when they believe that the oversight system is at least partially effective can incentive compensation curb managerial self-dealing: Although incentive compensation is required to curb self-dealing when the oversight system is ineffective, because of unraveling by backward induction, no contract can incentivize the manager to eschew self-dealing once outsiders know that the oversight system is ineffective. Second, the oversight system can crowd out incentive compensation: From the owner’s perspective, the oversight system and incentive compensation are substitutes since both curb managerial self-dealing. However, compensation is costly. Thus, in equilibrium, when the owner believes that the firm is the good type with a sufficiently high probability, the owner optimally relies solely on the oversight system to curb managerial self-dealing. The owner pays reputation-assuring compensation and assures the firm’s reputation only when the owner and outsiders expect the oversight system to be weakly effective (i.e., they believe there is only a low probability that the firm is the good type).

In our model, the firm’s reputation is captured by the price of its output. The reputation can differ considerably from outsiders’, including consumers’, beliefs about the firm’s oversight system, though these beliefs provide the foundation for the reputation. Incentive compensation curbs managerial self-dealing and, thus, protects output quality. Hence, output prices are higher with incentive compensation than if the firm relies solely on its oversight system to protect product quality. Since incentive compensation is only optimal when the outsiders expect the oversight system to be relatively ineffective, the firm’s reputation can be higher when outsiders have low expectations about the oversight system’s effectiveness than when they have high expectations. Thus, in stark contrast to typical reputation models, firm reputation can be highest when outsiders have a relatively low expectation that it is the good type.

We show that optimal executive compensation takes the following simple form: The manager receives a single payment contingent on the firm’s type remaining unrevealed to outsiders until the payment is made. Optimal compensation and retention policies operate in a fashion similar to “efficiency wages” in Shapiro and Stiglitz (1984). Providing the manager with rents by fixing compensation above the manager’s reservation wage ensures that the manager values employment continuation. Terminating the manager when the firm’s type is revealed, which is both ex post and ex ante optimal for the firm, deprives the manager of future rents and thus motivates reputable behaviour.

Related literature

Our paper is most closely related to the reputation literature featuring both private information and hidden actions. For the most part, the relations we assume between firm types, information, and outcomes are similar to the classic hidden action/hidden information reputation models of Kreps and Wilson (1982b) and Milgrom and Roberts (1982): (i) The manager has private information about the firm’s type; (ii) the good type is restricted to the reputable action, while the bad type can choose between the reputable action and a...
disreputable action (self-dealing); (iii) the reputable action produces the “good outcome” (high-quality output) with certainty. This is the outcome that would be selected if ex ante commitment were possible. These similarities with the KMWR framework distinguish our model from an alternative hidden action/hidden information framework developed by Mailath and Samuelson (2001). In their setting, the bad type cannot produce the good outcome. Only the good type can, but if it exerts effort.

While the disreputable action never produces the good outcome in the KWMR framework, in our model it produces the good outcome with a positive probability less than one. So, in contrast to KWMR, public monitoring is imperfect. Other papers have also considered how imperfect public monitoring arising from a stochastic relation between actions and output affects reputational incentives (e.g., Board and Meyer-ter Vehn, 2013; Cripps et al., 2004). However, the focus and conclusions of our model are quite different because these papers do not consider the agency conflict and how imperfect public monitoring impacts this conflict.

Our biggest departures from the KWMR framework are the inclusion of the agency conflict and the separation between firm reputation and the characteristics of the agent determining the reputation. The agency conflict is entirely missing from most models of firm reputation since they assume away all conflicts within the firm by examining “entrepreneurial” firms that are entirely owned and managed by a the same agent (e.g., Kreps and Wilson, 1982b; Milgrom and Roberts, 1982; Maksimovic and Titman, 1991; Mailath and Samuelson, 2001; Cripps et al., 2004; Liu, 2011). A few models of reputation in “partnerships” consider conflicts between agents within a firm (e.g., Cremer, 1986; Morisson and Wilhelm, 2004; Bar-Isaac, 2007). They focus on a team comprising multiple generations of agents that jointly controls the firm’s reputation and shares all the rents. In these models, in contrast to ours, reputation is threatened by freeriding within the team, and optimal compensation takes the form of inter-generational rent transfers within the team.

In our model, reputation is a “trans-individual” attribute of the firm since the reputation is separated from characteristics of individual agents. Other models also consider trans-individual reputations. Kreps (1996) founds corporate reputation on corporate culture. In other frameworks, the market for firms enables a “reputed” firm to live on after it is sold by its “reputed” entrepreneur (e.g., Tadelis, 1999; Hakenes and Peitz, 2007). In contrast with our model, these frameworks do not feature an agency conflict within the firm. Thus, they provide no insights into the interaction between compensation and governance. The partnership models do speak to such questions. However, their focus is different: the optimal organization of inter-generational rent transfers and effort allocation (e.g., Cremer, 1986; Morisson and Wilhelm, 2004; Bar-Isaac, 2007) or the selection of new generations of agents into the team (e.g., Levin and Tadelis, 2005).

Our paper also relates to the non-reputational models on owner/manager contracting. It departs from these models by adding an oversight system that partially restricts managerial opportunism and highlighting interactions between the oversight system and manager contracts. For the most part, interest in the effect of internal oversight on managerial opportunism post-dates the financial crisis and has been focused on the effect of risk-management systems on risk taking by financial firms (Garicano and Rayo, 2016; Kashyap et al., 2008; Ellul and Yerramilli, 2013). However, earlier papers considered oversight in broader contexts (Walsh and Seward, 1990). Also, in practice, risk-management systems are typically focused on managing both financial and brand risk (Economist Intelligence Unit, 2005). Thus, the idea that oversight systems
exist and can restrict opportunism is not novel. However, our focus on the substitutability/complementarity between oversight and compensation as well as on the inferential effects about oversight systems is novel.

2 Model

Consider an economy that operates for dates $\mathcal{T} = \{0, 1, 2, \ldots T\}$, $\infty > T \geq 2$. We refer to the interval of time between adjacent dates $t-1$ and $t$ as “period $t$.” The risk free rate is zero.$^{10}$ The economy has one firm. If the firm operates in a period, it produces one unit of a good, which we refer to as the period $t$ good. The firm sells each good for the numeraire good, “cash.” There is no storage technology, thus cash and all goods must be consumed immediately.

Agents The agents in the economy are all risk-neutral. They consist of a single owner for the firm, a continuum of identical consumers, and a continuum of potential managers.$^{11}$ The utility or payoff for each agent is given by her expected future cash flows plus the expected value of the goods they purchase. The owner has a sufficient endowment of cash in each period to fund all firm activities. The managers have identical abilities and preferences, both of which are common knowledge, and the market for managers is competitive. Thus, managers cannot command rents because of their abilities or preferences. The per-period reservation wage for managers is zero.$^{12}$ To operate in a period, the firm must have in place a manager who is responsible for the operation of the firm. The owner initially selects a manager at date zero. At each date the owner can replace an incumbent manager. The owner and managers have the same time horizon $T$. Later, we extend the model to account for different horizons.

Products Each good the firm produces may be either high, $h$, or low, $l$, quality. All agents observe the period $t$ good’s quality after it has been consumed. Hence, the period $t$ good’s quality is common knowledge at the end of period $t$. A good’s quality is neither verifiable nor contractible.

Goods’ price formation Consumers compete in Bertrand fashion by bidding for each good. The price they set for the period $t$ good, $p_t$, represents a bid that will be filled if the good is produced.$^{13}$ Prices are verifiable and contractible. Consumers have identical preferences and their preferences are common knowledge: They assign a value of one to a high-quality good and zero to a low-quality good. Consistent with Bertrand competition, we assume that $p_t$ equals consumers’ expected valuation of the period $t$ good.$^{14}$

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$^{10}$Our finite time framework is comparable to that employed in the KWMR framework, which uses a finite-time setting to facilitate a unique equilibrium. We assume a zero discount rate to improve exposition, and would obtain identical results if all agents discount at the same positive rate.

$^{11}$In our analysis, an owner neither extracts private benefits nor exerts personal effort on monitoring, so the assumption of a single owner simply makes the discussions of the results more compact.

$^{12}$The zero reservation assumption lowers the minimum level of managerial compensation and thus reduces the likelihood of reputable firm behavior. In this sense, our assumptions are conservative.

$^{13}$This timing for consumer bids ensures that in each period there is a price for the good on which contracts can be written. If prices are set after production, in any period in which the firm does not produce, the good would not have a price and a contract based on the period’s price would be ill defined. Alternatively, we could assume price setting after production, extend definition of “price” to include the “null price,” and specify contracts over this extended set. However, this would add to complexity without producing insight. Allen and Gale (1988) make a similar assumption.

$^{14}$This assumption rules out a “trivial” equilibrium in which consumers believe the good is worthless and bid zero, the good is not produced and, because consumer orders are never filled, Bayes rule cannot applied to consumer beliefs.
Production decisions In each period, after observing the price set by consumers, the owner chooses whether or not the firm will operate, i.e., produce a good. To ensure that the firm operates, the owner must supply the firm with capital equal to $e$. Otherwise, the owner shuts down production for the period, i.e., the owner supplies no capital and the firm does not produce a good in the period. The firm’s manager invests the capital supplied by the owner in the firm’s operations. If the manager invests the entire capital, $e$, the firm employs the reliable technology. This technology produces a high quality good with probability one. Another production technology is also available to the manager, the vulnerable technology. The vulnerable technology requires an investment in production of $I = e - c < e$, but only produces a high quality good with probability $\delta \in (0, 1)$, and a low quality good otherwise.

Oversight system and diversion The firm has an oversight system. The oversight system can either be secure, type-$S$ or insecure, type-$I$. If the oversight system is secure, the manager can only invest in the reliable technology. If the oversight system is insecure, the manager can unobservably choose between the reliable and vulnerable technologies. If the manager chooses the vulnerable technology, he can unobservably divert the cost savings, $c > 0$, from the firm’s account and consume them. We call the manager’s choice of the vulnerable technology diversion. If, in a given period, the manager follows the strategy of diverting whenever diversion is possible, i.e., choosing the reliable technology if and only if the oversight system is secure, we will say that the manager acts opportunistically during the period. If no period qualification is given, acting opportunistically should be interpreted as acting opportunistically in all periods. In contrast, if, in a given period, the manager follows the strategy of choosing the reliable technology regardless of whether the oversight system is secure or insecure, we will say that the manager acts reputably in that period.

Information At date zero, the manager, and only the manager, observes whether the oversight system is secure. The remaining agents (including the owner), whom we collectively refer to as “outsiders,” do not know whether the oversight system is secure. Instead, outsiders have a common prior distribution over the security of the oversight system. At the start of period 1, they believe that the oversight system is secure with probability $\rho_1$. Thus, $\rho_1$ measures outsiders’ initial assessment of the effectiveness of the oversight system.

Revelation A good’s quality can reveal the oversight system’s type: A low quality good can only be produced if the manager chooses the vulnerable technology, which is only possible if the oversight system is insecure. We refer to the firm and its oversight system as revealed once consumers observe a low quality good and, thus, learn that the oversight system is insecure. If the firm is revealed prior to period $t$, in period $t$ and all subsequent periods, the good’s price will equal one if outsiders conjecture the manager will act reputably in the period and will equal $\delta$ if they believe he will act opportunistically.

We assume an extreme division of gains from opportunism for simplicity. Our results do not dependent on such an extreme division. All that we require is that the manager captures part of the gain, thus depriving the owner from capturing the entire gain. We assume the managerial diversion is bounded by $c$ because “excessive” diversion would be observable. For example, if a manager took the owner’s entire capital infusion and diverted it to personal consumption, no workers would be hired, no contracts signed, no supplies purchased. Such a high level of diversion would be obvious and, thus, actionable in a court of law. However, the diversion of marginal funds accompanied by hiring lower quality workers or buying lower quality supplies is undetectable. To ensure that outsiders cannot detect diversion of funds by the manager, we assume that the firm’s cash flow—revenue less the cost of production—is not observable or contractible.
Prices and belief updating

So long as the oversight system’s type remains hidden from outsiders, they use the observed quality of goods to update their assessments of the system’s effectiveness. Specifically, suppose the firm is unrevealed at the beginning of period $t$ and outsiders conjecture the manager will act opportunistically in period $t$. Then, the period $t$ good’s price will equal its floor price, $f_t$, where

$$f_t = \rho_t + (1 - \rho_t) \delta,$$

and $\rho_t$ is the period $t$ posterior probability outsiders assess to the oversight system being type $S$. Note that $f_t < 1$, and if the firm operates in period $t$, $f_t$ also represents outsiders’ assessment that the firm will produce a high quality good and remain unrevealed in period $t$. If the period $t$ good is indeed high quality, Bayes rule implies that the period $t + 1$ floor price is given as follows:

$$\Gamma[f_t] = 1 + \delta - \frac{\delta}{f_t}.$$  \hspace{1cm} (2)

Next, suppose the firm is unrevealed at the beginning of period $t$ and outsiders conjecture the manager will act reputably in period $t$. In this case, $p_t = 1$. Moreover, outsiders will expect the firm to remain unrevealed until period $t + 1$ and by Bayes rule their assessment of the oversight system’s effectiveness will remain unchanged after observing a high quality period $t$ good. Therefore, the period $t + 1$ floor price will remain at $f_t$. Finally, suppose the firm is unrevealed until period $t$ but doesn’t operate in the period. Then, outsiders are unable to update their beliefs and thus, the period $t + 1$ floor price will remain at $f_t$.\footnote{The shut down decision is made by an uninformed agent. Thus, we simply require that the actions of an uninformed agent do not affect the beliefs of other uninformed agents. Perfect Bayesian equilibria exist where consumers believe that the uninformed owner’s decision to operate in a given period signals that the control system is insecure. Given this belief, the firm will not operate, so operating in the period is off the equilibrium path and thus Bayes rule cannot be applied. However, such equilibria are not Perfect Sequential Equilibria (Kreps and Wilson, 1982a) as any perturbation of the actions of the owner, no matter how small, with force the application of Bayes rule. Because owner actions are uninformed, they are independent of the control system’s effectiveness and thus cannot revise beliefs about the system’s effectiveness.} Note that $\Gamma[f_t] > f_t$ implying that $f_t \geq f_1$. Because, consumers’ valuations of a good, and the probability of revelation, do not...
directly depend on the probability that the oversight system is secure but rather on the probability that the
good is high quality, the exposition of price dynamics is considerably simplified by expressing Bayesian
updating in terms of good-quality assessments we have just described rather than the probability that the
oversight system is secure.

**Management compensation** In contrast to standard models of reputation formation, a professional man-
ger’s ability to unobservably divert funds intended to ensure product quality, and thereby reduce the prod-
uct’s expected quality, gives rise to an agency conflict. This conflict within the firm arises because decisions
affecting the firm’s reputation are made by managers who have no ownership rights over the rents from rep-
utation but who do capture gains from opportunistic diversion. To mitigate this agency conflict, the owner
contracts with the manager. In the baseline model, the compensation contract is publicly observable. Later
we consider the effect of unobservable compensation. A compensation contract specifies a non-negative
*bonus payment* to the manager in each period \( t \) conditioned on the history of prices from periods 1 to \( t \). The
timing of actions in the model is summarized by Figure 2.

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Figure 2: Time Line. This figure presents the sequence of actions within time period \( t \).

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**Equilibrium** A set of owner and manager actions, prices for goods, and outsider beliefs in each period is an
equilibrium under a given compensation contract if, under that compensation contract, the actions, prices,
and beliefs constitute a Bayesian Nash equilibrium, i.e.

(a) the owner’s shut down/operate and retain/replace strategies are incentive compatible,
(b) the manager’s divert/not divert strategy is incentive compatible,
(c) consumers set prices equal to the goods’ expected quality conditioned on the owner’s and manager’s
strategies, and
(d) belief updating by outsiders is consistent with Bayes’ rule.

A compensation contract is *optimal* if there exists an equilibrium under that contract such that no equilibrium
under any alternative contract produces a higher payoff for the owner.

The model has a number of moving parts and it is not very convenient to analyze them all at once. So we
first solve the model under two constraints: (a) The owner operates the firm in period \( t \) if and only if \( p_t \geq e \),
i.e., the firm can earn a non-negative operating profit. (b) The compensation contract offered by the owner
takes the form of a *bullet contract*, a contract that specifies a positive bonus payment in only one period,
conditioned on the firm being unrevealed at the start of period \( t^* \). As we will demonstrate, contracts conditioned on the firm being unrevealed at the start of any period \( t \) can be implemented by conditioning on the period \( t \) price, \( p_t \). We will complete the solution of the model by showing that these two constraints are not binding and thereby verify the optimality of bullet contracts under which equilibria satisfy (a).

2.1 Parameter restrictions and equilibrium

We impose the following restrictions to focus on model parameters that yield interesting results:

**Assumption 1.** \( \rho_1 \geq e \).

**Assumption 2.** \( I > \delta > 0 \).

Assumption 1 assures that \( f_1 \geq e \). This implies that the period one floor price and the floor price in all subsequent period in which the firm is unrevealed exceed the capital needed to operate the firm in the period. Thus, the owner will always operate the firm so long as it is unrevealed. Assumption 2 ensures that the vulnerable technology always produces a high-quality good with positive probability. However, if consumers anticipate the use of the vulnerable technology, production will be unprofitable for the owner. Assumptions 1 and 2 together ensure that the increase in value generated by choosing the reliable technology, \( 1 - \delta \), exceeds the increased cost of high-quality output, \( c \). Thus, the reliable technology is socially efficient. Competition between consumers ensures that the owner and manager capture the surplus generated by production. Absent the agency conflict caused by unobservable diversion, the owner would capture the entire surplus. Thus, the first-best solution is to use the reliable technology and always produce high-quality goods.

3 Terminating a manager and timing compensation

A manager’s only income sources are (1) diversion and (2) the bonus payment. His only choice is whether to divert. This choice and thus both the owner/manager and firm-consumer conflicts are material only when the oversight system is insecure. Therefore, to determine conditions under which reputation equilibria exist, we consider managerial behavior under an insecure oversight system.

In each period, the incumbent manager will weigh the cost and benefit of diversion. The benefit is an increase in current period consumption. The cost is the possibility that diversion will trigger revelation, which could eliminate future diversion opportunities and the bonus payment. A manager can face diversion choices in three possible environments: (i) the firm is revealed; (ii) the firm is unrevealed and the manager is not contracted to receive a bonus payment in the future; (iii) the firm is unrevealed and the manager is contracted to receive a bonus in the future. Consider the first two environments. If the firm is revealed, a manager’s only income source is diversion. Eschewing diversion in the current period can only reduce the number of periods in which the manager will have the opportunity to divert. Thus, once the firm is revealed, a manager will divert in every period in which the firm operates. For the same reason, even when the firm is unrevealed but a manager is not contracted to receive a bonus in a future period, he will divert in every period in which he operates the firm. This highlights the limitation of a bonus: It cannot influence a manager’s incentives in periods after which it is paid. Moreover, the bonus cannot prevent diversion in the period in which it is paid because the period’s good’s price is insensitive to the manager’s choice in
the period. This limitation of the bonus also ensures that a manager will always divert in period $T$. The following lemma formalizes these preliminary results and their consequence for the firm after it is revealed:

**Lemma 1.** (i) A manager will divert in period $T$. (ii) Managers will divert in every period after the firm is revealed. (iii) The firm will shut down after it is revealed. (iv) Managers will divert in every period starting in the period in which the bonus is paid.

Claim (iii) is a consequence of Claim (ii): Once the firm is revealed, since the manager will always divert so long as the firm operates, consumers will price goods at $\delta$. Production is unprofitable at this price and hence the owner will not operate the firm after it is revealed. Therefore, the manager is effectively terminated once the firm is revealed.

From Lemma 1 it is clear that, to prevent diversion, the firm must be unrevealed and the owner must offer a bonus. Since the bonus can only be effective in periods prior to which it is paid, the owner’s key control variable is timing—when to pay the bonus and when to replace the manager. Both the bonus and replacement influence the manager’s cost of diversion.

The latest the owner can pay a bonus is in period $T$. However, as Lemma 1 demonstrates, diversion is the strictly optimal strategy for the manager in period $T$. Since diversion results in a positive probability of low-quality output, no compensation contract can implement the first-best policy. At the same time, it is clear that a sufficiently large period-$T$ bonus will ensure that the manager does not divert in any period before $T$. Thus, Pareto efficient compensation contracts implement equilibria in which no diversion occurs before period $T$. We will refer to such equilibria as *reputation equilibria*. Because implementing reputation equilibria requires conceding rents to managers, reputation equilibria may not be optimal for the owner.

The rent concessions required to assure reputable managerial behavior depend on the manager’s continuation value under the diversion and reputable strategies when the firm is insecure. Since the manager is effectively terminated when the firm is revealed, his continuation value following revelation is zero. Define $v_M(t)$ as the manager’s value function when the oversight system is insecure and the firm has not been revealed up to period $t$. Then,

$$v_M(t) = b_t + \max[v_M(t + 1), \delta v_M(t + 1) + c],$$

where $b_t$ represents a period $t$ bonus, conditioned on the firm being unrevealed. Since the compensation contract is a bullet contract, $b_t = 0$ except in period $t^*$. The first term in the maximum expression reflects the manager’s expected payoff if he acts reputedly in period $t$. The second term reflects his expected payoff if he diverts. Comparing the two terms, it follows that the manager will act reputedly in period $t$ so long as

$$(1 - \delta) v_M(t + 1) \geq c.$$

Inequality (4) is the incentive compatibility condition for reputable behavior. It shows that the manager will forgo diversion in period $t$ when $v_M(t + 1)$ is large. It also shows that it is suboptimal to replace the manager while the firm remains unrevealed: Anticipated future replacement will lower the manager’s continuation value, and thus make it harder to satisfy the inequality. Moreover, since replacement managers have identical abilities and preferences, there is no other incentive in the model for replacing the manager. It follows that the manager hired at date zero will not be replaced so long as the firm is unrevealed, a result we state formally in the following lemma which, like all results in this paper, is formally derived in the Appendix.
Lemma 2. The manager will not be replaced so long as the firm is unrevealed.

Inequality (4) also provides insights into the timing of diversion. Since $b_t \geq 0$,
\[ v_M(t) \geq \max \{v_M(t + 1), \delta v_M(t + 1) + c\} \geq v_M(t + 1). \] (5)
The function $v_M$ is weakly decreasing in $t$ because with each passing period the manager has fewer periods in which he might divert and remain undetected. Since $v_M$ falls with time, the manager’s incentive to divert increases over time. Consequently, the set of periods in which the manager diverts is always an order interval. That is, if $\tau$ denotes the last period in which the manager does not divert, the manager will not divert in any period $t \leq \tau$. We will refer to $\tau$ as the “reputation cutoff period,” and refer to the lowest cost bonus that deters diversion through period $\tau$ as the $\tau$-policy. We interpret $\tau = 0$ as representing the case where the manager diverts in all periods.

4 Optimal compensation and the reputation cutoff period

The owner’s compensation policy, through its effect on the manager’s continuation value, fixes the reputation cutoff period. Because compensation that fixes a reputation cutoff period of $\tau$ implies that no diversion will take place at or before period $\tau$, we will say that such a policy assures reputation in these periods. For a given reputation cutoff period, $\tau$, the lowest-cost $\tau$-policy minimizes the expected bonus payment to the manager over all $\tau$-policies.

Since the owner does not observe the firm’s type, she pays the bonus both when the oversight system is secure as well as when it is insecure. When the oversight system is secure, the bonus is unnecessary. While the owner would prefer to pay the manager only when the oversight system is insecure, she cannot do so since she does not know the system’s type. When the oversight system is insecure, the bonus must satisfy the reputable behavior incentive constraint, condition (4). Consequently, an optimal $\tau$ policy minimizes the bonus conditioned on the oversight system being secure subject to the condition that the incentive constraint is binding when the system is insecure. The following proposition characterizes the lowest-cost $\tau$-policy.

Proposition 1. If $\tau \in \{1, 2, \ldots, T - 1\}$, under the lowest-cost $\tau$-policy, contingent only on the period $\tau + 1$ good’s price being at least equal to the period 1 floor price, $f_1$, the manager is paid the bonus $b_{\tau + 1}^*$ in period $\tau + 1$, where
\[ b_{\tau + 1}^* = \frac{c \delta^{T - \tau}}{1 - \delta}. \] (6)
Under this policy the manager never diverts during or before period $\tau$ and always diverts after period $\tau$.

Since a payment made in or before period $\tau$ does not contribute to satisfying the manager’s incentive constraint, condition (4), a low cost $\tau$-policy will not specify a bonus before period $\tau + 1$. Now consider a payment in period $\tau + 2$. The owner knows that, after period $\tau$, the manager will divert when the oversight system is insecure but cannot if the system is secure. Moreover, if period $\tau + 1$ diversion results in the firm being revealed, the manager will not receive an incentive payment at $\tau + 2$. So a period $\tau + 2$ bonus is more likely to be paid when the oversight system is secure. In contrast, since the manager does not divert in period $\tau$, a period $\tau + 1$ bonus is equally likely whether the oversight system is secure or insecure, and hence is less
wasteful than a period $\tau + 2$ bonus. Therefore, a period $\tau + 2$ bonus is not optimal. The same logic extends obviously to even later periods. Consequently, under the optimal $\tau$-policy, the bonus is paid in period $\tau + 1$.

Since $\delta \in (0,1)$, Equation (6) implies that the required bonus payment, $b_{\tau+1}^*$, is increasing in $\tau$. Thus, the owner’s cost of incentivizing the manager increases if she postpones the reputation cutoff period. The owner’s optimal contracting problem reduces to trading off the higher cost of compensation against the benefit of postponing $\tau$. This benefit takes two forms: Postponing the possibility of revelation, which eliminates future profit opportunities, and raising consumers’ expectations about product quality and thus operating profits. We refer to a switch from a $\tau$-policy to a $\tau + 1$-policy as a $\tau$-shift. The following proposition describes the marginal (net) gain from a $\tau$-shift and characterizes the optimal reputation cutoff period $\tau^*$:

**Proposition 2.** The optimal reputation cutoff period $\tau^* > 0$ so long as $(1 - f_1)(e - \delta) - c \geq 0$ or $T$ is sufficiently large. When $\tau^* > 0$, $\tau^*$ is the period following the largest $\tau \in \{1, \ldots, T - 2\}$ such that

$$\frac{(1 - f_1)(1 - e) + ((1 - f_1)(e - \delta) - (1 - \delta)c)\delta^{T-(\tau+1)}}{1 - \delta} \geq 0. \quad (7)$$

Proposition 2 provides important insights into the effects of several variables that influence the owner’s willingness to protect the firm’s reputation. The effects of these variables can be judged based on both their effect on ensuring that $\tau^* > 0$ and in increasing $\tau^*$. First, consider the initial oversight system rating, $\rho_1$. The floor price $f_1$ is a monotonically increasing function of $\rho_1$. A higher value of $f_1$ lowers the likelihood that the condition for setting $\tau^* > 0$ is satisfied. Thus, a higher initial effectiveness rating on the oversight system makes it less likely that the owner will ensure reputation for even one period. Expression (7) captures the owner’s net gain from a $\tau$-shift. The numerator of this expression is decreasing in $f_1$ and thus the profitability of $\tau$-shifts fall as the oversight system’s initial rating rises, potentially reducing the number of periods for which the owner will assure the firm’s reputation. These effects are intuitive: The owner’s gain from assuring consumers about the quality of the firm’s good is largest when the oversight system has a low effectiveness rating. Moreover, when the effectiveness rating is low, the owner is less likely to “waste” the bonus payment by paying the manager when there is no need to do so because the oversight system is actually secure.

Next, consider the role of the decision horizon, $T$. Raising $T$ makes it more likely that $\tau^* > 0$. The decision horizon also affects the profitability of $\tau$-shifts. It enters into the owner’s objective function via the second term in the numerator of expression (7). If $f_1$ is sufficiently small, the second term is always positive and the owner will set $\tau^* = T - 1$. For sufficiently high values of $f_1$, the second term is negative. In this case, increasing $T$ suppresses the effect of the second term and thus increases the gain from postponing the reputation cutoff period. The effect of extending the horizon is intuitive because an owner with a longer horizon enjoys a larger gain from protecting her firm’s reputation. In fact it is not hard to show that, past the reputation cutoff period, if the firm is not revealed, the price of goods rapidly converges to 1.18 Thus, the anticipated signaling benefit of offering compensation that ensures reputable behavior is fairly small a few periods after the reputation cutoff period. Most of the gain in operating earnings from reputation-assuring compensation for such periods is thus accounted for by its fundamental benefit—assuring reputable behavior— and thus protecting the owner’s operating rents.

Note that following $n$ periods of diversion, if the firm is unrevealed, the good’s price is given by $\Gamma^{(n)}(f_1) = 1 - (f_1/(1 - f_1))\delta^n + o(\delta^n)$, which is the $n$th iteration of the Bayes’ operator for floor prices from expression (2).
The manager’s gain from diversion is \( c \). Expression (6) demonstrates that the bonus needed to assure reputation rises with \( c \). The owner will be more willing to assure reputation by paying incentive compensation when compensation is less costly. This is apparent from the second term in the numerator of expression (7), which is always positive when \( c \) is sufficiently low. The owner will set \( \tau^* = T - 1 \) when the manager’s gain from diversion is sufficiently small. For higher values of \( c \) the numerator will be negative for periods close to \( T \) and the reputation cutoff period will not extend to period \( T - 1 \).

Finally, consider the effect of changing \( \delta \). Increasing \( \delta \) has two first-order effects: First, it raises the level of compensation required to assure reputation. Second, it reduces the probability that diversion will result in revelation. These first-order effects both favor lowering the reputation cutoff period. There is also, however, a second-order effect from increasing \( \delta \): It lowers the value of the option to shut down production because it reduces the losses the firm would incur were it forced to continue production after revelation. This effect lowers the value of the shut-down option, which can only be exercised if the firm is not assuring reputation through compensation. For a very narrow region of the parameter space, which is empty when the firm’s optimal policy is to implement the reputation equilibrium, this second-order effect dominates the two first order effects.\(^{19}\) However, in general, increasing \( \delta \) lowers the optimal reputation cutoff period.

4.1 Reputation equilibria

Propositions 1 and 2 enable us identify conditions for a reputation equilibrium in which the firm’s organizational reputation is assured through the owner’s decision horizon. Proposition 2 demonstrates that, when the initial floor price, \( f_1 \), is low enough to satisfy \( (1 - f_1) (e - \delta) - c \geq 0 \) the optimal reputation cutoff period \( \tau^* > 0 \). Moreover, when this condition is satisfied, expression (7) is positive for all \( \tau \)-shifts, implying that all \( \tau \)-shifts increase firm value. Hence, as we state in Proposition 3 below, the owner will choose \( \tau^* = T - 1 \) and thus offer the sole incentive payment in period \( T \). In contrast, expression (7) is negative for values of \( \tau \) approaching \( T \) when \( f_1 \) approaches one. Thus, the owner will offer the bonus payment in a period before \( T \), meaning that the manager will divert in at least one period before period \( T \).

**Proposition 3.** Whenever

\[
f_1 < 1 - \frac{c\delta}{(1 - e + \delta)(1 - \delta)},
\]

the owner will offer the manager a bonus payment equal to \((\delta c)/(1 - \delta)\) in period \( T \) conditional on the firm remaining unrevealed at the start of period \( T \). The manager will not divert in any period before \( T \).

Proposition 3 demonstrates that even a firm plagued by an agency problem between its ownership and management can support a reputation equilibrium. Moreover, the firm can do so even with a partially effective oversight system, and if its owners are uninformed. An essential support for the reputation equilibrium is deferred management compensation that is paid at the end of the manager’s tenure. Condition (8) demonstrates that the owner will employ deferred compensation to completely insure the firm against the loss of its organizational reputation when the initial floor price is sufficiently low. Otherwise, the owner will risk damage to the firm’s organizational reputation arising from the agency conflict with the manager. In some instances, the owner might even completely eschew incentive compensation and rely solely on the firm’s

\(^{19}\)See the appendix for an example.
oversight system to protect its reputation. The owner may also only use compensation to prevent diversion for a few periods, which contrasts with the optimal contracts in Edmans et al. (2012) where optimal compensation completely eliminates managerial short-termism.

Condition (8) demonstrates that reputation equilibria exist when \( f_1 \) is sufficiently low. Since \( f_1 \) is increasing in \( \rho_1 \), it implies that reputation equilibria will exist when the oversight system’s initial rating is sufficiently low. This is intuitive since the owner’s gain from assuring consumer’s about the quality of the firm’s good is largest when the oversight system has a low effectiveness rating. Thus, when \( \rho_1 \) is sufficiently low, organizational reputation, as measured by \( p_t \), will be higher than the floor price. Hence, for a range of values of the initial oversight system rating, the firm’s organizational reputation is not monotonically related to the oversight system’s rating. In contrast, if the oversight system’s initial rating is sufficiently high, it is optimal for the owner to eschew incentive compensation, and instead rely on the oversight system to maintain product quality. Over this range, the oversight system crowds out incentive compensation, and organizational reputation is monotonically increasing in the oversight system’s rating. However, as in Marinovic and Varas (2015), increased reliance on the oversight system leads to short-termism which, in our analysis, takes the form of diversion.

The effects of the manager’s gain from diversion and the likelihood that diversion will go unnoticed on the existence of reputation equilibria mimic their effects on the optimal reputation cutoff period characterized in Proposition 2. Because incentivizing the manager is cheaper when \( c \) is lower, condition (8) is more likely to be satisfied when \( c \) is low. Increases in \( \delta \) both raise the cost of incentivizing the manager and lower the owner’s benefit from providing incentive compensation. Thus, as condition (8) demonstrates, the net effect of raising \( \delta \) is to lower the likelihood of a reputation equilibrium.

The pattern of reputable behavior characterized by Proposition 3 stands in stark contrast to that in classic reputation models under incomplete information. In these models, reputation equilibria in which firm reputation is assured prevail when outsiders assess a sufficiently high probability to the firm being the “good” type that is hardwired to eschew disreputable behavior. In contrast, Proposition 3 shows that when ownership and management are separated, reputation is assured when the outsiders assess a high probability to the firm being the “bad” type that will indulge in disreputable behavior because its oversight system is ineffective. Moreover, unlike the classic models, when outsiders assess a high probability to the firm being the good type with an effective oversight system, the prices of its good’s vary monotonically with outsider beliefs. In contrast, in the classic models a similar link prevails when outsiders assess a low probability to the firm being the good type. These differences arise because, in the classic models only outsiders suffer when the firm behaves disreputably, while in our model disreputable behavior hurts both outsiders and the owner who responds optimally to contain her losses from disreputable behavior.

4.2 Verifying the optimality of the compensation and operating policies

In order to simplify the presentation of the results, until now we have assumed that compensation takes the form of a bullet payment and that the owner will shut down the firm in a given period if and only if the firm will not generate an operating profit. We now show that these assumed policy choices are in fact optimal.
4.2.1 Optimality of the compensation policy

We assumed that the owner could only make a single payment to the manager based on the firm remaining unrevealed through the previous period. In fact, this compensation scheme is optimal even when the owner can choose to pay the manager over multiple periods, so long as the payments are non-negative, non-decreasing in past prices, and satisfy limited liability. To show this formally, denote a payment in period \( t \) by \( B_t \), where \( 0 \leq B_t \leq p_t \) and \( B_t \) is non-decreasing in \( p_t \) and prices in periods before \( t \). First we establish the counterpart of Lemma 1 and show that it remains optimal to terminate and not pay the manager after the firm is revealed.

**Lemma 3.** (i) The manager will divert in period \( T \). (ii) The manager will divert in every period after the firm is revealed. (iii) The firm will shut down after it is revealed.

Claim (i) follows directly from the limited effectiveness of incentive compensation we discussed previously. The intuition behind Claim (ii) is frequently encountered in reputation models—unraveling. Once the firm is revealed and it is common knowledge that its oversight system is ineffective, consumers will price the period \( T \) good at \( \delta \), the lowest possible price, since they know the manager will divert in period \( T \). Therefore, the manager’s compensation in period \( T \) will be fixed and insensitive to his period \( T-1 \) action. These arguments extend backwards to each period after the firm is first revealed. Thus, the owner will never pay incentive compensation in any period after the firm is revealed. Hence, claim (ii) demonstrates the necessity of an oversight system that has a non-zero effectiveness rating for incentive compensation to effectively help a firm to maintain its organizational reputation. In doing so, it demonstrates why principal-agent theory-based incentive compensation alone cannot speak to the organizational reputation of firms. Claim (iii) follows directly from Claim (ii) because operating the firm is unprofitable once it is revealed and consumers price goods at \( \delta \).

The manager’s value function can be represented as follows to capture the effect of multiple payments:

\[
v_M(t) = B_t + \max\{v_M(t+1), \delta v_M(t+1) + c\}.
\]

Since \( B_t \geq 0 \), it continues to be the case that \( v_M(t) \geq v_M(t+1) \). Moreover, the manager will not divert in period \( t \) so long as \( (1-\delta) v_M(t) \geq c \). Because of this incentive compatibility condition for diversion, replacing the manager continues to be suboptimal while the firm remains unrevealed. Combining these two properties of the manager’s value function, it continues to be the case that if the manager does not divert in period \( t \), he will not divert in any period prior to \( t \). Therefore, there will exist a unique reputation cutoff period \( \tau < T \).

Now consider the timing of payments. We have demonstrated that incentive payments will only be made so long as the firm is unrevealed. We now show that an optimal contract, which we denote by \( b^\tau \), will specify a single positive payment in period \( \tau+1 \) conditioned on \( p_{\tau+1} \geq f_1 \) and a payment of 0 if \( p_{\tau+1} < f_1 \). In all periods other than period \( \tau+1 \), \( b^\tau(t) = 0 \). Moreover, the payment in period \( \tau+1 \) equals \( b^\tau(\tau+1) = b^\tau_{\tau+1} \), the optimal bonus payment specified in expression (6) in Proposition 1.

**Proposition 4.** Given the reputation cutoff period \( \tau \), it is optimal for the owner to make a single incentive payment. This payment equals \( (c \delta^{T-\tau})/(1-\delta) \) and is made in period \( \tau+1 \) contingent only on \( p_{\tau+1} \geq f_1 \).
Under this policy, the manager never diverts during or before period $\tau$ and always diverts after period $\tau$. No policy that provides positive payments in more than one period is optimal.

Although the proof of Proposition 4 is fairly tedious, its underlying logic is virtually identical to the logic underlying Proposition 1. Since payments made at or before period $\tau$ do not contribute to satisfying the manager’s incentive compatibility condition for period $\tau$, an optimal $\tau$-policy will not specify payments before period $\tau + 1$. Payments more than one period after the reputation cutoff period are also wasteful because they only serve to enrich the manager when the oversight system is secure and thus incentive payments are unnecessary. To see this note that deferring a payment from period $\tau + 1$ to a later period ensures that the manager is not sure to receive the payment if the oversight system is insecure. Thus, the value of the deferred payment must be raised to continue to satisfy the incentive compatibility constraint. However, this raises the value of the payment to the manager when the oversight system is secure. This is wasteful and raises the owner’s expected cost of incentivizing the manager. Given that the optimal compensation is identical to what we assume in the baseline model, the conditions and characteristics of reputation equilibria are unchanged from the baseline.

4.2.2 Optimality of the operating policy

We assumed that the owner operates the firm so long as it generates a positive operating profit during the period. Now we consider the effect of dispensing with this assumption and show that the operating policies we have assumed are indeed optimal.

Ex ante, shutting down production is never optimal. This result is an easy consequence of (i) Assumption 1 and (ii) the incentive compatibility condition for reputable behavior, expression (4). First note that Assumption 1 ensures that the per-period operating profit is positive so long as the firm is unrevealed. Now consider (4). This expression ensures that reducing the number of unrevealed periods in which the firm operates, lowers the manager’s continuation value after the reputation cutoff period. This increases the compensation payment required to ensure that the manager does not divert up to the reputation cutoff period. Because shutting down on the unrevealed path strictly lowers gross profits and weakly increases expected managerial compensation, shutting down on the unrevealed path is strictly suboptimal for the owner ex ante.

Now consider the owner’s operating decisions from an ex post perspective. First consider operating decision in periods $t < \tau + 1$. In these periods, no payments are made to the manager; the probability of the manager diverting is zero and thus beliefs about the oversight system are not revised. Thus, Assumption 1 ensures that it is never optimal ex post to shut down in periods $t < \tau + 1$.

Next consider periods $t \geq \tau + 1$. In this case, the operating decision will affect the belief revision process. Suppose the firm operates at date $\tau + 1$. Then, either the firm will be revealed with probability $1 - f_1$ and will shut down, or the firm will remain unrevealed with probability $f_1$. If the firm remains unrevealed and operates in period $\tau + 2$, the price of the period $\tau + 2$ good, $p_{\tau+2} = \Gamma[f_1]$. Note the following property of the belief revision function $\Gamma$: If an unrevealed firm operates in period $t$, period $t + 1$’s expected floor price equals period $t$’s floor price, i.e.,

$$f_t \Gamma[f_t] + (1 - f_t) \delta = f_t.$$  \hfill (10)

Hence, assuming the firm operates in period $\tau + 1$, its gross expected profit in period $\tau + 2$ conditioned on
operating in period $\tau + 2$ when unrevealed is given by
\[ f_1(\Gamma[f_1] - e) + (1 - f_1)0 > f_1(\Gamma[f_1] - e) + (1 - f_1)(\delta - e) = f_1 - e, \] (11)
where the last equality follows from Assumption (2) and expression (10). However, the right-hand side of equation (11) equals the expected gross profit in period $\tau + 2$ conditioned on the firm shutting down for period $\tau + 1$ and resuming operations in period $\tau + 2$. Thus, the expected gross profit in period $\tau + 2$ conditioned on operating in period $\tau + 1$ and operating when unrevealed at $\tau + 2$ is always higher than the expected gross profit in period $\tau + 2$ conditioned on shutting down in period $\tau + 1$. This implies, by an easy backward induction argument, that operating in any period $t \geq \tau + 1$ leads to a higher gross continuation value than shutting down for the period. Because no payments are made to the manager after period $\tau + 1$, the owner’s continuation value is thus always higher if the firm operates rather than shuts down when unrevealed.

Finally consider the operating decision in period $\tau + 1$. In this period, $p_{\tau+1} = f_1$. Moreover, the owner must pay the manager $b^*_{\tau+1}$ regardless of whether the firm operates. Hence, the owner’s current payoff from operating is larger than her payoff from shutting down. Therefore, operating is ex post optimal in period $\tau + 1$. It follows that the operating policy we assumed previously satisfies ex post incentive compatibility and is in fact dynamically incentive compatible.

## 5 Extensions

In our baseline model we assumed that (i) the manager’s compensation contract is observable to outsiders; (ii) the owner can commit to the manager’s compensation at date 0; (iii) the owner’s and manager’s time horizons are aligned at $T$. We now demonstrate that our results survive loosening each of these assumptions.

### 5.1 Unobservable compensation policy

We have assumed that consumers observe the manager’s compensation and form rational conjectures taking this information into account. How crucial is this assumption to our results? First note that observed compensation increases product prices. Hence, if the owner pays the manager and can make verifiable disclosures about the payment, she has every incentive to do so and no incentive to keep the payment secret. If anything, the owner might want to make secret “subtractions” from the manager’s disclosed compensation, e.g., strike a deal with the manager whereby the manager agrees to return some or all of the disclosed bonus to the owner as a condition of employment. However, enforcing such an agreement seems problematic as the very fact that the agreement is sub rosa would make it difficult for the legal system to verify. If such an agreement could be enforced, compensation would be effectively unobservable by consumers as they would not be able to ascertain net compensation, compensation less secret payment by the manager to the owner. Compensation would also be unobservable if the owner could not make verifiable disclosures of compensation. This would be the case if there are no accounting systems capable of verifying the owner’s report of managerial compensation. Such a possibility appears far fetched for firms operating in any advanced economy. Compensation would also be effectively unobservable if consumers simply do fail to observe verifiable compensation disclosures by the owner because of either some behavioral bias or rational inattention. We are not sure if any of these scenarios are plausible. Regardless of their plausibility, however,
the analysis in this section shows that our basic result—that reputation equilibria exist even when the agents
determining reputation have not reputations themselves—also holds when compensation is unobservable.

If compensation is unobserved, consumers will make decisions on the basis of their conjecture about
compensation policy and thus, the quality of goods. Suppose consumers conjecture that the compensation
policy sets the reputation cutoff period at $T - 1$. Then, so long as they do not observe a low quality good, until
period $T - 1$ the period $t$ good’s price will equal one and the period $T$ good’s price will equal $f_1$. At date zero,
the owner, taking the consumers’ conjecture as given, will choose an “actual” compensation policy. Since the
manager’s diversion decision depends only on his compensation and the likelihood that diversion will reveal
the firm, the same arguments used in the baseline model to establish the optimality of a bullet payment apply
in the setting with unobservable compensation. Thus, the optimal compensation policy will either involve
no compensation or a bullet payment of the same size and timing as in the baseline model, which will ensure
reputable actions in all periods before the period the payment is made. Suppose the owner fixes the payment
period at $\tau + 1$ and thus an “actual” reputation cutoff of $\tau$. Let $n = T - 1 - \tau$, i.e., $n$ equals the number of
periods between the actual reputation cut-off period $\tau$ chosen by the owner and the consumers’ conjectured
reputation cutoff period $T - 1$. For expositional ease, we will refer to a compensation policy that sets the
reputation cutoff period $n$ periods before $T - 1$ as an $n$-defection. Because some bullet compensation policy
always maximizes firm value, the reputation equilibrium will be sustainable under unobserved compensation
if and only if no $n$-defection where $n \neq 0$ produces a higher firm value than the $T - 1$ reputation cutoff.

An $n$-defection will have two effects on the owner’s payoff. Regardless of whether the control system
is secure or insecure, an $n$-defection will reduce the compensation that must be paid to the manager. If
$n = T - 1$ and the firm owner opts to pay no compensation at all, the owner saves the entire reputation-
assuring bullet payment of $\delta c/(1 - \delta)$ made in period $T$ conditioned on the firm being unrevealed at the
start of period $T$. Otherwise, the $n$-defection lowers required compensation from the level required to prevent
diversion through period $T - 1$ to the payment required to prevent diversion through $T - 1 - n$. Equation (6)
reveals that this reduction in compensation is given by

$$\frac{\delta c}{1 - \delta} - \delta^n \frac{\delta c}{1 - \delta} = (1 - \delta^n) \frac{c \delta}{1 - \delta}.$$

When the owner draws up the compensation contract at date zero, the owner believes the control system
is secure with probability $\rho_1$ and insecure with probability $1 - \rho_1$. If the control system is secure the man-
ger cannot divert and retracting the reputation cutoff period will have no effect on the owner. If the control
system is insecure, retracting the reputation cutoff period will lower the owner’s expected stream of oper-
ating profits. Without observable compensation a retraction in the reputation cutoff period is unobservable.
Therefore, in contrast to the case with observable compensation, retracting the reputation cutoff period by a single
period will not trigger a fall in the good’s price. However, retracting the cutoff by a single period exposes
the firm to revelation in period $T - 1$. Revelation will cost the owner the period $T$ operating rent $f_1 - e$.

An $n$-defection where $n > 1$, risks not only the loss of the period $T$ operating rent, $f_1 - e$, but also rents in
periods before $T$ and, in such periods the operating rent is $1 - e > f_1 - e$. Thus, conditional on an insecure
control system, an \( n \)-defection lowers the owner’s operating profits by

\[
\sum_{k=1}^{n-1} \left( (1-e) - \delta^k (1-e) \right) + ((P_1 - e) - \delta^n (P_1 - e)) =
\]

\[
(1-\delta^n) \left( (1-e) \frac{(n-1)(1-\delta) - \delta (1-\delta^{n-1})}{(1-\delta)(1-\delta^n)} + (P_1 - e) \right)
\]

The owner’s expected operating profit loss equals the operating profit loss when the control system is insecure times the probability that the control system is insecure. Combining the compensation saving gain and the expected operating profit loss from and \( n \)-defection, using the relation between the prior probability \( \rho \) and and the floor price (equation (2)), we can represent the owner’s gain from an \( n \)-defection by \( \mathcal{D} \), where

\[
\mathcal{D}(n) = \begin{cases} 
(1-\delta^n) \left( \frac{\delta c}{1-\delta} - \frac{1-f_1}{1-\delta} \left( (1-e) \Psi(\delta,n) + (f_1 - e) \right) \right) & \text{if } n < T-1, \\
\frac{\delta c}{1-\delta} - \frac{1-f_1}{1-\delta} \left( (1-e) \Psi(\delta,T-1) + (f_1 - e) \right) & \text{if } n = T-1,
\end{cases}
\]

and

\[
\Psi(n,\delta) = \frac{(n-1)(1-\delta) - \delta (1-\delta^{n-1})}{(1-\delta)(1-\delta^n)}, \quad n \in \{1,2,\ldots,T-2\}, \delta \in (0,1).
\]

It follows that defection is optimal under \( n \), if \( \mathcal{D}(n) > 0 \). If defection is not optimal under any \( n \in \{1,2,\ldots,T-1\} \), the reputation equilibrium is sustainable under unobserved compensation.

In expression (12), \( \Psi \) measures the long-run cost of defection in terms of lost future rents caused by diversion. It is not hard to show that \( \Psi(\delta,n) > (n-1)/2 \) and thus long-run costs rapidly increase as the number of periods before \( T-1 \) in which diversion is not deterred increases. Hence, when the time horizon is fairly long, defection is optimal only if the \( n = 1 \) defection is optimal. The following proposition formalizes these insights and provides simple sufficient conditions for the sustainability of reputation equilibria when compensation is not observed.

**Proposition 5.** If under observable compensation the reputation equilibrium condition of Proposition 3, equation (8), is satisfied and

(i) \( \delta c - (1-f_1) (f_1 - e) < 0 \), and

(ii) \( T > 2 \left( \frac{1-f_1}{1-e} + \frac{1-\delta}{1-\delta} \right) \),

then, under unobservable compensation, reputation-assuring compensation is sustainable.

Proposition 5 is fairly intuitive. Reputation equilibria require reputation-assuring compensation. There are two incentives in the baseline model for the owner to pay reputation-assuring compensation: A signaling effect and a fundamental effect. The signaling effect is produced because compensation that assures reputable behavior by the manager is observed by consumers as is the failure to pay such compensation. Thus, compensation which assures reputation in a given period increases the price of the good in that period. The fundamental effect results because diversion by the manager risks revelation, and revelation eliminates firm rents in future periods. Unobservable compensation turns the signaling effect off without affecting the fundamental effect. Thus, the owner’s incentive to adopt reputation-assuring compensation is attenuated but not eliminated. When the time horizon is long, the negative fundamental effect of defecting is so large that if any defection increases owner welfare, defection to assuring reputation for just one period less than \( T-1 \) is an optimal defection. In which case, as shown by condition (i) in Proposition 5, defection is only optimal when, relative to the cost of reputation ensuring compensation, the initial floor price is high and also very
close to the cost of production.

The sufficient conditions provided by Proposition 5 are not necessary as they are produced by imposing simple upper bounds on defection gains. The rather limited effect of observability on sustainability is illustrated for specific model parameters in Figure 3, which uses the exact expressions for defection gains provided by equation (12).

![Figure 3: Effect of unobservable compensation on the sustainability of reputation equilibria. In the figure, the horizontally hatched region represents combinations of per period diversion opportunities, \(c\), and initial consumer assessments of good quality, \(f_1\), under which reputation equilibria are sustainable under both observable and unobservable compensation. The vertically hatched region represents combinations of \(c\) and \(f_1\) under which reputation equilibria are sustainable only under observable compensation. In the gray region reputation equilibria are not sustainable even when compensation is observable.](image)

### 5.2 Compensation without precommitment

In the baseline model, the owner commits to a compensation contract for the manager at date zero. We now consider two ways of weakening this assumption. First, we allow the owner to commit to a contract at a later date. Second, we consider a setting in which the owner cannot commit to a long-term compensation package. Instead, each period, the owner can choose whether to offer the manager a compensation payment in the next period consisting of a bonus that depends on the good’s price in the next period. Our results are robust to either change.

#### 5.2.1 A trial period

Suppose the owner can commit to a contract after some “trial” periods. This delay will allow the owner to potentially “learn” the oversight system’s type by observing the quality of goods for some periods. Note, however, that the owner can learn about the oversight system’s type during the trial period only if the manager diverts. Consider a candidate equilibrium in which the manager diverts with positive probability for the first \(k\) periods. Then, in period \(k + 1\), the floor price \(f_{k+1} > f_1\) if the firm remains unrevealed or \(f_{k+1} = \delta\) otherwise. In the latter case, by Lemma 1, compensation will be ineffective and the firm will cease to operate when it is revealed. In the former case, Propositions 1, 2 and 3 can be viewed as characterizing equilibria in the sub-game starting in period \(k + 1\). Thus, if learning via a trial period is optimal at date 0
when the floor price is $f_1$, by the logic underlying Propositions 1, 2 and 3, the owner has even less incentive to commit to compensation for the manager when the floor price is $f_{k+1} > f_1$. The underlying intuition is as follows: A trial period can help the owner to avoid offering compensation when it is likely to be wasted because the firm is secure. Since the firm is more likely to survive the trial period unrevealed if it is secure, at the end of the trial period compensation is even more likely to be wasted. Moreover, note that if the owner will only offer incentive compensation after a trial lasting $k$ periods, the manager will eschew diversion in all periods prior to period $k + 1$ because of the monotonicity of the manager’s value function. This undermines the possibility of owner learning. It follows that the owner will never institute a trial period before contracting with the manager.

5.2.2 No long-term contract

Consider a scenario in which the owner cannot pre-commit to a long-term contract and must offer only a bonus based on the good’s price in the following period. Like the baseline model, we restrict our attention to monotone increasing, limited liability bonuses. Specifically, we assume that a bonus contracted in period $t$ is conditioned on the good’s price in period $t + 1$. Since the owner can only commit to a bonus one period ahead, the manager will make decisions based on his conjectures about bonus payments in future periods. Once the firm is revealed, bonus payments cannot be effective because of unraveling as described in Lemma 3. Hence, the manager will not anticipate bonus payments after the firm is revealed and the firm will shut down according to the same logic as in Lemma 3. This implies that positive bonuses will only paid if the firm is unrevealed.

Now consider the manager’s value function. Expression (3) describes the period $t$ value to the manager under the assumption that he receives a contract with bonus $b_{t+1} > 0$. By setting $b_{t+1} = 0$ in expression (3), we obtain the value to the manager in period $t$ if he does not receives a bonus contract in the period. Thus, as is the case in the baseline model, (i) the manager’s value function (weakly) decreases over time; (ii) if the manager’s no-diversion incentive constraint (expression (4)), is satisfied in period $t$ it is satisfied in every prior period. As in the baseline model, this implies that there will exist a unique reputation cutoff period $\tau \in \{0, \ldots, T - 1\}$. Moreover, a single bonus of $b^*_{\tau+1}$, described in expression (6) and contracted in period $\tau$, will deter diversion in all periods prior to $\tau + 1$.

Let $\tau^*$ be described as in Proposition 2 and suppose the manager conjectures that, in period $\tau^*$, the owner will contract a single bonus and the bonus will satisfy expression (6). Given the properties of the manager’s value function, he will not divert in until period $\tau^*$ and will divert in every period subsequent to $\tau^*$. The firm will shut down once it is revealed. To establish there exists an equilibrium that supports the same outcome as the baseline model, we have to establish that it is optimal for the owner to contract for a bonus in period $\tau^*$ that will completely deter diversion until period $\tau^*$. To see this note that, in the period $\tau^*$ the owner’s expected payoff will equal $1 - e$, in period $\tau^* + 1$ it will equal $f_1 - e - b^*_{\tau+1}$, and in each subsequent period

\[ \text{As before, the bonus cannot depend on (unverifiable) quality. Moreover, an effective bonus cannot depend on the realizations of verifiable performance variables in the current period: The current period good’s price is independent of the manager’s current technology decision. Therefore, a bonus payment contingent on the current period’s price cannot motivate performance. To influence the manager’s behavior, the bonus will at least have to depend on verifiable information available in the next period. The good’s price is the only suitable contracting variable. Thus, we assume that bonus payments contracted in the current period are based on the good’s price in the next period.} \]
it will equal the floor price less the periodic investment $e$ conditional on the firm remaining unrevealed. Delaying contracting to period $\tau^* + 1$ will add an additional payoff of $1 - e$ in period $t + 1$ and eliminate the last expected payoff. Thus the owner’s decision is identical to the owner’s $\tau$-shift decision in the baseline model. Hence, the owner will not postpone contracting to period $\tau^* + 1$ so long as it is not optimal to set the reputation cutoff period to $\tau^* + 1$ in the baseline model. The owner will not move the contracting to period $\tau^* - 1$ or even earlier for the same reason. Since offering a bonus is optimal in period $\tau^*$, it easily follows that the lowest bonus that will set the reputation cutoff period to $\tau^*$ is given by expression (6).

5.3 Reputation when firms operate longer than managers

We have focused on the case where the firm’s operating horizon, $T$, is the same as that of its manager. Is a firm still able to maintain its reputation by incentivizing its managers when the firm can continue operating for $T$ periods but the manager’s horizon is shorter than $T$?

Kreps (1996) describes how a short-lived professional manager may be induced to maintain the reputation of a long-lived firm. The basic intuition is easily extended to our model. To illustrate the intuition suppose that managers live for only two periods but the firm can operate for $T > 2$ periods. Suppose that the firm employs a new manager each period, each manager is employed only in the first period of his life, and is paid in the second period of his life if the firm remains unrevealed. It is clear from our previous analysis that a sufficiently high payment will induce a manager to eschew diversion. The owner will be willing to make the now periodic payments so long as the price gain from reputation is larger then the cost of the incentive compensation. As we have shown in our baseline model, this tradeoff will favor the maintenance of firm reputation when the initial rating of the firm’s oversight system is sufficiently low and thus the expected gain from maintaining its reputation is large. As we have shown previously, the owner will not be able to prevent diversion in period $T$ since she will be not able to incentivize the period $T$ manager with deferred compensation.

6 Empirical Predictions

In firms where management and owners are separate, our model implies a non-monotone relationship between the quality of the firm’s oversight/oversight system and its organizational reputation. When their oversight systems are sufficiently strong, firms may achieve a high reputation by relying on their oversight systems alone (i.e., without incentive compensation). However, managerial actions will repeatedly put the reputation at risk if the oversight systems can be exploited. On the other hand, when firms’ oversight systems are sufficiently ineffective, owners will pay deferred compensation to insure the firms’ reputations, possibly for an extended period of time. Whether reputation is maintained and, if so, how, depends on interactions between expectations, incentives and the costs and benefits of reputation. These factors vary considerably across firms, even those within an industry.

In the terminology of production processes, we model a batch or mass production process with production periods between which parties can update beliefs. Our model applies best in industries where quality matters to consumers, is observable ex post, but is not fully observable ex ante. This essentially rules

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21Examples of the production process terminology include Russell and Taylor (2006) and Chase et al. (2001).
out commodity industries. Managing the production process requires expertise. Simple, standardized and transparent production processes will limit uncertainty over the effectiveness of the oversight system and the ability of managers to divert funds. Thus, we expect our model to apply when production processes are relatively complicated and proprietary.

Three factors interact to determine whether we observe reputation equilibria: (1) outsiders’ rating of the oversight system’s effectiveness ($\rho_1$), (2) the benefits of diversion ($c$) and (3) how tightly observed quality is tied to the production process (i.e., $\delta$) which determines the probability of undetected diversion.

Having a more effective oversight system decreases the likelihood of incentive compensation. In some industries, oversight systems are mandated, sophisticated and tightly controlled. Consider pharmaceuticals, where drugs undergo considerable testing under supervision before being released to the public. In such industries, we anticipate little role for incentive compensation. Owners are more likely to rely on the oversight system to ensure quality. Other industries where quality is also important may have considerably less effective oversight systems giving managers more room to divert. Consider the automobile industry. Quality control is very important, but largely conducted inside the firm. Further, as one blogger states: “despite the incredible advances in automotive quality control, the most important component in building a quality car is the human touch” (Deaton, 2017). This leaves the possibility open that management might act to lower product quality without observation, as was the case with the Takata airbag and Volkswagen diesel emissions scandals.

Higher potential managerial benefits from diversion increase the cost of incentive contracting and make it less likely owners will use it to assure reputations. For managers to benefit from diversion, the production process needs to be relatively high cost and opaque (e.g., proprietary and complicated). Consider, for example, differences in textile production. Traditional weaving of wool and cotton uses well known, low cost processes that have been around for thousands of years. In contrast, new “high tech” synthetic textiles are often produced using high cost, complicated, proprietary processes. Companies in this sector of the textile industry may find it much more expensive to use incentive compensation to defer diversion than companies in more traditional textile sectors.

A higher probability of undetected diversion decreases the chances of companies using incentive compensation. A key feature in our model is that, sometimes, using the inferior technology goes undetected. Formally, we model this by assuming quality is revealed after purchase and that the inferior technology produces a high quality good with probability $\delta$. But, this is tantamount to assuming that a low quality good is not revealed as low quality with probability $\delta$. There is a legal concept of defects that differentiate obvious defects (i.e., “patent defects”) from defects that are hidden and not easily revealed (i.e., “latent defects”). To see the difference, consider defects in toys. In 2007, Mattel and RC2 Corporation produced some similar simple toys: Pixar Cars (Mattel) and Thomas the Tank Engine trains (RC2). A toy with an obvious broken part (e.g., a bad wheel) is patently defective. In contrast, lead in the paint is a latent defect, only detectable

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22Deaton goes on to say: “As a result, many car makers try to build a corporate culture where every single employee is responsible for quality.” This is consistent with our earlier discussion of the “Toyota way.”

23See The Economist (2013). This is more than just issues like the Lululemon yoga pants scandal discussed earlier. The Economist gives examples of inferior textiles causing cargo plane crashes.

24See, for example, Bell (1959).
through sophisticated testing or long term exposure. Industries or products with higher rates of patent defects effectively have a low $\delta$ and those with higher rates of latent defects effectively have a high $\delta$. We should see more (less) incentive compensation for companies that produce products with higher rates of patent (latent) defects. Consider the modern electronics industry. Hardware (e.g., a computer monitor or TV) generally works or it doesn’t when you turn it on. Often, bugs in software are not found for years. Our model argues that it might be easier for software companies to divert without detection. This makes it more costly to use incentive compensation and owners are more likely to rely on quality oversight systems such as extensive beta testing (or ex post patching) to eliminate defects. Hardware companies would rely more on incentives.

7 Discussion

In this paper, we considered the question of whether corporations whose values depend on their reputations can have reputations even when their managers are anonymous, replaceable, and reputationless, and their shareholders are anonymous and uninformed. In a stylized fashion, our analysis captures a basic fact: large bureaucratic organizations, which are owned by passive shareholders, possess vast reputational capital. The value of this reputation capital depends on the actions of managers with no inherent interest in the organizations’ reputation and whose own reputational capital is infinitesimal by comparison to that of the organizations. We show that the “natural” mechanism for aligning manager incentives with reputation protection—incentive compensation—is always ineffective if employed in isolation. However, when conjoined with the sort of partially effective oversight systems characterizing modern corporations, compensation can ensure reputation. Thus, in some sense, oversight systems and compensation are complementary. However, when oversight systems are “too effective” shareholders, in an effort to reduce managerial rents, may adopt socially suboptimal risky reputation-protection strategies that are over reliant on the oversight systems.

The shareholder-optimal compensation of managers relies on deferred payments and is conditioned on the firm not suffering from scandal over the deferral period. Even though managers are patient in our analysis and thus weight future payments the same as current payments, lengthening the deferral period increases the cost of incentive alignment. However, when the value of a firm’s reputation capital is sufficiently large, the deferral period corresponds to the manager’s tenure.

As well as rationalizing corporate reputation formation in a world of reputationless agents, and determining the relation between reputation and optimal compensation, the analysis makes a number of predictions regarding the relation between firm characteristics and reputation preservation. Furthermore, the analysis is extensible. For example, this paper focuses on firms with endowed oversight systems that cannot be “reformed” by owners. Extending the analysis to consider the ex ante incentive effects of a technology that permits rebuilding oversight systems after corporate scandals would be able to assess the welfare effects of investment in corporate-reputation reform, a pervasive corporate response to scandals, the focus of many consultancy firms, and the subject of considerable academic research.

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25 In 2007, both companies had lead paint scandals. See Jennings (2007) and Story (2007).
References


Economist Intelligence Unit. The evolving role of the CRO. *The Economist Intelligence Unit*, May 2005.


On-line appendix to “Organizational reputation and agency”

Appendix

Proof of Lemma 1. Proof of Claim (i). The manager’s period $T$ technology choice does not affect $p_T$. Therefore, the period $T$ technology choice does not affect a bonus contracted in period $T$. However, if the manager diverts, he receives an additional $c$. Therefore, the manager maximizes his payoff in period $T$ by diverting.

Proof of Claims (ii) and (iii). Once the firm is revealed, a manager will not expect any future bonus. Suppose the firm is revealed prior to period $T$. By Claim (i), the manager will divert in period $T$. Recognizing this, consumers will price the period $T$ good at the floor price $\delta$. At this price production is unprofitable so the owner will shut down the firm. Now suppose the firm is revealed by period $T-1$. Since the firm will not operate in period $T$, the manager maximizes his expected payoff by diverting in period $T-1$. However, this implies that consumers’ best response is to price the period $T-1$ good at $\delta$ and the owner will not operate the firm in period $T-1$. This chain of logic extends backwards to the period in which the firm is first revealed.

Proof of Claim (iv). Let $M_t$ represent the period $t < T$ expected value of the manager’s current and future payoffs if no bonus will be paid in or after period $t$ and he diverts in every period starting with period $t$. Suppose the manager expects to be retained so long as the firm remains unrevealed. Since the firm will shut down once it is revealed (Claim (iii)), it follows that

$$M_t = c + \sum_{i=t}^{T} \delta^{T-(i+1)} c.$$  \hfill (A.1)

If the manager chooses not to divert in period $t$ but starts diverting in period $t+1$ his expected payoff will equal $M_{t+1} < M_t$. This argument holds for every $t < T$. Thus, it is a best response for the manager to divert in every period after the bonus is paid. If the bonus is paid in period $t$ the manager’s expected payoff from continually diverting starting in period $t$ equals $M_t + b_t$. The proof is completed by noting that postponing diversion by one period yields him a lower expected payoff of $M_{t+1} + b_t$. A virtually identical argument will establish the claim when the manager expects to be separated from the firm prior to period $T$ even if it remains unrevealed.

Proof of Lemma 2. The proof follows directly from the discussion preceding the lemma.

Proof of Proposition 1. From Claim (iv) in Lemma 1 it follows that the bonus cannot be paid in or before period $\tau$. Hence, we examine a payment after period $\tau$. In period $\tau$ the manager’s incentive constraint, inequality (4), must be satisfied. Claim (iv) in Lemma 1 shows that the manager will divert in every period after period $\tau$. Hence, if the bonus is paid in period $\tau+1$, the manager’s incentive constraint can be rewritten
Thus, \( b_{\tau+1} + \mathcal{M}_{\tau+1} \geq c + \delta \left( b_{\tau+1} + \mathcal{M}_{\tau+1} \right) \). \hspace{1cm} (A.2)

Since the manager does not divert up to period \( \tau \), the bonus will be paid whether or not the oversight system is secure. Thus, the owner’s expected cost from paying the manager in period \( \tau + 1 \) equals \( b_{\tau+1} \). This cost is minimized by setting \( b_{\tau+1} \) to satisfy (A.2) as an equality. Doing this and solving for \( b_{\tau+1} \) yields \( b^*_\tau \) as defined in (6).

Now consider the effect of a \( \tau \)-policy. Then, \( b_{\tau+1} = \frac{b^*_\tau}{\delta} \) and the owner’s expected cost of incentivizing the manager is \( \rho_1 \times \frac{b^*_\tau}{\delta} + (1 - \rho_1) \times b^*_\tau > b^*_\tau \). Thus, the owner will not defer the bonus to period \( \tau + 2 \) and the owner will shut down the firm in period \( \tau + 2 \) if it is revealed, \( b_{\tau+2} \) must satisfy

\[
\delta b_{\tau+2} + \mathcal{M}_{\tau+1} = c + \delta \left( \delta b_{\tau+2} + \mathcal{M}_{\tau+1} \right).
\]

Thus, \( b_{\tau+2} = \frac{b^*_\tau}{\delta} \) and the owner’s expected cost of incentivizing the manager is \( \rho_1 \times \frac{b^*_\tau}{\delta} + (1 - \rho_1) \times b^*_\tau > b^*_\tau \). Thus, the owner will not defer the bonus to period \( \tau + 2 \). Applying the same argument to future periods demonstrates that the cost of incentivizing the manager is minimized by paying the bonus in period \( \tau \).

**Proof of Proposition 2.** By Lemma 1, under a \( \tau \)-policy, the manager will divert in every period starting with period \( \tau + 1 \). Thus, the period \( \tau + 1 \) good’s price will equal \( f_1 \) and, so long as the firm remains unrevealed, in each subsequent period the good’s price will equal the floor price for the period. The floor prices will be updated according to the Bayes’ operator defined in equation (2). Thus, if the firm remains unrevealed for \( n \geq 1 \) periods after \( \tau + 1 \), the good’s price will equal

\[
\Gamma^{(n)}(f_1) = \frac{(f_1 - \delta) + (1 - f_1) \delta^{n+1}}{(f_1 - \delta) + (1 - f_1) \delta^n}, \hspace{1cm} (A.4)
\]

where and \( \Gamma^{(n)} \) is the \( n \)-fold composition of the Bayes’ operator. Since the floor price also captures the probability that the firm will remain unrevealed until the next period when the manager diverts, the ex ante probability that the firm will remain unrevealed at the beginning of period \( \tau + 2 \) is \( f_1 = \Gamma^{(0)} \), and the ex ante probability that the firm will remain unrevealed until the beginning of period \( \tau + 1 + n \), where \( n > 1 \) equals

\[
\Gamma^{(0)}(f_1) \times \ldots \times \Gamma^{(n-1)}(f_1) = \frac{(f_1 - \delta) + (1 - f_1) \delta^n}{1 - \delta}. \hspace{1cm} (A.5)
\]

Now consider the effect of a \( \tau \)-shift to \( \tau + 1 \) on the firm’s expected operating profit, which is is the owner’s gain from a \( \tau \)-shift. Let \( O_\tau \) represent the date zero expected value of the stream of operating profits under the \( \tau \)-policy. Then,

\[
O_\tau = \overbrace{(1 - e) + \ldots + (1 - e)}^{\tau \text{ terms}} + \overbrace{f_1 \Gamma^{(1)}(f_1) - e}^{T - \tau \text{ terms}} + f_1 \Gamma^{(2)}(f_1) - e + \ldots + f_1 \left( \prod_{i=1}^{T-\tau-2} \Gamma^{(i)}(f_1) \right) \left( \Gamma^{(T-(\tau+1))}(f_1) - e \right)
\]
Thus, the gain in expected operating profits from a $\tau$-shift by one period to $\tau + 1$ is

$$\Delta \theta_\tau \equiv \theta_{\tau + 1} - \theta_\tau = (1 - e) - f_1 \Gamma f_1 \Gamma f_2 \Gamma f_3 \cdots \Gamma f_{\tau - 1} f_1 f_{\tau - 1} f_{\tau - 2} f_{\tau - 3} \cdots f_1 e$$

$$= (1 - e) - (f_1 \delta (1 - e) - (1 - f_1) (e - \delta) \delta \tau^{-1})$$

$$= (1 - f_1) (1 - e) + (1 - f_1) (e - \delta) \delta \tau^{-(\tau + 1)}.$$

(A.6)

Consider a $\tau$-shift from $\tau = 0$. Under the $\tau = 0$ policy, the manager is not paid a bonus. To incentivize him to eschew diversion in period one, he will have to be paid a bonus in period two equal to $b^*_2 = \delta \tau^{-1} c e$. This is the owner’s cost of a $\tau$-shift from $\tau = 0$. Hence, from definition (A.6), it follows that the owner’s net gain from a $\tau$-shift from $\tau = 0$ equals $\Delta \theta_0 - \delta \tau^{-1} c e$, or equivalently

$$\frac{(1 - f_1) (1 - e) + ((1 - f_1) (e - \delta) - c) \delta \tau^{-1}}{1 - \delta}.$$

(A.7)

Condition (A.7) is always positive so long as $(1 - f_1) (e - \delta) - c \geq 0$. When $(1 - f_1) (e - \delta) - c < 0$, condition (A.7) is positive so long as

$$\delta \tau^{-1} \leq \frac{(1 - f_1) (1 - e)}{((1 - f_1) (e - \delta) - c)}.$$

Thus, $\tau^* > 0$ so long as either $(1 - f_1) (e - \delta) - c \geq 0$ or $T$ is sufficiently large.

Now consider a $\tau$-shift when $\tau > 0$. The owner’s gain from a $\tau$-shift by one period to $\tau + 1$ remains equal to $\Delta \theta_\tau$. The bonus payment required to ensure reputable behavior up to $\tau$ is given by

$$b^*_\tau \equiv \delta \tau^{-1} c e.$$

(A.8)

Thus, the increase in compensation required to ensure reputable behavior for one more period is given by

$$b^*_{\tau + 1} = \delta \tau^{-1} c e.$$ 

Let $\Delta \Pi_\tau$ represent the owner’s net gain from shifting to the $\tau + 1$-policy from the $\tau > 0$-policy, where

$$\Delta \Pi_\tau = \frac{(1 - f_1) (1 - e) + ((1 - f_1) (e - \delta) - (1 - \delta) c) \delta \tau^{-(\tau + 1)}}{1 - \delta}.$$

(A.9)

Comparing $\Delta \Pi_\tau$ with $\Delta \Pi_{\tau + 1}$ we obtain

$$\Delta \Pi_{\tau + 1} - \Delta \Pi_\tau = \delta \tau^{-(\tau + 2)} (1 - \delta) ((1 - f_1) (e - \delta) - (1 - \delta) c).$$

(A.10)

So long as $(1 - f_1) (e - \delta) - (1 - \delta) c > 0$, expression (A.10) is positive, implying that expression (A.9) is convex and increasing in $\tau \in \{1, \ldots, T - 2\}$. Hence, when $(1 - f_1) (e - \delta) - (1 - \delta) c > 0$, the owner will set $\tau^* = T - 1$ ensuring a reputation equilibrium. When $(1 - f_1) (e - \delta) - (1 - \delta) c < 0$, $\Delta \Pi_{\tau + 1} < \Delta \Pi_\tau$, implying that the owner’s gain from a $\tau$-shift is concave in $\tau$. Hence, conditional on setting $\tau^* > 0$, the owner will set $\tau^*$ equal to the period following the largest $\tau \in \{1, \ldots, T - 2\}$ that satisfies condition (7).

Proof of Proposition 3. Note that so long as

$$\delta \tau^{-(\tau + 2)} (1 - \delta) ((1 - f_1) (e - \delta) - (1 - \delta) c) > 0$$

(A.11)

expression (A.7) is positive, which ensures that $\tau^* > 0$. Moreover, expression (A.9) and thus $\Delta \Pi_\tau$ are positive for all $\tau \in \{1, \ldots, T - 2\}$. Therefore, $\tau^* = T - 1$. We conclude the proof by noting that expression (8) follows by solving expression (A.11) for $f_1$.

Proof of Lemma 3. Proof of Claim (i). If the period $T$ good’s price is $p_T$, the manager is contracted to
receive an incentive payment $B_T(p_T)$ in period $T$. Note that $p_T$ and the manager’s incentive payment are unaffected by his period $T$ technology choice. However, if the manager diverts, he receives an additional $c$. Therefore, the manager maximizes his payoff in period $T$ by diverting.

**Proof of Claim (ii).** Once the firm is revealed, consumers know that the manager will divert in period $T$. This fixes the price of the period $T$ good at $\delta$. Therefore, the manager’s period $T$ compensation is fixed whether or not he is discovered to have diverted in period $T-1$. Hence, period $T-1$ diversion is optimal for the manager. This argument extends backwards to the period in which the firm is first revealed and establishes that the manager will divert in every period that the firm operates after it is revealed.

**Proof of Claim (iii).** Claim (ii) establishes that the price of the period $t$ good will equal $\delta$ if the firm produces in period $t$ after it is revealed. By Assumption 2, period $t$ production is not profitable if the period $t$ good’s price is $\delta$. Therefore, if the oversight system is known to be insecure in period $t$, the firm will shut down.

**Proof of Proposition 4.** Let $\mathbf{b}$ represent a vector of payments to the manager that are conditioned on the firm being unrevealed in the period in which the payment is made. A necessary condition for a payment schedule to be optimal is that over all payment schedules inducing the same reputation cutoff period, it maximizes the payoff to the owner. The anticipated value to the owner at date 0 equals gross firm profit (firm profit excluding the cost of management compensation) less managerial compensation. Under our assumptions that the firm has committed to a policy of not shutting down on the unrevealed path, expected gross profit is fixed. Thus, an optimal schedule must minimize expected payments to the manager over all schedules that implement the same reputation cutoff period.

If the oversight system is secure, $\text{EP}^S$, the expected payments to the manager simply equals the sum of the promised payments, i.e.,

$$\text{EP}^S[\mathbf{b}] = \sum_{t=1}^{T} b(t).$$

If the oversight system is insecure, then up to period $\tau+1$, the expected payment also equals the sum of payments. Subsequent to period $\tau+1$ the manager will be paid only if the firm remains unrevealed, which occurs with probability $\delta$ in each such period. Thus, the expected payments to the manager given the oversight system is insecure, $\text{EP}^I$, are given by

$$\text{EP}^I[\mathbf{b}] = \sum_{t=1}^{\tau} b(t) + b(\tau+1) + \sum_{t=\tau+2}^{T} \delta^{t-(\tau+1)} b(t).$$

Expected payments to the manager, $\text{EP}[\mathbf{b}]$, equal the expectation over the secure and insecure states, i.e.,

$$\text{EP}[\mathbf{b}] = \rho_1 \text{EP}^S + (1-\rho_1) \text{EP}^I. \quad (A.12)$$

Let $v_{M}[\mathbf{b}](t)$ represent the manager’s value function in period $t$ under the payment vector $\mathbf{b}$ when the oversight system is insecure, i.e.,

$$v_{M}[\mathbf{b}](t) = b_t + \max \left[ v_{M}[\mathbf{b}](t+1), \delta v_{M}[\mathbf{b}](t+1)+c \right]. \quad (A.13)$$

Then, when the oversight system is insecure, the manager’s value in period $\tau+1$ can be represented as

$$v_{M}[\mathbf{b}](\tau+1) = c + b(\tau+1) + \sum_{t=\tau+2}^{T} \delta^{t-(\tau+1)} (c + b(t)). \quad (A.14)$$
His reputable behavior constraint for period $\tau$ is given by

$$(1 - \delta)v_M[b](\tau + 1) \geq c. \quad (A.15)$$

An optimal schedule $b$ must satisfy the condition that it minimizes payments to the manager subject to the incentive constraint, (A.15), i.e., an optimal schedule that induces a reputation cutoff period of $\tau$ must solve the following problem:

$$\min_{b \geq 0} EP[b], $$

s.t. $$(1 - \delta)v_M[b](\tau + 1) \geq c. \quad (A.16)$$

The Lagrange, $\mathcal{L}$ for this problem is

$$\mathcal{L}[b] = EP[b] - \lambda \left((1 - \delta)v_M[b](\tau + 1) - c\right). \quad (A.17)$$

Let $\partial_t \mathcal{L}$ represent the partial derivative of the Lagrange with respect to $b(t)$. Then, using equation (A.14),

$$\partial_t \mathcal{L} = \begin{cases} 1 & \text{if } t < \tau + 1, \\ \rho_1 - ((1 - \delta)\lambda - (1 - \rho_1)) & \text{if } t = \tau + 1, \\ \rho_1 - \delta^{t-\tau-1}((1 - \delta)\lambda - (1 - \rho_1)) & \text{if } t > \tau + 1. \end{cases} \quad (A.18)$$

First note that since, $\partial_t \mathcal{L} > 0$ for $t < \tau + 1$, by the Kuhn-Tucker conditions, $b(t) = 0$, for all $t < \tau + 1$. Next, note the following two items: (i) Because positive compensation must be paid in at least one period to ensure reputable behavior, it must be the case that $\partial_t \mathcal{L} \leq 0$ for some period $t \geq \tau + 1$. (ii) Because infinite compensation is not optimal, it must be the case that, for all $t$, $\partial_t \mathcal{L} \geq 0$. Condition (i) implies that $(1 - \delta)\lambda - (1 - \rho_1) > 0$ which, in turn, implies that $\partial_{\tau+1} \mathcal{L} < \partial_t \mathcal{L}$, for $t > \tau + 1$. This implies, combined with (ii) that (a) $\partial_{\tau+1} \mathcal{L} = 0$ and (b) $\partial_t \mathcal{L} > 0$, for $t > \tau + 1$. By the Kuhn-Tucker conditions, (b) implies that $b(t) = 0$ for all $t > \tau + 1$. Thus, we have shown that if $b$ is an optimal payment schedule over all payment schedules, and, under $b$, the last period of reputable behavior is $\tau$, then the performance schedule will call for one positive payment at date $\tau + 1$. This payment will exactly satisfy the incentive compatibility condition and thus, the contract will specify $b(t) = 0$ for $t \neq \tau + 1$ and specify a payment $b(\tau + 1)$ that satisfies

$$(1 - \delta) \left(c + b(\tau + 1) + \sum_{t=\tau+2}^{T} \delta^{t-\tau-1}c\right) = c. \quad (A.19)$$

Simple algebra shows that this contract design coincides with the payments specified in Proposition 4. \(\square\)

**Proof of Proposition 5.** The proof follows from the following lemmas.

**Lemma 1.** For all $\delta \in (0, 1)$,

(i) For a fixed $\delta$, the function that maps $n$ into $\Psi(\delta, n)$, represented by $n \mapsto \Psi(\delta, n)$, is strictly increasing.

(ii) $\Psi(\delta, n) \geq \frac{1}{2}(n - 1)$.

**Proof.** We first prove part (i). Note that the derivative of $\Psi$, (where the definition of $\Psi$ is extended to the interval $[1, T - 2]$) is given by

$$\frac{\partial}{\partial n} \Psi(\delta, n) = \frac{1 - \delta^n (1 - n \log(\delta))}{(1 - \delta^n)^2}. \quad (A.20)$$

Next, note that

$$\frac{\partial}{\partial \delta} (\delta^n (1 - n \log(\delta))) = n \delta^{n-1} ((1 - n \log(\delta)) - 1).$$
Because \( \log(\delta) < 0 \), \( 1 - n \log(\delta) > 1 \), and thus the function \( \frac{\partial}{\partial n} (\delta^n (1 - n \log(\delta))) > 0 \). Thus \( \delta \mapsto \delta^n (1 - n \log(\delta)) \) is increasing. Hence, \( 1 - \delta^n (1 - n \log(\delta)) > 1 - 1^n (1 - n \log(1)) = 0 \). Inspecting equation (A.20) we see that this implies that \( \frac{\partial}{\partial n} \Psi(\delta, n) > 0, \delta \in (0, 1) \).

Now consider part (ii). The assertion is obvious when \( n = 1 \), so suppose that \( n > 1 \). The Lemma claims that

\[
\text{Diff}(\delta, n) \equiv \Psi(\delta, n) - \frac{1}{2}(n - 1) \geq 0.
\]  
(A.21)

We can express \( \text{Diff} \) as follows:

\[
\text{Diff}(\delta, n) = \frac{n (1 - \delta) (\delta^n + 1) - (\delta + 1) (1 - \delta^n)}{2(1 - \delta)(1 - \delta^n)}.
\]  
(A.22)

The denominator on the right hand side of this equation is clearly positive. Let \( \text{Num} \) represent the numerator. We will show that \( \text{Num} \) is also positive. Differentiation shows that \( \text{Num} \) is strictly convex in \( \delta \). For this reason, if the partial derivative of \( \text{Num} \) with respect to \( \delta \), \( \partial_\delta \text{Num} \leq 0 \) at \( \delta = 1 \), then \( \partial_\delta \text{Num} < 0 \), for \( \delta \in [0, 1] \), and thus \( \text{Num} \) is decreasing over \( [0, 1] \). Evaluating \( \partial_\delta \text{Num} \) at \( \delta = 1 \) shows that \( \partial_\delta \text{Num} < 0 \). Thus, we have established that \( \text{Num} \) is decreasing, implying that \( \text{Num}(\delta, n) > \text{Num}(1, n) \). Evaluating \( \text{Num} \) at \( \delta = 1 \) shows that \( \text{Num}(1, n) = 0 \). Therefore, the numerator on the right hand side of equation (A.22) is non-negative, which establishes that \( \text{Diff} \) is non negative.

**Lemma 2.** If equation (8), the condition for a reputation equilibrium in Proposition 3 is satisfied then

\[
\frac{c \delta}{1 - \delta} < (1 - \delta) (1 - e).
\]

**Proof.** Equation (8) is equivalent to

\[
1 - f_1 \geq \frac{1}{1 - (e - \delta)} \frac{c \delta}{1 - \delta}.
\]  
(A.23)

Assumption 1 is equivalent to

\[
1 - f_1 \leq (1 - e)(1 - \delta).
\]  
(A.24)

Equations (A.23) and (A.24) cannot be satisfied for any \( f_1 \) unless

\[
\frac{1}{1 - (e - \delta)} \frac{c \delta}{1 - \delta} \leq (1 - e)(1 - \delta).
\]  
(A.25)

Because \( 0 < 1 - (e - \delta) < 1 \),

\[
\frac{c \delta}{1 - \delta} < \frac{1}{1 - (e - \delta)} \frac{c \delta}{1 - \delta}.
\]  
(A.26)

Thus, (A.25) and (A.26) imply the result.

**Lemma 3.** If equation (8), the condition for a reputation equilibrium in Proposition 3 is satisfied and

\[
T < 2 \left( \frac{1 - f_1}{1 - e} + \frac{1 - \delta}{1 - f_1} \right).
\]

then defection to \( n = T - 1 \), which implies not assuring reputation at any date, is not optimal.

**Proof.** The defection gain under \( n = T - 1 \) is given by equation (12). First, note that Lemma 1 and Lemma 2 imply that

\[
\frac{\delta c}{1 - \delta} \leq (1 - e)(1 - \delta) \quad \text{and} \quad \Psi(\delta, T - 1) > \frac{1}{2}(T - 2).
\]
Because $\delta \in (0, 1)$, $1 - \delta^n > 1 - \delta$, it follows that

$$D(T-1) < (1-e)(1-\delta) - (1-f_1) \left( \frac{1}{2} (1-e) T - (1-f_1) \right).$$

(A.27)

Our parameter restrictions imply that $0 < \delta < e < f_1$ thus

$$(1-e)(1-\delta) - (1-f_1) \left( \frac{1}{2} (1-e) T - (1-f_1) \right) < 0 \iff T > 2 \left( \frac{1-f_1}{1-e} + \frac{1-\delta}{1-f_1} \right).$$

(A.28)

Thus, the right hand side of (A.28) is sufficient to ensure that $D(T-1) < 0$.

\[\text{Lemma 4. If defection is optimal under any compensation policy involving positive compensation payments, it is optimal under } n = 1, \text{ the policy that fixes the reputation cutoff date at } T - 2, \text{ i.e., } \mathcal{D}(n) > 0 \Rightarrow \mathcal{D}(1) > 0 \text{ for } n \in \{1, 2, \ldots, T - 2\}.\]

\[\text{Proof. Claim i in Lemma 1 shows that } \Psi \text{ is strictly increasing in } n. \text{ Inspection of equation (12) in light of this result shows that } \mathcal{D}(n) \text{ is decreasing in } n. \text{ Therefore, } \mathcal{D}(n) > 0 \Rightarrow \mathcal{D}(1) > 0.\]

The proof of Proposition 5 is completed by noting that inspecting equation (12) shows that condition (i) is equivalent to $\mathcal{D}(1) \leq 0$. By Lemma 4 this implies that $\mathcal{D}(n) \leq 0$, for $n \in \{1, 2, \ldots, T - 2\}$. Condition (ii) implies that the hypothesis of Lemma 3 is satisfied and thus $\mathcal{D}(T-1) < 0$. Thus, $\mathcal{D}(n) \leq 0$ for $n \in \{1, 2, \ldots, T - 1\}$.

\[\text{Counterexample: A case where the marginal gain from increasing the cutoff is not decreasing in } \delta, \text{ the probability that diversion will not be revealed.}\]

\[\text{Figure A.1: In Panel A, } f_1 = 0.935, e = 0.7625, c = 0.0331, T = 3. \text{ } \delta \text{ is varied between 0.50 and } \delta, \text{ the highest possible value of } \delta \text{ given the parameters chosen and Assumptions 1 and 2. Panel B plots the region of the parameter space where the relationship between the marginal gain from increasing the reputation cutoff period is, for some values of } \delta, \text{ not increasing. The dot corresponds to the point determined by the parameters selected in Panel A.}\]

Panel A, plots the marginal gain from increasing the reputation cutoff period, as a function of $\delta$. In Panel A, the marginal gain is not monotonically decreasing. The parameter range over which such examples such can be constructed is very small and, in fact, is not visible if we plot the entire admissible parameter space. As Panel B illustrates that a non-decreasing relation between $\delta$ and marginal gain from extending the reputation cutoff period can only be supported when both the cost of production, $e$, is very high relative
to the initial floor price, $f_1$, and the manager’s reward from diversion, $c$, is very small relative to the cost of production.