Organizational reputation in firms with owner-manager conflicts

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Abstract

We model a professionally managed firm with a single asset — its organizational reputation. In contrast to classic economic models of reputation under incomplete information, (1) the firm’s owner and manager are distinct agents with conflicting interests, (2) reputation adheres to the firm and arises from a feature of its organization and not the “type” of its manager. The inclusion of these realistic features of modern corporations dramatically changes the calculus of firm reputation from classic economic models: Firm reputation depends on outsiders’ perceptions about the viability of its oversight system that restricts the manager’s ability to act in his own interests, and is highest when outsiders believe the firm is highly likely to be the “bad type” with a relatively ineffective oversight system.

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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 aspects of firm reputation that are central to the management literature. First, the literature recognizes that, like brand value with customers, firm reputation is an intangible asset that adheres to firm itself (e.g., Burke, 2011; Davies, 2011; Barnett and Pollock, 2012), and this “organizational reputation” is distinct from “managerial reputation” which depends on characteristics of the firms’ employees rather than the firm itself (e.g., Hodges, 2011; Macey, 2013). Second, the literature recognizes that corporate reputations are constantly threatened by agency problems arising from the separation of firm ownership and management: Managers’ actions influence firm reputation but managers do not enjoy the full benefit or cost of reputation since these flow primarily to firms’ owners. Frequent incidents of corporate reputation damage arising from the actions of managers provide ample evidence of this agency conflict and its consequences.¹

Economists have developed models that explain why firms maintain reputations and why reputations are valuable.² However, these models do not account for the owner-manager conflict. Nor do they distinguish between organizational reputation and managerial reputation.³ Consider for example the classic models of reputation under asymmetric information of Kreps and Wilson (1982) and Milgrom and Roberts (1982). In the Kreps/Wilson and Milgrom/Roberts (KWMR) framework, the firm has a “type”. This type is determined solely by its manager’s characteristics/preferences, which he observes privately. The firm’s reputation is wholly founded on its manager’s characteristics since it operates profitably and earns reputation rents only so long as the manager’s actions do not “reveal” him to be a “bad type” to uninformed outsiders.⁴ While the manager’s interests conflict with those of firm outsiders, the models completely suppress the owner-manager agency conflict since the manager claims all of the firm’s reputation rents as its sole owner. These two omissions ensure that the classic models are best suited to capture reputations in entrepreneurial firms. The omissions limit their ability to speak to reputations of large corporations with relatively anonymous

¹Recently engineers at Volkswagen adopted systems that falsified emissions readings, damaging its reputation for producing quality automobiles. Wells Fargo’s reputation as customer centric retail bank was damaged by the unauthorized actions at its branches. Lululemon Athletica’s reputation for product quality was damaged by mid-level factory managers who skimmed on material quality. An anonymous trader’s losses (the “London Whale”) damaged J.P. Morgan’s reputation for risk management through excessive risk taking.
²See Bar-Isaac and Tadelis (2008) for an extensive survey of reputation models.
³Kreps (1996) is an exception and demonstrates how firm reputation can be supported by firm culture. Levin and Tadelis (2005) explore the comparative advantage of the partnership organizational form in supporting reputation.
⁴Tirole (1996) develops a model in which firm reputation is based on the average characteristics of a group.
“reputationless” managers and distant owners, that rely on distinctive features of the firms’ organizational structures.

In this paper, we adapt the KWMR framework to more closely fit three key stylized characteristics of reputations of modern corporations: (i) Reputation is valuable and is tied to the firm’s past actions. (ii) Reputation depends on features of the firm’s organization. (iii) Reputation is constantly threatened by the separation of ownership and control of the firm since managers who choose the firm’s actions are distinct from the firm’s owners who, as the firm’s residual claimants, have first claim on any reputation rents. Because of shared foundations, the underlying mechanics of reputation in our model resemble the mechanics underlying the classic KWMR reputation models: The firm earns reputation rents so long as the manager’s actions do not reveal it to be a bad type to outsiders. Therefore, as stated by Weigelt and Camerer (1988, p. 443), in our model too, “A corporate reputation is a set of attributes ascribed to a firm, inferred from the firm’s past actions”. However, in contrast to the classic models, our analysis demonstrates how a firm can overcome the conflict between reputationless managers and owners to preserve a reputation with consumers. In doing so, it provides several insights into the conditions and managerial contracts required to sustain firm reputation that are quite distinct or entirely absent from the classic models.

We make only the following necessary modeling changes: To completely break the link between the firm’s reputation and that of its owners or management, we assume that all managers share the same characteristics, which are common knowledge. Similarly, the owner’s characteristics are common knowledge. Thus, there are no owner or manager types, and consistent with the views of March and Weil (2005), no reputation can arise from their characteristics. Instead, we allow a feature of the firm’s organizational structure to provide the foundation for its reputation: An “oversight system” that restricts the manager’s ability to act in his own interest at the expense of the organizational. We interpret the oversight system broadly to represent organizational features that are intended to restrict managerial self-dealing. The oversight system is either completely effective or is ineffective. As in the classic models, its effectiveness determines the firm’s type, and the firm’s type is privately known to the manager but not to outsiders. Finally, we assume that the manager is self-interested, and self-dealing by the manager can jeopardize the firm’s reputation. The manager poses a real threat to the firm’s reputation because he is the primary beneficiary of the gain from self-dealing but he is not endowed with an ownership claim on the firm’s reputational rents to offset his destructive impulses. The owner, as the residual claimant, shoulders the reputation risk of the manager’s self-dealing. Consequently, in addition to the conflict between the firm and outsiders featured in the KWMR framework, our model features a second agency problem between the owner and manager. The owner, like

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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)).

6Ellul and Yerramilli (2013) provide evidence that speaks to the effectiveness of oversight systems. However, as many recent corporate scandals demonstrate, oversight systems are often ineffective. Recent examples of oversight system failures include Lululemon’s “too sheer” yoga pants problem, Toyota’s braking systems problem, and Volkswagen’s emissions problem.
consumers, is uninformed about the firm’s type and can only learn it from the manager’s actions. This information gap between the manager and owner exacerbates their agency conflict. To align the manager’s interests and limit the adverse effects of this conflict, the owner can offer the manager compensation.

By design, in our model, the oversight system plays a key role in firm reputation: The firm can operate profitably so long as its (oversight system’s) type isn’t revealed to be ineffective to outsiders. Managerial self-dealing, which can only occur under an ineffective oversight system, stochastically precipitates a drop in the quality of the firm’s output. Following a drop in quality, the oversight system is revealed to be ineffective to outsiders, and “unraveling” by backward induction, akin to that in KWMR, ensures that the firm becomes economically unviable. Thus, the firm’s reputation is founded on outsider beliefs about the effectiveness of its oversight system: The firm’s reputation is preserved so long as outsiders believe that its oversight system is at least “partially effective”.

To assure outsiders’ that the oversight system is at least partially effective, the manager must eschew self-dealing and act “reputably”. If the oversight system is effective, it alone can ensure that the manager acts reputably. If the oversight system is ineffective, an incentive contract is necessary to curb managerial self-dealing. The owner’s and outsiders’ shared beliefs about the oversight system play a key and complex role in the owner’s decisions to award incentive compensation. First, incentive compensation is only effective when the shared belief is that the oversight system is at least partially effective: While incentive compensation is the only way to curb managerial self-dealing when the oversight system is ineffective, because of unraveling by backward induction, no contract can incentivize the manager once outsiders know that the oversight system is ineffective. Second, from the owner’s perspective, the oversight system and incentive compensation are substitutes because they both curb managerial self-dealing. Consequently, as we demonstrate, in equilibrium, because compensation is costly, 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”. When the probability that the firm is the good type is sufficiently high, the owner optimally relies solely on the oversight system to curb managerial self-dealing and thus, the oversight system crowds out incentive compensation.

The firm’s reputation in our model is captured by the price it receives for its output. 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 oversight system is expected to be relatively ineffective, the firm’s reputation can be higher when its oversight system is expected to be relatively ineffective than if its oversight system is expected to be highly effective.

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7While attempting to circumvent oversight systems, insiders are likely to learn more about the actual effectiveness of these systems than firm owners. For example, insiders at Volkswagen identified and exploited flaws in its oversight system for a considerable period, and judging by its stock price’s reaction to the emissions cheating revelation, shareholders were surprised to learn that the firm’s oversight systems had been circumvented. This perspective on the inherent information superiority of operators over the actual workings of the firm reflects the general view, succinctly stated by Peter Drucker (Drucker, 1998) that “knowledge workers must know more about their job than their boss does—or what good are they?”
We show that the design of reputation-preserving executive compensation is simple: The manager receives a single payment contingent on the firm’s type remaining unrevealed till the payment is made. Making the payment contingent on the firm remaining unrevealed is sufficient to cost effectively deter managerial self-dealing. Thus, optimal compensation need display only limited and weak sensitivity to firm performance. Moreover, only one payment is necessary: Earlier payments are wasteful since they duplicate the incentive effects of the deferred payment. Later payments are more likely to be wasted because the firm is more likely to remain unrevealed in later periods if its oversight system is effective, and thus later payments are more likely to made when the oversight system is effective. To preserve the firm’s reputation through a manager’s entire tenure with the firm, the timing of the payment period must coincide with the manager’s retirement. The optimal contract, which captures both the incentive payment and hiring and retention policies, resembles efficiency wage contracts in Shapiro and Stiglitz (1984): It fixes compensation above the manager’s reservation wage in order to provide him with an incentive to value employment continuation. To tie the manager’s payoff more closely to the firm’s reputation rents, the manager is terminated if and only if the firm’s type is revealed.

Related literature

Our paper is closely related to the reputation literature. Ours is a hidden action/hidden information reputation model in which the agent making the decision that affects firm reputation has private information. For the most part, the relations we assume between agent types, information, and outcomes are similar to those in the classic papers in this area—Kreps and Wilson (1982) and Milgrom and Roberts (1986). For example, as in the KWMR framework, (i) private information is represented by the firm’s type; (ii) the “good type”, the secure type in our case, is restricted to the reputable action, the reliable technology in our case, while the “bad type” can choose between the reputable action and a disreputable action, the vulnerable technology in our case; (iii) the reputable action produces the “good outcome” with certainty, the good outcome being the outcome that would be selected if ex ante commitment were possible, which in our case is high-quality output.

In contrast to KWMR, we do not assume that the disreputable action never produces the good outcome. Instead, it produces the good outcome with a positive probability less than one. So in our model, in contrast to KWMR, public monitoring is imperfect. The alternative hidden action/hidden information specification to our framework and KWMR is the Mailath and Samuelson (2001) framework. They model competition in product markets under the assumption that the bad type cannot produce the good outcome but the good

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8Some researchers restrict their use of the term “reputation model” to such models. Other authors include pure private information models of quality choice (e.g., Tadelis, 1999) as well as pure moral hazard models, (Klein and Leffler, 1981). See Bar-Isaac and Tadelis (2008) for a typology of reputation models.

9This framework has been applied to investigate many other facets of corporate behavior: product quality and financing policy (Maksimovic and Titman, 1991), capital structure (John and Nachman, 1985), and debt markets (Diamond, 1989).

10A number of papers have considered the effect the nature of the stochastic relation between actions and output on the ability of reputational incentives to sustain reputable actions over long horizons (e.g., Board and Meyer-ter Vehn, 2013; Cripps et al., 2004). The focus and conclusions of this model are quite different.
type can, if it exerts effort. Thus, in Mailath and Samuelson (2001), the type whose actions are fixed is the bad rather than the good type. Our setting, where the action represents willingness to expend resources to maintain reputation rather than ability to produce non-defective goods, is better approximated by the KWMR framework than by the Mailath and Samuelson (2001) framework.

Our most significant departure from the KWMR framework is that we separate the ownership and control of reputation as well as separate the locus of reputation from the characteristics of the agent determining reputation. The firm’s managers control firm reputation, while a different agent, the owner, is endowed with a claim on the entire rent from the reputation. Reputation is founded on its oversight system and not the characteristics of the agent whose actions determine reputation, the manager. As we describe below, because of these changes, we are able to develop novel insights into firm reputation and the design of reputation-assuring incentive contracts.

The separation between the ownership of reputation rents and the operating decisions that determine reputation makes managerial compensation design key to assuring reputation. This aspect of the model contrasts with “entrepreneurial” models of firms that are entirely owned and managed by a single agent (e.g., Kreps and Wilson, 1982; Milgrom and Roberts, 1986; Maksimovic and Titman, 1991; Cripps et al., 2004; Liu, 2011). Although other reputation models consider conflicts between agents within a firm, these models focus on “partnerships” where a team of agents belonging to multiple generations jointly controls the firm’s reputation, and reputation is threatened by freeriding within the team (e.g., Cremer, 1986; Morisson and Wilhelm, 2004; Bar-Isaac, 2007). In contrast to our analysis, in these models, optimal compensation calls for inter-generational rent transfers within the team.

The separation between the locus of reputation and individual firm agents makes reputation a “trans-individual” attribute of the firm. 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 “reputable” 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 and thus provide no insights into the interaction between compensation and governance. The partnership models do speak 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 is also related to the non-reputational models on owner/manager contracting. It’s point of departure from these models is that it augments them by adding an oversight system that partially restricts managerial opportunism. 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, some earlier papers considered oversight in broader contexts (Walsh and Seward, 1990). Also, in practice, risk-management officers of firms are typically tasked with 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, we believe that our focus on the substitutability/complementarity between
oversight and compensation as well as on the inferential effects about oversight systems is novel.

In Section 2, we develop the base model for organizational reputation. In Section 3, we discuss the owner’s operating, employment and compensation strategies. We also derive conditions for a reputation equilibrium in which maximizes the firm’s reputation given that incentive compatibility and the need to overcome the agency problem between the owner and manager. We discuss a number of model extensions in Section 5. Our model yields empirical predictions that we discuss in Section 6. We conclude with a discussion in Section 7.

2 Model

Consider an economy populated by risk-neutral agents. The economy operates for dates $T = \{0, 1, 2, \ldots, T\}, \infty > T \geq 2$. We refer to the interval of time between adjacent dates $t - 1$ and $t$ as “period $t$.” Agents are “patient” and do not discount future cash flows.\(^{11}\)

In this economy, there is a firm with a single owner who has the sole residual claim on its cash flows but does not have the human capital necessary to operate the firm.\(^{12}\) She hires a professional manager to operate the firm, and can replace the incumbent manager in each period. Managers are drawn from a continuum of potential managers, each having identical abilities and preferences, both of which are common knowledge. The managerial labor market is competitive. Thus, managers cannot command rents because of their abilities or preferences. The per-period reservation wage for managers is zero.\(^{13}\) The owner and managers have the same time horizon $T$. Later, we extend the model to account for different horizons.

In each period, the firm can produce one unit of a good. The good’s quality may be either high or low, which we denote by $h$ and $l$, respectively. There is no storage technology. Thus, a good produced in a period $t$, a “period $t$ good,” must be sold and consumed during the period. Moreover, any cash flow received in a period must be spent in that period. All agents observe the period $t$ good’s quality after it has been consumed. A good’s quality is neither verifiable nor contractible.\(^{14}\)

Bertrand competition between consumers fixes prices. Consumers have identical preferences, which are common knowledge: They assign a value of one to a high-quality good and a value of zero to a low-quality good. The price, $p_t$, consumers set for the period $t$ good represents a bid that will be filled if the good is produced.\(^{15}\) Prices are verifiable and contractible. Consistent with the Bertrand competition assumption, we

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\(^{11}\)Our finite time framework is comparable to that employed in classic models of reputation (e.g., Kreps and Wilson, 1982; Milgrom and Roberts, 1982). It facilitates a unique equilibrium. Given the finite horizon, zero discounting is assumed without loss of generality.

\(^{12}\)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.

\(^{13}\)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.

\(^{14}\)For discussion of the “observable, but not verifiable” assumption we make on product quality here, see Grossman and Hart (1986) and Hart and Moore (1990).

\(^{15}\)We assume that consumers bid before the good is produced simply to ensure that a the market for the good is always “open” regardless of the production decision of the firm. If consumer’s bid after production, then, if the owner decided not to produce in a given period, the good would not have a price in that period, rendering contracts defined based on prices ill defined. Alternatively, we could assume price setting after production and extend definition of
assume that consumer bids equal their expected valuation of the good.\footnote{Bidding expected value is not the only consumer bidding strategy consistent with rational expectations. A “trivial” equilibrium also exists in which consumers believe the good is worthless and bid 0 for the good, in which case the good is not produced and, because consumer orders are never filled, Bayes rule cannot applied to consumer’s beliefs.}

In each period, after the price is fixed, the owner decides whether to operate the firm, i.e., fill consumers’ order or shut the firm down. If the owner decides to operate, the owner must fund the firm by providing the manager with operating capital equal to \( e \). If the owner shuts the firm down for the period, the good is not produced and the owner bears no cost.

By investing \( e \) in the firm’s operations, the manager can employ a reliable production technology that always produces a high-quality good. However, a standard agency conflict exists between the owner and the manager: The manager may be able to divert \( c < e \) of the operating capital towards personal consumption without being observed. Following diversion, the manager can invest only \( I = e - c \), which covers the cost of a vulnerable technology that produces a high-quality good with probability \( \delta \in (0, 1) \) and a low-quality good with probability \( 1 - \delta \).\footnote{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.}

At date 0, the owner can offer the manager a compensation contract. In the baseline model, the compensation contract is publicly observable.\footnote{Consistent with this assumption, in a letter to customers following the recent scandal arising from the opening of unauthorized bank accounts by Wells Fargo employees, its CEO advertised key features of employee compensation designed to motivate them to focus solely on customer interests.} Later we consider the effect of unobservable compensation. The 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 1.

\[\text{Figure 1: Time Line. This figure presents the sequence of actions within time period } t.\]
The firm has an oversight system intended to restrict managerial diversion. The oversight system can either be “secure,” type-$S$ or “insecure,” type-$I$. A type-$S$ system blocks managerial diversion. A type-$I$ system does not block diversion. To simplify the discussion, we will sometimes use the phrase “the manager diverts” without any qualifications to represent the manager’s choice of the following diversion strategy: choose the vulnerable technology when the oversight system is type-$I$ and choose the reliable technology when the oversight system is type-$S$. We will use the phrase “the manager does not divert” to represent the manager choosing the reliable technology regardless of whether the oversight system is type-$I$ or type-$S$. We refer to the firm as type-$I$ (type-$S$) when its oversight system is type-$I$ (type-$S$).

Only the manager observes the firm’s type. He does so at the beginning of the first period. The owner and consumers, whom we collectively refer to as “outsiders,” have a common prior distribution over the firm’s type: At the start of period one, they believe that the firm is type-$S$ with probability $\rho_1$, which measures outsiders’ initial rating of the oversight system’s effectiveness. The outsiders’ rating is updated each period based on the events that occurred in previous periods. The quality of goods provides the information that prompts updates. For instance, because only managerial diversion leads to a low-quality good, outsiders can infer that the oversight system is type-$I$ once they observe low-quality output. When this occurs, we will say the firm is “revealed.” Otherwise the firm is “unrevealed.”

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, $t^*$, conditioned on the firm being unrevealed at the start of period $t^*$. As we will soon 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).

The first step in solving the model is identifying the link between consumer beliefs and prices, and the dynamics of price revision. A good’s price equals consumers’ expectation of its quality. If consumers

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19 Our assumption that $S$ systems completely block diversion and $I$ are completely ineffective is without loss of generality because any probability of blocking diversion can be represented as a convex combination of these two systems and agents are risk-neutral.
believe the manager will not divert in period \( t \), the period-\( t \) good’s price, \( p_t \), equals 1. The price falls with the good’s expected quality. The lowest quality is the expected quality conditioned on the manager diverting. If the firm is unrevealed and the manager diverts, he implements the reliable technology when the firm is secure and the vulnerable technology when the firm is insecure. Thus, the lowest price for the period-\( t \) good if the firm is unrevealed, which we denote by \( f_t \) and refer to as the floor price in period \( t \), is given by

\[
 f_t = \rho_t + (1 - \rho_t) \delta .
\]  

(1)

Note that \( f_t < 1 \), and \( f_t \) also equals the probability that firm remains unrevealed at the start of period \( t + 1 \) if the manager follows the strategy of diverting. When the firm is unrevealed in period \( t \), the floor price evolves over time as follows: If either (a) the firm does not operate in period \( t \) or (b) outsiders believe that the manager will not divert in period \( t \), because outsiders learn nothing about the oversight system from good quality, \( f_{t+1} = f_t \). When outsiders believe that the manager will follow the strategy of diverting and the period \( t \) good is high quality, following Bayes’ rule, \( f_{t+1} \) will equal \( \Gamma[f_t] \), where

\[
 \Gamma[f_t] = 1 + \delta - \frac{\delta}{f_t} .
\]  

(2)

Note that \( \Gamma[f_t] > f_t \). Thus, \( f_t \geq f_1 \). If the period-\( t \) good is low quality, the firm is revealed in period \( t \). Following revelation in period \( t \), the price falls to \( \delta < f_1 \) in period \( t + 1 \) and all subsequent periods. Figure 2 illustrates these dynamics.

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, but, 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 or not 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 manager weighs 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, and thus eliminate future diversion opportunities and the bonus payment. The 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 in the current or future periods; (iii) the firm is unrevealed and the manager is contracted to receive a bonus payment in the future. Consider the first two environments. Once the firm is revealed, the manager’s only income source is diversion. Eschewing diversion in the current period only reduces the number of periods in which the manager will have the opportunity to divert. Thus, once the firm is revealed, he will divert in every period in which the firm operates. For the same reason, even when the firm is unrevealed but the manager is not contracted to receive a bonus in a future period, he will divert in every period in which the firm operates. This highlights the limitation of a bonus: It cannot influence the 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 the 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) 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. (iv) The manager will divert in every period starting in the period in which he receives the bonus.
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 the manager 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—revelation which eliminates future diversion opportunities and the bonus payment.

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 depends on the manager’s continuation value under the diversion and non-diversion 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,

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

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 does not divert in period $t$. The second term reflects his expected payoff if he diverts. Comparing the two terms, it follows that the manager will not divert in period $t$ so long as

$$(1 - \delta) v_M(t + 1) \geq c.$$  \hspace{1cm} (4)

Inequality (4) is the incentive compatibility condition for non-diversion. 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:

**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 non-diversion 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
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

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

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 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.\(^{20}\) Thus, the anticipated signaling benefit of offering compensation that ensures non-diversion is fairly small a few periods after the reputation cutoff period. Most of the gain in operating earnings from reputation-assuring

\(^{20}\) 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).
compensation for such periods is thus accounted for by its fundamental benefit—assuring non diversion—and thus protecting the owner’s operating rents.

The manager’s gain from diversion is \( c \). Expression (6) demonstrates that the bonus needed to assure reputation falls 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.\(^{21}\) 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

\(^{21}\)See the appendix for an example.
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
oversight system to protect its reputation. The owner may also only use compensation to prevent diver-
sion 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 in-
creasing 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 sys-
tem 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 character-
ized 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 rep-
utation 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 own-
ership 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 owner’s compensation and operating policy

In order to simplify the presentation of the results, we have heretofore assumed that compensation takes the form of a bullet payment and that the owner will shut the firm in a given period if and only if the firm does 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 in the previous period. We will now demonstrate that this compensation scheme is in fact 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, let us 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 after the firm is revealed it is still the case that the manager will not be paid and will be terminated.

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 have 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. Therefore, 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:

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

(9)

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 $\tau < T$. 

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Now consider the timing of payments. We have demonstrated that incentive payments will only be made so long as the firm is unrevealed. We will now show that an optimal contract, which we denote by $b^*$, 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 $\tau + 1$, $b^*(t) = 0$. Moreover, the payment in period $\tau + 1$ equals $b^*(\tau + 1) = b^*_{\tau+1}$, 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, which 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 non-diversion, expression (4). First note that Assumption 1 ensures that that 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 and thus 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 ex ante for the owner.

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.,

$$f_t \Gamma[f_t] + (1 - f_t) \delta = f_t.$$  (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. Hence, operating is ex post optimal in period $\tau + 1$. It follows that the operating policy we have assumed previously satisfies ex post incentive compatibility and is in fact dynamically incentive compatible.

## 5 Extensions

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

### 5.1 Unobservable compensation policy

We have assumed that the manager’s compensation is observed by consumers who formed rational conjectures taking this information into account. How crucial is this assumption to our results? First note that we have demonstrated 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, as
a condition of employment, to return some or all of the disclosed bonus to the owner. 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 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, as would be the case if there are no accounting systems
capable of verifying the owner’s report of managerial compensation. This possibility appears far fetched
for firms operating in any advanced economy. Compensation would also be effectively unobservable if con-
sumers, because of either some behavioral bias or rational inattention, simply do fail to observe verifiable
compensation disclosures by the owner. We are not sure if any of these scenarios are plausible. Regardless
of their plausibility, however, the analysis in this section will show 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,
till period \( T - 1 \) the period-\( t \) good’s price will equal one and in period \( T \) it 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 as 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 the fixes 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 expository 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 unobservable 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’s assessment of the probability that the control system is secure is \(\rho_1\) and the probability that it is insecure is \(1 - \rho_1\). If the control system is secure the manager cannot divert and thus the retraction of the reputation cutoff period will have no effect on the owner. If the control system is insecure the retraction of the reputation cutoff period will lower the owner’s expected stream of operating profits. Since compensation and thus a reduction in the reputation cutoff period is unobservable, the owner’s gain form lowering the reputation cutoff by a single period, in contrast to the observable compensation case, will not trigger a fall in the good’s price. However, lowering the cutoff by a single period exposes the firm to revelation in period \(T\). When the owner draws up the compensation contract at date zero, the owner’s assessment of the probability that the control system is insecure is \(\rho_1\) and the probability that it is insecure is \(1 - \rho_1\). If the control system is insecure the retraction of the reputation cutoff period will lower the owner’s expected stream of operating profits. Since compensation and thus a reduction in the reputation cutoff period is unobservable, the owner’s gain form lowering the reputation cutoff by a single period, in contrast to the observable compensation case, will not trigger a fall in the good’s price. However, lowering the cutoff by a single period exposes the firm to revelation in period \(T - 1\). In period \(T\), such 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 \(T\) 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} (1-e) - \delta^k (1-e) + ((P_1 - e) - \delta^n (P_1 - e)) =

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

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 the floor price (equation (1)), we can represent the owner’s gain from an \(n\)-defection by \(\mathcal{D}\), where

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

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

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 fundamental negative 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.

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. We show that 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, because of the monotonicity of the manager’s value function, the manager will eschew diversion in all period prior to period \(k + 1\). 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.\(^{22}\) 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, as we have described in Lemma 3, bonus payments cannot be effective because of unraveling. Hence, the manager will not anticipate bonus payments after the firm is revealed and, by the same logic as in Lemma 3, the firm will shut down. 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. 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 be sufficient to 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 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 till 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 it will equal the floor price less the periodic investment \(e\) conditional on the firm remaining unrevealed.

\(^{22}\)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 will assume that bonus payments contracted in the current period are based on the good’s price in the next period.
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 it 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) and Cremer (1986) describe 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 the 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, 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.\textsuperscript{23} 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

\textsuperscript{23}Examples 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 process are relatively complicated and proprietary.

Three factors interact to determine whether we observe reputation equilibria: (1) outsiders’ rating of the oversight system’s effectiveness ($\rho_0$), (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 produce 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 that 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

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24 Deaton 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.”

25 See 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.

26 See, for example, Bell (1959).
broken part (e.g., a bad wheel) is patently defective. In contrast, lead in the paint is a latent defect, only detectable through sophisticated testing or long term exposure.\textsuperscript{27} Industries or products with higher rates of patent defects correspond to a low $\delta$ and those with higher rates of latent defects correspond to 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.

\textsuperscript{27}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.


**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 the 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, the 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 \( t \). Since the firm will shut down once it is revealed (Claim (iii)), it follows that

\[
M_t = c + \sum_{i=t}^{T} \delta^{T-(t+1)} c. \tag{A-1}
\]

If the manager chooses not to divert in period \( t \) but starts diverting in period \( t + 1 \) his expected payoff will equal \( M_{t+1} \). 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 \( \tau + 1 \), the manager’s expected payoff from continually diverting starting in period \( \tau + 1 \) equals \( M_{\tau+1} + b_{\tau+1} \). The proof is completed by noting that postponing diversion by one period yields him a lower expected payoff of \( M_{\tau+1} + b_{\tau+1} \).

**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 as

\[
b_{\tau+1} + M_{\tau+1} \geq c + \delta \left( b_{\tau+1} + M_{\tau+1} \right). \tag{A-2}
\]

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 \( b_{\tau+1}^{*} \) as defined in (6).

Now suppose that the owner defers the bonus payment by one period and sets it equal to \( b_{\tau+2} \) to exactly satisfy the manager’s incentive compatibility condition. Since the manager will divert in period \( \tau + 1 \) and the owner will shut down the firm in period \( \tau + 2 \) if it is revealed, \( b_{\tau+2} \) must satisfy

\[
\delta b_{\tau+2} + M_{\tau+1} = c + \delta \left( \delta b_{\tau+2} + M_{\tau+1} \right). \tag{A-3}
\]

Thus, \( b_{\tau+2} = \frac{b_{\tau+1}^{*}}{\delta} \) and the owner’s expected cost of incentivizing the manager is \( \rho_1 \times \frac{b_{\tau+1}^{*}}{\delta} + (1 - \rho_1) \times b_{\tau+1}^{*} > b_{\tau+1}^{*} \). 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’ price will equal

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

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

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

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 \( \mathcal{O}_\tau \) represent the date zero expected value of the stream of operating profits under the \( \tau \)-policy. Then,

\[
\mathcal{O}_\tau = (1 - e) + \ldots (1 - e) + (f_1 - e) + f_1 \left( \Gamma^{(1)}(f_1) - e \right) + f_1 \Gamma^{(1)}(f_1) \left( \Gamma^{(2)}(f_1) - e \right) + \ldots + f_1 \Gamma^{(1)}(f_1) \ldots \Gamma^{(T-(\tau+2))}(f_1) \left( \Gamma^{(T-(\tau+1))}(f_1) - e \right)
\]

Thus, the gain in expected operating profits from a \( \tau \)-shift by one period to \( \tau + 1 \) is

\[
\Delta \mathcal{O}_\tau \equiv \mathcal{O}_{\tau+1} - \mathcal{O}_\tau = (1 - e) - \Gamma^{(1)}(f_1) \Gamma^{(2)}(f_1) \ldots \Gamma^{(T-(\tau+2))}(f_1) \left( \Gamma^{(T-(\tau+1))}(f_1) - e \right)
\]

\[
= (1 - e) \frac{(f_1 - \delta)(1 - e) - (1 - f_1)(e - \delta)\delta^{T-1}}{1 - \delta}
\]

\[
= \frac{(1 - f_1)(1 - e) + ((1 - f_1)(e - \delta) - c)\delta^{T-1}}{1 - \delta}. \tag{A-6}
\]

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 \( b^*_2 = \delta^{T-1} \frac{c}{1 - \delta} \). 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 \( \Delta \mathcal{O}_0 = \delta^{T-1} \frac{c}{1 - \delta} \), or equivalently

\[
\frac{(1 - f_1)(1 - e) + ((1 - f_1)(e - \delta) - c)\delta^{T-1}}{1 - \delta} \tag{A-7}
\]

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

$$\delta^{T-1} < \frac{(1 - f_1)(1 - e)}{-(1 - f_1)(e - \delta) - c)}.$$  

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 \( \Delta \theta \). The bonus payment required to ensure reputable behavior up to \( \tau \) is given by

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

(A-8)

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

$$b^{*+2}_{\tau+2} - b^{*+1}_{\tau+1} = \delta^{T-(\tau+1)} c.$$  

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

$$\Delta \Pi = \frac{(1 - f_1)(1 - e) + \left( (1 - f_1)(e - \delta) - (1 - \delta)c \right) \delta^{T-(\tau+1)}}{1 - \delta}.  

(A-9)

Comparing \( \Delta \Pi \) with \( \Delta \Pi_{\tau+1} \) we obtain

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

(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 \((1 - f_1)(e - \delta) - (1 - \delta)c < 0 \), \( \Delta \Pi_{\tau+1} < \Delta \Pi \), 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

$$\Delta \Pi = \frac{(1 - f_1)(1 - e) + ((1 - f_1)(e - \delta) - c) \delta > 0}.$$  

(A-11)

expression (A-7) is positive, which ensures that \( \tau^* > 0 \). Moreover, expression (A-9) and thus \( \Delta \Pi \) are positive for all \( \tau \in \{1, \ldots, T - 2\} \). Therefore, \( \tau^* = T - 1 \). We conclude the proof of Claim (3) 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 $t$-period good’s price is $\delta$. Therefore, if the oversight system is known to be insecure in period $t$, the firm will shut down. \(\square\)

**Proof of Proposition 4.** Let $b$ 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.,

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

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

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

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

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

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

$$v_M[b](t) = b_t + \max[v_M[b](t + 1), \delta v_M[b](t + 1) + c]. \quad (A-13)$$

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

$$v_M[b](\tau + 1) = c + b(\tau + 1) + \sum_{t=\tau + 2}^{T} \delta^{-r} (c + b(t)). \quad (A-14)$$
His non-diversion 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:

$$\min_{b \geq 0} \text{EP}[b],$$
$$\text{s.t. } (1 - \delta)v_M[b](\tau + 1) \geq c. \quad (A-16)$$

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

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

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

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

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 non-diversion, 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 non-diversion period 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. \qed

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

**Lemma 4.** 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) $\Psi(\delta, n) \geq \frac{1}{2}(n - 1)$. 

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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

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

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 $\frac{\partial}{\partial \delta} (\delta^n (1 - n \log(\delta))) > 0$. Thus $\delta \to \delta^n (1 - n \log(\delta))$ 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

$$\text{Diff}(\delta, n) = \Psi(\delta, n) - \frac{1}{2}(n - 1) \geq 0. \quad \text{(A-21)}$$

We can express Diff as follows:

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

The denominator on the right hand side of this equation is clearly positive. Let Num represent the numerator. We will show that Num is also positive. Differentiation shows that Num is strictly convex in $\delta$. For this reason, if the partial derivative of 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 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 Num is decreasing. Thus, $\text{Num}(\delta, n) > \text{Num}(1, n)$. Evaluating Num at $\delta = 1$, shows that $\text{Num}(1, n) = 0$. Thus, the numerator on the right hand side of equation (A-22) is non-negative and thus Diff is non negative.

Lemma 5. 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

$$1 - f_1 \geq \frac{1}{1 - (e - \delta)} \frac{c \delta}{1 - \delta}. \quad \text{(A-23)}$$

Assumption 1 is equivalent to

$$1 - f_1 \leq (1 - e)(1 - \delta). \quad \text{(A-24)}$$
Equations (A-23) and (A-24) cannot be satisfied for any \( f_1 \) unless
\[
\frac{1}{1-(e-\delta)} \frac{c \delta}{1-\delta} \leq (1-e)(1-\delta). \tag{A-25}
\]
Because \( 0 < 1-(e-\delta) < 1 \),
\[
\frac{c \delta}{1-\delta} \leq \frac{1}{1-(e-\delta)} \frac{c \delta}{1-\delta}. \tag{A-26}
\]
Thus, (A-25) and (A-26) imply the result.

**Lemma 6.** 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 4 and Lemma 5 imply that
\[
\delta c \leq (1-e)(1-\delta) \quad \text{and} \quad \Psi(\delta, T-1) > \frac{1}{2}(T-2).
\]
Because \( \delta \in (0,1), 1-\delta^n > 1-\delta \), it follows that
\[
\mathcal{D}(T-1) < (1-e)(1-\delta) - (1-f_1) \left( \frac{1}{2}(1-e)T -(1-f_1) \right). \tag{A-27}
\]
Our parameter restrictions imply that \( 0 < \delta < e < f_1 \) thus
\[
(1-e)(1-\delta) - (1-f_1) \left( \frac{1}{2}(1-e)T -(1-f_1) \right) < 0 \iff T > 2 \left( \frac{1-f_1}{1-e} + \frac{1-\delta}{1-f_1} \right). \tag{A-28}
\]
Thus, the right hand side of (A-28) is sufficient to ensure that \( \mathcal{D}(T-1) < 0 \).

**Lemma 7.** If defection is optimal under any compensation policy involving positive compensation payments, it is optimal under \( n = 1 \), the policy that fixes the reputation cutoff date at \( T-2 \), i.e., \( \mathcal{D}(n) > 0 \Rightarrow \mathcal{D}(1) > 0 \) for \( n \in \{1,2,\ldots,T-2\} \).

**Proof.** Claim i in Lemma 4 shows that \( \Psi \) is strictly increasing in \( n \). Inspection of equation (12) in light of this result shows that \( \mathcal{D}(n) \) is decreasing in \( n \). 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 7 this implies that \( \mathcal{D}(n) \leq 0 \), for \( n \in \{1,2,\ldots,T-2\} \). Condition (ii) implies that the hypothesis of Lemma 6 is satisfied and thus \( \mathcal{D}(T-1) < 0 \). Thus, \( \mathcal{D}(n) \leq 0 \) for \( n \in \{1,2,\ldots,T-1\} \).
**Counterexample:** A case where the marginal gain from increasing the cutoff is not decreasing in \( \delta \), the probability that diversion will not be revealed.

![Graph A: Marginal gain from extending the reputation cutoff period](image1)

**Figure 4:** In Panel A, \( f_1 = 0.935, e = 0.7625, c = 0.0331, T = 3 \). \( \delta \) is varied between 0.50 and \( \bar{\delta} \), the highest possible value of \( \delta \) 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 \( \delta \), 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.