

The Separation of Firm Ownership and Management: A Reputational Perspective

Thomas H. Noe
Saïd Business School and Balliol College
University of Oxford

Michael J. Rebelló
School of Management
University of Texas at Dallas

Thomas A. Rietz
Henry B. Tippie College of Business
University of Iowa

This version: March 2015

Abstract

We examine the effect of ownership and governance structures on what is arguably a firm's most valuable asset: its reputation. We model reputations based on alterable organizational and structural firm characteristics rather than the personal characteristics of the management team. We show that, in some cases, delegated "professional" management combined with outside shareholder governance supports reputable firm behavior even when owner management cannot. The option to reform after a reputation is damaged further increases the advantage of delegated management because the reform option reduces the ability of owner managers to commit ex ante to reputable behavior.

JEL Classification Codes: C91, D82, G31, G32, L15

Keywords: adverse selection, reputation

We thank the Oxford University Centre for Corporate Reputation for financial support. For helpful comments and suggestions, we thank Amil Dasgupta, Daniel Diermeier, Amrita Nain, and seminar participants at the Oxford University Centre for Corporate Reputation and the Cambridge Corporate Finance Theory Symposium. We are especially grateful to Alan Morrison for perceptive comments on an earlier draft of this paper. All errors are our own.

1 Introduction

Corporate reputations are valuable. Nakamura [2009], for example, finds that the stock of corporate intangible assets is worth approximately 3 trillion dollars and has roughly the same value as the stock of tangible assets.¹ Much of this value is brand capital, and brand capital depends on reputation. Not surprisingly, given its key role in driving corporate valuations, a significant body of research has been developed in economics and finance to explain how firms maintain reputations, and how reputations are influenced by firms' organizational structures and financing.² These models share some important features: (a) firm reputation is tied to specific characteristics of an agent or team of agents, (b) these agents bear the *entire* cost and enjoy *all* the benefits of the firm's reputation, (c) the agent's or team's actions influence the reputation, and (d) when reputation is based on a team, agents who act disreputably must be replaced and the firm's reputation changes along with the team's composition. Models based on this "standard reputation framework" are best suited to describe reputation acquisition and loss in owner-managed firms and partnerships in the service industry, for example, legal firms, investment banks and money management firms.

Our paper diverges from the standard reputation framework in two respects. First, we model reputation as adhering to the organization rather than to agents employed by the organization. Second, we assume that firm owners may not "own" the human capital required to manage the firm. Instead, only a pool of fairly anonymous "reputationless" agents may possess managerial human capital. In this world, firm ownership and management are *per force* separated. We examine how firms will be governed, and how separation between ownership and management affects corporate reputations, economic efficiency, and firm value. Since Jensen and Meckling [1976], the consensus of the contracting literature has been that separation of ownership from management generates agency costs. In contrast, in our framework, this separation frequently generates agency benefits by promoting reputation formation and increasing economic efficiency.

The specifics of our model closely reflect the views of practitioners and management consultants—firm reputation is founded on alterable organizational and structural traits, it is not an aggregation of employee reputations, and it is maintained not through the actions of owners but rather by the actions of professional managers. This perspective is best illustrated by a prototypical case of corporate reputation loss that echoes themes advanced in the management literature: the 2013 reputation crisis of Lululemon Athletica.³

¹By some estimates, reputation accounts for more than 60% of firm value (Gaines-Ross [2008]). Corporate reputations are valuable because reputable firms better motivate and retain employees (Edmans [2011]), are better able to maintain customers (Armour et al. [2010]), can charge higher prices for their products (Milgrom and Roberts [1982, 1986] and Allen [1984]), maintain higher profitability (Roberts and Dowling [2002]), and obtain financing on favorable terms (Srivastava et al. [1997] and Billett et al. [2012]).

²See Milgrom and Roberts [1982], Allen [1984], Milgrom and Roberts [1986], Cremer [1986], Maksimovic and Titman [1991], Tirole [1996], Tadelis [1999], Levin and Tadelis [2005], and Noe et al. [2012].

³There are many examples of structural reputation loss and reform in firms that separate ownership and management: Barclays established a "Brand and Reputation Committee" to review any issues that might negatively affect its reputation (Gaines-Ross [2008, p. 136]). Toyota developed the "Toyota Way" in which all employees are required to identify and fix problems that might affect its reputation for quality (Gaines-Ross [2008, p. 139]). After a wave of recalls, Toyota also reformed its oversight structure to give its "Customer First Committee" more oversight and control over decisions that might affect quality (Gaines-Ross [2008, p. 140]). What these examples have in common is the structural control aspect of reputation management independent of the specific agents managing the companies.

Lululemon is a firm with a reputation for high-quality athletic clothing. Its stock price and revenues dropped sharply when customers discovered that yoga pants made from the firm's signature fabric, Luon, became too sheer when practicing yoga. The problem was traced to anonymous mid-level managers who altered fabric quality to lower production costs, but the resulting economic costs were borne primarily by its investors. Although the guilty managers may have been dismissed, neither they nor their replacements had reputations either with consumers or Wall Street analysts. Lululemon's board's response focused on organizational and control systems reforms. It adopted a reform package that included (a) a new system of factory oversight, and (b) a new cross-functional organizational structure. The replacement of the errant managers with more reputable managers was not a key part of the board's recovery strategy. In fact, when disclosing the reforms, the board did not refer to the fates of the offending managers. It was also silent about the departure of CEO, Christine Day, who left the company shortly thereafter, even though she did not undertake any actions that directly reduced the quality of Lululemon yoga pants. The natural interpretation of this crisis and the board's response is that Lululemon lost a reputation for having an organizational structure and control system (or equivalently from the perspective of our analysis a corporate culture) that ensures high quality output. Consistent with the recommendations of much of the literature on corporate reform, the board's response was clearly aimed at increasing consumer and investor confidence in Lululemon's organizational structure and control systems.

Our model aims to capture the effect of firm ownership and governance on essential tradeoffs present in contexts such as Lululemon's. We assume that, under delegated management, the owner hands control of operating decisions to a professional manager whose characteristics are common knowledge. Employment is hire-at-will as the owner has the option to replace the manager at any time from a pool of managers who are perfect substitutes. Upon hiring the manager, the owner incentivizes him with a compensation contract. The firm also has in place a governance mechanism to control the manager's actions, which we will henceforth refer to as the "control system." Only the manager knows whether the control system is "insecure." The manager can exploit an insecure control system to enrich himself by implementing low-cost production strategies. The failure of a low-cost strategy results in low-quality goods, which alters the owner's and consumers' beliefs about future product quality by revealing that the control system is insecure. Consequently, the firm's reputation is based on the probability that agents other than the manager assign to the control system being secure. The reputation is tied to systemic characteristics of the control system and not the personal characteristics of the manager. However, the manager's actions affect the reputation. In contrast, under owner management, the owner manages the firm by retaining control of the operating decisions, and chooses production quality knowing the efficacy of the control system.

We show that the incentives for reputation maintenance are quite different under owner management and delegated management. Under owner management, the owner captures the entire gain from opportunistic reputation harvesting as well as suffers the entire reputation cost of harvesting. As in the standard reputation framework, the gain from harvesting is short term and independent of the firm's current reputation. The

Gaines-Ross [2008] clearly attributes reputation loss to organizational failure, citing dozens of examples of reputations lost and reputations rebuilt through changes in governance, organization structure and culture. Reputation restoring structural changes can be targeted as high as board level oversight or as low as factory worker behavior.

cost of harvesting is increasing in reputation. This tradeoff results in the, by now, standard result: when the reputation is sufficiently high, an owner-manager refrains from harvesting.

Under delegated management, an owner's incentives are very different since the manager captures the gain from reputation harvesting while the owner bears the cost of harvesting. An owner only affects reputation indirectly through retention decisions and the manager's incentive contract. She has to make these decisions without knowing if the control system is secure. However, the owner does know that, if the system is insecure, absent effective incentive compensation, the manager's self-interested operating decisions will likely damage the firm's reputation by revealing that the control system is insecure. The owner also knows that reputation damage will significantly reduce her wealth. Because the firm's reputation represents the probability that the control system is secure, when this probability, and thus reputation, is low, the owner has the strongest incentive to ensure reputable managerial behavior through compensation. Thus, in contrast to an owner manager, a non-managing owner's incentives for maintaining reputation are strongest when the firm's reputation is low. For this reason, in some cases, delegated management is *more* effective and efficient than entrepreneurial owner management.

To protect the firm's reputation, under delegated management, the owner must transfer some reputational rents to the manager via the incentive contract. In contrast, under owner management, all of the rents from reputation accrue to the owner-manager. Therefore, it is not surprising that, even when the total value generated by delegated management is higher, firm value may be higher under owner management. However, we identify conditions where, in spite of the rent concession to managers, delegated management produces higher firm value than owner management.

The effectiveness of delegated management in maintaining firm reputation depends crucially on the corporate governance environment. First, effective delegated management requires governance to be controlled by "outsiders," that is, control over governance must be vested in owners or their agents, such as board members, who do not have private information regarding the control system's security. Governance by (informed) insiders fails because consumers infer the insiders' private information regarding the control system from insider actions. We show that this effect is so large that, when insiders know the control system is insecure, they prefer to "cover up" by mimicking the optimal policies of firms with secure control systems. This cover up prevents insider-controlled firms from reaping the benefits of delegated management. Thus, our model predicts that professional delegated management will be correlated with governance institutions that vest control in outsider dominated boards.

Second, transparency about corporate compensation increases the effectiveness of delegated management. When compensation policy is transparent, optimal compensation has two benefits: (i) it increases the firm's expected continuation revenue by dissuading the manager from undertaking actions which risk revealing the insecurity of the control system and (ii) it increases current revenue by assuring consumers that the quality of current output will be high. When compensation is opaque, the second benefit (ii) is lost. This limits the situations under which delegated management is effective. For this reason, we predict that institutions that facilitate corporate transparency (e.g., disclosure requirements) will increase reliance on delegated management.

The third, and in our view, most interesting “institutional complement” to delegated management is the option for “corporate reform,” which allows an owner to make an investment aimed at replacing the existing control system with a more secure system. Successful reform results in a new secure control system. The effectiveness of corporate reform thus depends on the probability that reform will, in fact, produce a more effective control system. The availability of fairly low cost, moderately effective corporate reform mechanisms greatly increases the advantage of delegated management over owner management. The option to reform lowers an owner-manager’s ex ante incentives to behave reputably while increasing the non-managing owner’s value from maintaining reputation under delegated management. Thus, we predict that the growing effectiveness of corporate reform, suggested by the management literature, should lead to increased adoption of professional delegated management structures.

Our discussion, thus far, has steered clear of the question of the exact form of optimal compensation and retention policies. We show that optimal compensation contracts take the form a back-loaded payment conditioned on the firm acting reputably at all previous dates. This payment is sufficient to ensure reputable behavior by the manager at all dates preceding the payment. Under the optimal contract, managers are “bureaucrats” whose compensation only depends on the firm having a viable revenue stream at the payment date, usually close to or at the end of their tenure. For some model parameters, the optimal compensation resembles the “hold-till-retirement” stock plans at firms like Deere and Citigroup, where executives must hold shares they are granted until retirement. It also resembles Supplemental Executive Retirement Plans (SERPs), under which deferred compensation is funded out of firm cash flows. For other model parameters, it is optimal to pay the manager before his tenure ends. These optimal contract designs resemble the “fixed-date” contracts adopted by Exxon that require executives to hold shares acquired through grants or the exercise of option grants for up to 10 years.

The optimal retention policy is to terminate the manager if and only if the quality of the firm’s output reveals that the control system is insecure. Terminating a professional manager who acts disreputably maximizes his penalty for jeopardizing the firm’s reputation. This ex ante incentive effect ensures that termination following reputation damage is optimal even though it does not affect the quality of firm management ex post. However, consistent with the management literature on corporate reform, the termination of errant managers is neither necessary nor sufficient for repairing corporate reputations.

In summary, our analysis predicts that, in a world that provides effective mechanisms for disclosure and reform, firms staffed with well-compensated professional managers, supervised by outsider boards, can dominate owner-managed firms. Agency, in our setting, generates tangible benefits when firm value is based on intangible reputations.

The remainder of the paper is organized as follows: In Section 2 we review related research. We describe our baseline model in Section 3. In Section 4, we derive conditions for reputation equilibria under delegated management. In Section 5, we compare the effectiveness of owner management and delegated management in supporting firm reputation. Section 6 contains several extensions of our analysis of delegated management. In Section 7, we analyze the relation between firm value, its reputation, reputation reform, and ownership structure. We conclude in Section 8 with a brief discussion and summary of our results. Proofs

of all claims are presented in the Appendix.

2 Related Literature

This paper is indebted to a very comprehensive literature on reputation. In fact, the structure of our model—ex post but not ex ante quality observability and a finite multiperiod time horizon—reflects our desire to make reputation formation under owner-management match as closely as possible seminal models of firm reputation (Milgrom and Roberts [1982] and Kreps and Wilson [1982]).

This paper also relates closely to literature that focuses on organizational structure and reputation when the characteristic upon which reputation is based is not affected by agent actions. Tadelis [1999] models how agents with a hard-wired propensity for reputable actions affect firm reputation through trading their ownership rights. He demonstrates that, when the agents can *unobservably* sell their firms to other agents, a firm's reputation can be valuable even when the firm is separated from the agent upon whose characteristics its reputation is founded. As in Tadelis, in our baseline model, the characteristic upon which reputation is based, the security of the control system, is not directly affected by agent actions. In contrast to Tadelis, in our model, the detachment between a firm and agents who support its reputation need not be disguised by unobservable control transfers because reputation adheres to firms' control systems—a hard-wired characteristic of firms rather than agents. Moreover, inferences about the effectiveness of these control systems are affected by the endogenous actions of agents who, in contrast to the standard reputation framework, do not themselves have reputations.

Levin and Tadelis [2005] focus on a setting where consumer monitoring of quality is imperfect and the firm's reputation for quality is fixed by hard-wired actions of its employees, who have heterogeneous agent-specific human capital. They demonstrate that the corporate form of organization may be dominated by a partnership. Our analysis also demonstrates that organizational form can affect firm performance. However, we focus on a very different economic environment; one in which human capital is general, managers are interchangeable, and the hard-wired attribute—security of the control system—is agent independent. In this environment, we identify conditions under which bureaucratic corporate management is optimal.

Of course, outside the reputation framework, other researchers have considered the effect of organizational form on the sort of opportunistic insider diversion modeled in this paper. For example, Glaeser and Shleifer [2001] assume that organizing as a not-for-profit firm blocks diversion of funds and thus acts as a commitment device against insider diversion. The cost of organizing as a not-for-profit is that blocking diversion forces owners to extract gains through inefficient perk consumption. When the commitment benefit outweighs the cost of inefficient perk consumption, firms organize as not-for-profits. In our analysis, as in Glaeser and Shleifer, by separating ownership and management, owners affect their ability to capture rents from opportunism. However, in contrast to Glaeser and Shleifer, in our model, separating ownership and management does not directly block diversion. In fact, the opportunities for diversion are the same for owner and non-owner managers. Nevertheless, in our analysis, separation of ownership and management sometimes inhibits opportunistic diversion.

3 Model

Consider an economy populated by risk-neutral agents and one firm. Time is indexed by a finite set of dates, $\mathcal{T} = \{0, 1, \dots, T\}$, and all agents are “patient” and do not discount future cash flows.⁴ We refer to the interval of time between adjacent dates $t - 1$ and t in the set \mathcal{T} as “period t .” There is no storage technology. Thus, any cash flow received in a period must be spent in that period, and any good produced in a period must be consumed during the period. The firm has a single owner. We first consider the case of an “outside owner” who delegates operating decisions to a professional non-owner-manager who gains an information advantage. Later, we examine the effect of removing the owner’s information disadvantage, and allowing the owner to also operate the firm.

Each period, the owner must choose whether to operate or shut down the firm for the period. If the owner chooses to shut down in a particular period, she can resume operating the firm in later periods. Each period in which the owner wants to operate the firm, she must provide the manager with operating capital equal to e .⁵ This equals the cost of a high-quality production technology the manager can implement in the period. The manager can instead implement a low-quality production technology costing $I < e$. Both production technologies produce one unit of a good whose quality can be either high, h , or low, l . The high-quality technology always produces a high-quality good. The low-quality technology produces a high-quality good with probability $\delta \in (0, 1)$ and a low quality good with probability $1 - \delta$.

The manager’s technology choice is unobservable, and he may be able to unobservably divert the entire cost saving from implementing the low-quality technology, $c = e - I$, to personal consumption. The firm has a control system to restrict diversion. The control system can either be “secure,” type- \mathcal{S} , or “insecure,” type- \mathcal{J} . Only the manager observes the control system’s type. At the beginning of the first period, consumers and the owner share a prior belief that the control system is type- \mathcal{S} with probability ρ_1 . If the control system is type- \mathcal{S} , the manager cannot divert *any* of the firm’s funds. The manager can divert c when the control system is type- \mathcal{J} . However, the manager cannot deplete the firm’s funds below I , the minimum expense consistent with operating, through diversion. This assumption captures the idea that “excessive” diversion becomes observable. For example, if the 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.

Thus, when the control system is insecure, the manager will undertake one of two actions if the owner

⁴We have chosen a finite time setting so that our framework is comparable to that employed in seminal models of reputation. In these models, a finite time horizon facilitates a unique equilibrium. In our model, a finite time horizon is not necessary to ensure a unique equilibrium under delegated management, but is necessary under owner management. We have assumed a zero discount rate to improve exposition. The assumption that all agents discount at the same positive rate would produce identical results.

⁵We have made this assumption in the interest of brevity. As will become clear below, the owner never has an incentive to inject more than e into the firm in a period since the extra funds cannot improve product quality. The owner will never want to inject less than e since the manager can then only implement the low-quality technology, which is less profitable than not operating, and this policy also has no advantage over not operating from the perspective of producing information about the nature of the firm’s control system.

finances operations for the period: (a) divert, consume c , and use the low-quality technology, or (b) not divert, not consume c and use the high-quality technology. When the control system is secure, if the owner finances operations, the manager can take only action (b). 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 strategy: choose action (a) when the control system is insecure and choose action (b) when the control system is secure. Similarly, we will use the phrase “the manager does not divert” to represent the manager choosing action (b) both when the control system is secure and when it is insecure. Also to improve exposition, when consumers and the owner assess a high (low) probability to the control system being secure, we capture their beliefs by referring to the control system as robust (fragile).

Since goods cannot be stored, a good produced in period t is also sold in period t ; we refer to the good produced and sold in period t as the “period t ” good. Each good is sold to a continuum of consumers through Bertrand competition, and its market price is set at the beginning of the period before the owner’s operating decision. Thus, consumers do not know the good’s quality when they set its price. The market price is common knowledge, verifiable and contractible. Consumer preferences are common knowledge: all consumers assign a value of 1 to a high-quality good and 0 to a low-quality good. Thus, a good’s value equals its probability of being high quality. All agents learn a good’s quality after consumers purchase it and thus, its quality is common knowledge at the start of the subsequent period. While a good’s quality is observable, we assume that it is not verifiable for contracting purposes.⁶ Figure 1 provides a snapshot of the timing of decisions in the model and within each period.

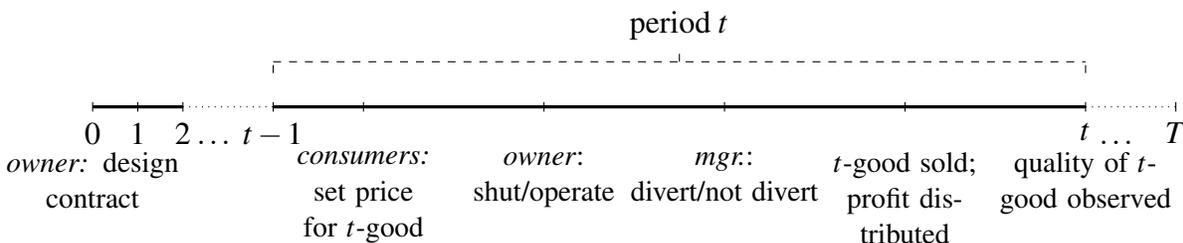


Figure 1: *Time Line*. This figure presents the sequence of actions within a typical time period under delegated management

The owner can offer the manager a compensation contract whose terms are set at the beginning of period one.⁷ Under the contract, in each period t , the payment, $B_t(p)$, depends on the period t good’s price, p .⁸ We focus solely on contracts where B is non-decreasing in the good’s price in each period, and assume that the manager has limited liability, which ensures that payments to the manager are non-negative. These

⁶For discussion of the “observable, but not verifiable” assumption we make on product quality here, see Grossman and Hart [1986] and Hart and Moore [1990].

⁷We make this assumption without any loss of generality. In an earlier version of this paper, we derived the optimal contract when the owner cannot commit to a long-term contract and can only contract on a payment in the subsequent period. The optimal contract under this more restrictive condition is identical to the optimal contract we derive below. Also, as one can verify from discussion before Proposition 1, the owner’s welfare cannot be increased by contracting payments at date t dependent on revenues realized before $t - 1$.

⁸We impose this restriction to simplify the definition of non-decreasing contracts required below.

restrictions are standard in the contracting literature (see, for example, Innes [1990], Nachman and Noe [1995] and DeMarzo and Duffie [1999]).⁹ Thus, a compensation contract is a vector of nondecreasing non-negative functions $(B_1(\cdot), B_2(\cdot), \dots, B_T(\cdot))$. In summary, compensation must be a non-decreasing function of price, and directly contracting on output or net profit is not permitted. In a sense, our framework is the most restrictive contracting environment consistent with any dependence between compensation and managerial actions.

To simplify the analysis, we normalize the manager's per-period reservation wage to zero. We assume that the manager is drawn from a continuum of managers with identical ability and preferences, both of which are common knowledge. Thus, firm reputation is not dependent on the manager's characteristics, and the owner has all the bargaining power in compensation negotiations. The owner's absolute bargaining advantage limits the likelihood of reputable firm behavior under delegated management. Our assumption that the manager is drawn from a limitless pool of identical potential managers raises the issue of whether there will be any manager turnover. The following analysis will transparently show that, if the control system is fixed and cannot be reformed, the owner has no incentive to replace the manager. Hence, in order to simplify our exposition, we will assume, in the baseline model, that the manager is not replaced. When we extend the analysis to model control system reform, we will show that manager replacement can be optimal. Consequently, when we consider reform, we will assume that during the owner's action phase, the owner can choose to replace the manager and draw an identical manager from the pool of potential managers.

In order to focus on the subset of the parameter space that yields interesting and insightful results, we impose the following restrictions on prior beliefs and the low-quality technology:

Assumption 1.

$$\rho_1 + (1 - \rho_1)\delta \geq e.$$

Assumption 2.

$$I > \delta > 0.$$

Assumption 1 ensures that the firm will produce in period 1. Given period 1 prior beliefs, even if consumers believe that the manager will always divert when the control system is insecure, the price they set will be sufficiently high to ensure that period 1 production is profitable. Assumption 2 ensures that the low-quality technology always produces a high-quality good with positive probability, but once the control system is revealed to be insecure, the probability of producing a high-quality good is too low for production to be profitable for the owner.

When the owner also manages the firm, her information set is the union of the information sets of the owner and the manager under delegated management. Moreover, the owner chooses the production tech-

⁹The argument used by these authors rests on the assumption that, if contracts are decreasing in revenue, the manager will have an incentive to sabotage revenue. Under the assumption that the manager can freely obstruct revenue production, e.g., by selling the good at a price below the maximum price bid by consumers, and that this sort of obstruction cannot be verified, decreasing contracts will never be optimal. Rather than modeling the free destruction explicitly, we follow the literature and simply rule out such contracts. Limited managerial liability rests on similar non-modeled constraints on the scope of contracting: Given no storage technology, the manager enters each period with a 0 cash balance, ensuring that he is unable to pay any contracted negative payments.

nology and decides whether to consume funds she allocated for production. Consumers cannot observe the owner's technology and diversion choices. Therefore, as is the case under delegated management, consumers are unable to determine the quality of the goods produced by the firm ex ante. Finally, as is the case under delegated management, the owner cannot divert funds if the control system is secure.

4 Reputation under delegated management

For a fixed compensation contract, given the contract, we define an equilibrium as a Bayesian Nash equilibrium, i.e., a set of owner and manager actions, good prices, and beliefs in each period such that

- a. the owner's shut down/operate strategy is incentive compatible,
- b. the manager's divert/not divert strategy is incentive compatible
- c. consumers set prices equal to expected quality conditioned on the owner's and manager's strategies, and
- d. belief updating by consumers and the owner is consistent with Bayes' rule.

A solution to the model is a contract B^* and an associated equilibrium such that there exists no other contract B' with an associated equilibrium that produces a higher ex ante expected payoff for the owner.

In each period, the manager's optimal action is determined by the firm's control system and the good's expected future price path. The owner's optimal action results from her expectation about the good's price in the period, its price in subsequent periods, and the manager's expected action. Consumers' optimal actions depend on their assessment of the firm's control system and the manager's expected action. Thus, in each period, only the information that fixes the good's current-period price is relevant. The price only depends on the consumers' and owner's shared belief about the firm's control system and their belief about the manager's technology choice. Hence, we will seek equilibria in which agents' strategies at each history depend only on the current assessment of the control system, ρ_t , and the period in which the decision is made, t . For ease of exposition, we refer to histories before low-quality output is observed as "unrevealed" histories. We refer to histories after low-quality output is observed as "revealed" histories. We refer to the firm and its control system as "revealed" once consumers learn that the control system is insecure.

Since the preferences and abilities of the owner and manager are common knowledge, the firm's reputation is based solely on consumers' assessment of its control system. The reputation is maintained if ρ , consumers' assessment of the probability that its control system is secure, does not fall. Since managerial diversion generates a positive probability of low-quality output, which reveals that the firm is insecure, the reputation can only be maintained with certainty if the manager completely eschews diversion. We will focus on solutions where the manager eschews diversion for at least some periods, and will refer to an equilibrium in which the firm maintains its reputation until period T as a *reputation equilibrium*.

4.1 General properties of the solution

We start by establishing general properties of the optimal compensation contract and equilibria. To maintain the firm's reputation, the owner must pick a compensation contract that specifies positive payments to the manager. To see this, suppose the owner chooses a contract that does not pay the manager. If the control system is insecure, the manager can raise his payoff in a period by diverting. In fact, diversion is the only way the manager can raise his payoff. To control the manager, the owner can threaten to withhold future funding and thus deprive the manager of future opportunities to divert. However, since the manager's only avenue to a higher payoff is to divert, both delaying diversion and eschewing diversion entirely are suboptimal. It follows from straightforward backward induction that the threat to withhold future funding is never sufficiently strong to deter diversion, and the resulting technology choices will jeopardize the firm's reputation in every period it operates.¹⁰

While incentive compensation is essential to maintain the firm's reputation, it cannot prevent diversion in period T . The reason is straightforward. Since the manager's diversion is unobservable, a period t good's price cannot vary with period t diversion. Thus, the manager's period t diversion cannot be influenced by a payment tied to the period t good's price. This argument also applies in period T . Moreover, since the firm does not operate after period T , period T diversion cannot be influenced by a payment in a subsequent period. Finally, incentive payments in prior periods cannot influence the manager's period T decisions.

Incentive compensation also cannot deter diversion once the control system has been revealed. The reason is frequently encountered in reputation models—*unraveling*. Suppose that the control system has been revealed before period $T - 1$. Recognizing that the manager will divert in period T , consumers will price the period T good accordingly, which fixes the period T good's price at δ . Thus, a period T incentive payment also cannot vary with the manager's period $T - 1$ action. Moreover, by our earlier argument, period $T - 1$ compensation cannot vary with the manager's period $T - 1$ action. Therefore, period $T - 1$ and T incentive compensation cannot deter the manager from diverting in period $T - 1$. Since consumers will then price the period $T - 1$ good assuming the manager will divert with certainty, we can repeat this argument and extend this result to earlier periods where it is known that the control system is insecure.

Lemma 1. *If the firm's control system is insecure, the manager will divert in period T . The manager will also divert in every period after the control system has been revealed.*

Once the firm has been revealed, in every subsequent period, because incentive compensation is ineffective, consumers know that the manager will always divert if the firm operates and will set a price of δ for goods. By Assumption (2), production is unprofitable at this price. Therefore, the owner will withhold funding in every period after the firm has been revealed. We formalize this result in the following lemma:

Lemma 2. *The firm will shut down after its control system is revealed, i.e., the owner will not fund the firm's operation in any subsequent period once the control system is revealed.*

¹⁰We have not provided a formal proof for this statement in the interest of limiting the length of the paper, but we are happy to comply with a request for a proof.

Consumers and the firm are directly affected by the value of a period t good. The probability that the control system is secure, ρ , only matters through its effect on this value. Consequently, a state variable that directly represents the good's value and the price consumers are willing to pay will facilitate exposition by allowing for more compact expressions. Therefore, we will use the state variable P in our analysis, where

$$P = \rho + (1 - \rho) \delta. \quad (1)$$

P clearly captures the price of a good, p , when consumers conjecture that the firm will operate and the manager will divert in the period. If the consumers' conjecture is correct, P also represents the probability that the firm will remain unrevealed at the start of the next period. Because there is a one-to-one relation between P and ρ , we can define how Bayes' rule applies to P . Specifically, by Bayes' rule, when consumers conjecture that the manager will divert and the firm produces a high quality good in the period, the state variable at the start of the next period will equal $\Gamma[P]$, where

$$\Gamma[P] = 1 + \delta - \frac{\delta}{P}. \quad (2)$$

Note that $\Gamma[P] > P$. If the firm produces a low quality good and is revealed, then $P = \delta$ in the next period and all subsequent periods, and as shown in Lemma 2, the firm will cease to operate. If the firm is unrevealed and either consumers conjecture that the manager will not divert or the firm does not operate, the state variable at the start of the next period will also equal P and the firm will remain unrevealed with probability 1.

Let P^+ be the next period's state variable if the firm remains unrevealed. Conditioned on the manager diverting, the firm will remain unrevealed with probability P , and the next period's state variable will equal $\Gamma[P]$. The firm will be revealed with probability $1 - P$, in which case, the next period's state variable will equal δ . It follows that, if consumers conjecture the manager will divert, the expected value of the next period's state variable is

$$PP^+ + (1 - P) \delta = P\Gamma[P] + (1 - P) \delta = P. \quad (3)$$

In contrast, $P^+ = P$ if the firm does not operate or consumers conjecture that the manager will not divert even if the control system is insecure, since the production of high quality output (if it occurs) will have no effect on consumers' beliefs about the control system. Thus, regardless of consumers' conjectures about managerial behavior, the unrevealed price in the subsequent period, $P^+ \in [P, \Gamma[P]]$.

These observations have significant implications for the owner's shut down decision. When the firm operates and the manager diverts, equation (3) implies that expected upward revision in the good's price following high-quality output is exactly offset by the expected fall in its price following low-quality output. However, because the owner can shut down production in the next period, she can limit the influence of the price decline following low-quality output on her payoff. Thus, the shut-down option induces a convexity in the owner's continuation value function when the manager diverts. Because of this convexity, the expected continuation value is always weakly higher if the owner operates. Assumption (1) and $\Gamma[P] > P$, implies that the current period payoff is always higher if the firm operates. Thus, ignoring the effect on the cost of

contracted payments to the manager, ex post, in each period, the owner prefers to operate the firm as long as the firm is unrevealed. Assumption (1) ensures that, even when the manager diverts when the control system is insecure, operating increases the owner's date-0 ex ante value. Thus, when designing the manager's compensation contract at date 0, it is in the interest of the owner to choose a contract that does not generate ex post incentives to shut down the firm in periods in which the manager diverts.

Management compensation contracts that specify payments that vary with unrevealed prices of the good can generate "perverse" incentives since the owner can influence the payments by shutting down the firm, which affects consumer updating. Contracts that specify the same payment to the manager for all policy choices by the owner so long as the firm is unrevealed, eliminate these perverse incentives to shut down the firm. We define such a "simple" compensation contract as a vector of payments to the manager, $b = (b(1), b(2), \dots, b(T))$, conditioned on the firm being unrevealed in the period. Specifically, the price-contingent contracted payment in each period t , $B_t(p_t)$, satisfies

$$B_t(p_t) = \begin{cases} b(t) & \text{if } p_t \geq P_1 \\ 0 & \text{if } p_t < P_1. \end{cases} \quad (4)$$

Under these simple contracts, the manager's payment if the firm is unrevealed at the next date is independent of the owner's operate/shutdown decision because the manager receives the payment whenever the firm is unrevealed. Thus, the level of such payments will not influence the owner's operating decision. This ensures that a simple contract is always optimal.

Under a simple contract, the firm will always operate while it is unrevealed. When the control system is insecure, the manager has the option to divert. His gain from diversion is an increase in current period consumption. Its cost is the possible loss of future consumption from diversion and compensation payments triggered by revelation. This loss is proportional to the manager's continuation value. Define $v_M(t)$ as the manager's value function when the firm has not been revealed up to period t . If it has been revealed, the manager's continuation value is 0 since the firm shuts down and his reservation is 0. Thus, the expected value of the manager's payoffs in period t is the sum of the manager's current period payoff and continuation value, i.e.,

$$v_M(t) = b(t) + \max [v_M(t+1), \delta v_M(t+1) + c]. \quad (5)$$

The first term in the maximum expression on the right-hand side of equation (5) reflects the manager's payoff from not diverting in period t . The second term reflects the manager's gain from diverting. Since

$$v_M(t) = b(t) + \max [v_M(t+1), \delta v_M(t+1) + c] \geq \max [v_M(t+1), \delta v_M(t+1) + c] \geq v_M(t+1), \quad (6)$$

$v_M(t)$ is weakly decreasing in t . The manager's continuation value declines with each passing period because he has fewer periods in which he can expect to receive a payoff before the terminal period, T . Because the manager's continuation value falls as the terminal date approaches, the manager's incentive to divert increases over time. Thus, the set of dates at which the manager diverts is always an order interval that

includes the final date, T . These results are summarized in Proposition 1.

Proposition 1. *If B^* is an optimal solution to the owner's compensation contract design problem, then*

- a. The firm operates in every period in which the control system has not been revealed to be insecure.*
- b. Either the manager diverts whenever the control system is insecure or there exists $t^+ < T$ such that in every period $t \leq t^+$, the manager does not divert when the control system is insecure and, in every period $t > t^+$, the manager diverts whenever the control system is insecure.*
- c. There exists a simple contract, b^* , that produces the same date 0 owner payoff as contract B^* .*

We refer to t^+ , the last period in which the manager does not divert, as the *reputation cutoff period*, and we refer to a compensation policy that deters diversion through period t^+ as a t^+ -policy. It is clear that each simple contract $b = (b(2), b(3), \dots, b(T))$ generates a reputation cutoff period $t^+(b)$. By Lemma 1, $t^+ < T$. We interpret $t^+ = 0$ as representing the case where the manager diverts in all periods.

4.2 Firm reputation and the optimal compensation design

Since a simple contract is always optimal, we restrict attention to simple contracts and determine their optimal structure. Since the manager's continuation value, $v_M(t)$, declines with each passing period, expression (5) implies that the manager will not divert in period $t \leq t^+$ if and only if

$$(1 - \delta)v_M(t^+ + 1) \geq c. \quad (7)$$

Equation (7) indicates that there is essentially no role for replacing the manager under the current model structure. Replacement following revelation is meaningless since the firm ceases to operate and the manager is effectively replaced. Replacement is suboptimal while the firm is unrevealed since anticipated future replacement will lower the manager's continuation value and thus make the incentive compatibility condition for non-diversion, (7), harder to satisfy. Moreover, there is no gain from replacement since replacement managers have identical ability and preferences.

The owner's contract design problem is fairly straightforward: for a given reputation cutoff period, minimize expected contract payments to the manager. Since the owner does not know whether the control system is secure, the manager is paid both when the structure is secure and when it is insecure. When the control system is secure, the payments are wasted as they are unnecessary. Consequently, the owner's problem can be thought of as minimizing payments to the manager when the control system is secure, conditional on providing sufficient payments to satisfy the incentive compatibility condition when the system is insecure (7). If (7) is satisfied then, until the start of period $t^+(b) + 1$ the expected value of the contract payments to the manager are the same regardless of the control system. After $t^+(b) + 1$, the manager diverts if the control system is insecure, which risks revelation and the resulting loss of future contracted payments. Thus, after $t^+ + 1$, each dollar of promised incentive payment has a higher expected value when the control system is secure than when it is insecure. Consequently, a larger fraction of payments after $t^+(b) + 1$ are "wasted" on a manager operating under the secure control system, and it is optimal for the owner to eschew

making payments after $t^+(b) + 1$. It is also not optimal for the owner to make incentive payments before $t^+(b) + 1$. An incentive payment in period t has no effect on the manager's incentives in period t itself or in subsequent periods. Therefore, payments contracted on periods before $t^+(b) + 1$ will not relax the incentive constraint (7) and thus are clearly not optimal for preventing diversion through period $t^+(b)$.

Proposition 2. *The optimal compensation contract always specifies a single incentive payment to the manager in period $t^+(b) + 1$, where $t^+(b) \in \{1, 2, \dots, T - 1\}$. When the control system is insecure, the manager never diverts during or before period $t^+(b)$ and always diverts after period $t^+(b)$.*

To determine the ex ante optimal contract, we need to determine the level and timing of the single compensation payment identified in Proposition 2. Under the optimal contract, subsequent to period $t^+ + 1$, the manager's payoffs are entirely produced by diversion. In prior periods, the manager also expects to receive the period $t^+ + 1$ incentive payment. Solving a simple recursive equation shows that the manager's continuation value is given by

$$v_M(t) = \begin{cases} b(t+1) + \frac{c(1-\delta^{T-t^+})}{1-\delta} & \text{if } t \leq t^+ + 1 \\ \frac{c(1-\delta^{T-(t-1)})}{1-\delta} & \text{if } t > t^+ + 1. \end{cases} \quad (8)$$

To maximize the owner's value while ensuring that the manager does not divert in period t^+ , $b(t+1)$ must be set to ensure that the manager's incentive condition binds, i.e., $(1-\delta)v_M(t^+ + 1) = c$. Using this condition together with (8) gives the optimal payment at $t^+ + 1$, which we denote by $b^*[t^+](t^+ + 1)$, where

$$b^*[t^+](t^+ + 1) = \frac{c\delta^{T-t^+}}{1-\delta}. \quad (9)$$

From Proposition 2, it follows that $b^*[t^+](t) = 0$ when $t \neq t^+ + 1$. Evaluating the manager's continuation value under the optimal t^+ -policy when the firm is insecure, which we represent by $v_M[t^+](\cdot)$, yields

$$v_M[t^+](\cdot) = \begin{cases} \frac{c}{1-\delta} & \text{if } t \leq t^+ + 1 \\ \frac{c(1-\delta^{T-(t-1)})}{1-\delta} & \text{if } t > t^+ + 1. \end{cases} \quad (10)$$

Equation (9) implies that the cost of reputation-assuring compensation increases with δ , the noisiness of output quality under the low-quality technology. The reason is that an opportunistic manager can expect to remain undetected longer and thus enjoy a longer expected run of profitable diversion as δ rises. The optimal incentive payment is also increasing in t^+ . Current diversion possibly reveals an insecure control system which prevents the firm from operating in future periods and denies the manager opportunities for future diversion. The incentive payment has to rise to compensate for the fall in this opportunity cost of diversion with each passing period.

To identify the optimal payment period, consider the consequence of " t^+ -shifts": incrementing the reputation cutoff period t^+ by one period to $t^+ + 1$. When evaluating a t^+ -shift, the owner has to consider

changes in both the cost of the manager's compensation and the firm's expected revenue stream.¹¹ First consider the change in the manager's compensation, which is simply the change in expected compensation under $b^*[t^+ + 1]$ and $b^*[t^+]$. This difference is given by

$$c \delta^{(T-t^+)-1}. \quad (11)$$

Expression (11) implies that the owner must bear a higher compensation cost to increase the number of periods over which the manager does not divert. This increase is required to offset the decrease in the manager's opportunity cost of diversion over time. Expression (11) also implies that the incremental cost of incentivizing the manager falls with T , the firm's horizon. The lower cost reflects the rise in the manager's opportunity cost of diversion as the horizon T increases.

Now consider the effect of a t^+ -shift on *gross firm value*, the expected value of the owner's claim gross of any payments to the manager. We use the term *gross firm profit* to refer to the total cash inflow to the owner in a specific period gross of any payment to the manager in the period. Since, under the t^+ -policy, the manager diverts in all periods after t^+ and does not divert in any period before t^+ , the good's price is given by $p[t^+](\cdot)$, where

$$p[t^+](t) = \begin{cases} 1 & t \leq t^+ \\ \Gamma^{(t-(t^++1))}(P_1) & t > t^+, \end{cases} \quad (12)$$

$P_1 = \rho_1 + \delta(1 - \rho_1)$, and $\Gamma^{(n)}$, the n -fold composition of the Bayes' operator defined in equation (2), is defined as

$$\Gamma^{(n)}(P) = \frac{(P - \delta) + (1 - P) \delta^{t+1}}{(P - \delta) + (1 - P) \delta^t}. \quad (13)$$

The owner's gross profit in period t is given by $1 - e$. Following a t^+ -shift, the good's price will follow the process described by (12) and (13) with a one period delay. Thus, the change in gross firm value caused by the t^+ -shift is given by

$$\begin{aligned} 1 - e - \left[\frac{(P_1 - \delta)(1 - e) - (1 - P_1)(e - \delta) \delta^{T-t^+-1}}{1 - \delta} \right] \\ = \frac{(1 - P_1)(1 - e) + (1 - P_1)(e - \delta) \delta^{T-t^+-1}}{1 - \delta} > 0. \end{aligned} \quad (14)$$

Consequently, gross firm value increases with the t^+ -shift. The amount of the increase rises with the horizon T and falls with the firm's initial reputation P_1 .

The net effect of the t^+ -shift on firm value comes from combining its effect on compensation (given

¹¹Note that a t^+ shift only affects the firm's payoffs in periods t^+ and $t^+ + 1$. Thus, under a contracting regime where the firm could not commit to long-term contracts and instead was restricted to contracting period-by-period, the tradeoffs faced by the firm at date t^+ in fixing contract terms would be the same as they are at date 0 in our contracting regime when considering the t^+ -shift. Hence, our contract design results are robust to our assumption that firms commit to long-term contracts.

by (11)) and its effect on gross firm value (given by (14)). It is

$$\frac{(1 - P_1)(1 - e) + ((1 - P_1)(e - \delta) - c)\delta^{T-t^+-1}}{1 - \delta}. \quad (15)$$

Expression (15) demonstrates that, when the firm's initial reputation, P_1 , is low enough to satisfy $(1 - P_1)(e - \delta) - c \geq 0$, all t^+ -shifts increase firm value. Therefore, when the firm's initial reputation is sufficiently fragile, it is optimal for the owner to defer compensation until period T , ensuring no diversion through period $T - 1$, i.e., a sufficiently fragile initial reputation supports a reputation equilibrium under delegated management. In contrast, expression (15) is negative for values of t^+ approaching T when P_1 approaches one. Consequently, when the firm's initial reputation is sufficiently robust, the cost of deferring the incentive payment becomes prohibitively high close to period T . Thus, the owner will make the incentive payment before period T , meaning that the manager will divert in at least one period. Expression (15) also implies that the cost of incentivizing the manager falls as the owner's horizon, T , increases. As a result, with a sufficiently long horizon, there will always exist a period when the owner will offer the manager incentive compensation. We formalize these results in the following proposition:

Proposition 3. *Reputation formation under delegated management has the following characteristics:*

(i) *Whenever initial firm reputation, P_1 , is sufficiently fragile, i.e.,*

$$P_1 < 1 - \frac{c\delta}{1 - e + \delta}, \quad (16)$$

the owner will offer the manager a single incentive payment paid conditional on the firm remaining unrevealed by period T . The bonus payment will equal $(\delta c)/(1 - \delta)$. When the control system is insecure, the manager will not divert in any period before T .

(ii) *Whenever initial firm reputation is sufficiently robust, the owner will never offer the manager a bonus payment conditioned on remaining unrevealed until period T . When the control system is insecure, the manager will always divert in some period before period T .*

(iii) *For all admissible parameters of the model other than T , there exists T^* such that if $T > T^*$, the owner will offer incentive compensation conditioned on the firm remaining unrevealed through at least period 1.*

This analysis of firm reputation under delegated management provides four primary insights. First, a firm can maintain a reputation founded solely on its control system. Second, it can do so even when its management is separate from its ownership, and owners are uninformed. Third, when a firm's control system is fragile, it is optimal for arms-length owners to bear the cost of incentive payments to reassure consumers about product quality. In contrast, when the control system is robust, it is optimal for owners to eschew incentive compensation, and instead rely on the control system to maintain product quality. Fourth, the longer a owner's horizon, the greater the likelihood that she will pay the manager incentive compensation to maintain product quality.

5 Ownership structure, firm reputation, and firm value

To explore the implications of unifying firm ownership and management, we now assume the owner has the same ability as a professional manager, and the owner's ability and preferences are common knowledge. Moreover, the owner knows the control system's type, and internalizes the entire cost of her technology choice on the firm's current period profit as well as the entire benefit from the firm's reputation. We demonstrate that owner management and delegated management provide different incentives to maintain firm reputation.

Consider the owner-manager's period T technology choice. Since consumers cannot observe the choice, the technology choice cannot affect the good's price. Moreover, since the firm will not operate in the future, the choice has no reputational consequences. Therefore, in equilibrium, the owner-manager will always divert to maximize period T profit. The owner-manager's technology choices also have no reputational implications once the firm's control system is revealed. As a result, the owner will divert in every period after the firm is revealed. Recognizing the owner's incentives, consumers will set a price that will make production unprofitable and the owner will halt production after the firm is revealed.

Lemma 3. *Every equilibrium under owner management has the following characteristics:*

- (i) *If the control system is insecure, the owner will divert in period T .*
- (ii) *Once the control system is revealed as insecure, the firm will cease production and the owner's payoff will equal 0 in all future periods.*

Before period T , the benefits from firm reputation can be strong enough that the owner-manager always picks the high-quality technology. To see this, first consider the owner's choice in period $T - 1$ when (a) consumers expect a high-quality good in the period, (b) the firm is unrevealed, and (c) the control system is insecure. The owner's expected payoff from choosing the high-quality technology in period $T - 1$ equals $1 - e + p(T) - I$. If she diverts instead, the firm's organizational structure will be revealed with probability $1 - \delta$. In this event, the firm will shut down in the final period (see Lemma 3). Therefore, the owner-manager's expected payoff from diverting in period $T - 1$ is $1 - e + \delta(p(T) - I) + c$. It follows that the owner will choose the high-quality technology in period $T - 1$ if and only if

$$(1 - \delta)(p(T) - I) \geq c. \tag{17}$$

Given that equilibrium prices are updated according to Bayes' rule, $p(t) \geq P_1$ in equilibrium. It follows that the owner will choose the high-quality technology in period $T - 1$ whenever the firm's initial reputation P_1 is sufficiently high. In expression (17), $(1 - \delta)(p(T) - I)$ represents the owner's opportunity cost of diverting in period $T - 1$. This opportunity cost is higher in earlier periods since the owner forgoes more periods of profitable production if the firm fails to produce a high-quality good. In contrast, the owner's gain from diverting in a given period remains fixed at c . Thus, if the owner finds it profitable to eschew diverting in a period, she will also find this choice optimal in every prior period. Consequently, when the firm's initial reputation is high enough to satisfy condition (17), the owner-manager will eschew diverting in every period

until period T . That is, when the firm's control system is robust, there exist only reputation equilibria, i.e., equilibria in which diversion only occurs in period T . Moreover, since the owner's opportunity cost of diverting rises along with the remaining horizon, successively weaker conditions on the firm's reputation ensure that the owner-manager will eschew diverting in earlier periods.

Proposition 4. *Under owner management,*

(i) *In any period t , the firm will produce high quality whenever*

$$c \leq (p(t) - I) (1 - \delta^{T-t}). \quad (18)$$

(ii) *Only reputation equilibria in which only high quality is produced until period $T - 1$ exist if and only if*

$$\frac{c}{1 - \delta} < (P_1 - I). \quad (19)$$

(iii) *If*

$$\frac{c}{1 - \delta} \geq \max_{s=\{0,1,\dots,T-t\}} (1 - I - c)s + \frac{(1 - I) (1 - \delta^{T-t-s})}{1 - \delta} \quad (20)$$

then, at date t , the firm will adopt the low-quality technology.

Proposition 4 demonstrates that owner-managed firms can maintain reputations founded solely on their control systems. They are likely to do so when their control systems are robust. Owner-managed firms are also more likely to ensure product quality when their owners' horizons are long.

5.1 The effect of ownership structure on firm reputation and firm value

Proposition 3 demonstrates that an owner who delegates will pay incentive compensation to protect her firm's reputation when its control system is fragile. When the control system is robust, incentive compensation is no longer optimal and the firm's reputation will be in jeopardy. In contrast, Proposition 4 demonstrates that an owner-managed firm protects its reputation when its control system is robust. Thus, a fragile control system means a firm will maintain its reputation only if it delegates management, and a robust control system means that a firm will maintain its reputation only under owner management.

Corollary 1. (i) *If a firm's initial reputation, P_1 , is sufficiently fragile, i.e., if*

$$P_1 < \min \left[\frac{e(1 - \delta) + c\delta}{1 - \delta}, 1 - \frac{c(1 - \delta)}{e - \delta} \right], \quad (21)$$

then delegated management supports reputation equilibria and owner management does not.

(ii) *If the firm's initial reputation is sufficiently robust, then owner management supports reputation equilibria and delegated management does not.*

What drives the effect of ownership structure on reputation? The owner-manager's decision problem is one of optimal harvesting. If she opportunistically harvests the reputation to raise current period profit, she may reveal the firm's control system and eliminate future gains that flow from the reputation. When the control system is fragile, the future gains from reputation are small relative to the current gain from opportunism. Therefore, the owner-manager is unlikely to maintain the firm's reputation. Under delegated management, to raise her payoff, the owner has to ensure the firm's reputation by paying the manager incentive compensation. When the control system is actually secure (insecure), the compensation is irrelevant (effective). Thus, when the control system is fragile, the compensation is cost effective since it guarantees product quality. As a result, the owner will be willing to pay to guarantee the firm's reputation when the control system is fragile. Under both ownership structures, this calculus reverses under a robust control system. The owner-manager now has a strong incentive to maintain reputation by eschewing opportunism because her cost of reputation harvesting will be high. When the owner delegates management, she has to pay the manager relatively high compensation to guarantee product quality. However, there is high likelihood that the firm's control system alone is sufficient to prevent diversion. Thus, the owner will avoid using incentive compensation and risk the firm's reputation instead.

Ownership structure also impacts firm value. The direction of the impact depends on the control system's perceived strength. Suppose the control system is robust. Then, under owner management, the firm will preserve its reputation and generate an expected per-period profit of $1 - e$ through period $T - 1$. In period T , it will earn an expected profit of $P_1 - I - \frac{P_1 - \delta}{1 - \delta}c$. Firm value is a sum of these profits. Under delegated management, if a period T incentive payment is optimal, the firm will earn the same expected profits through period $T - 1$ as it would under owner management. In period T , however, its profit will be lower by the amount of the manager's compensation. Thus, firm value is lower under delegated management when both owner and delegated management ensure reputational equilibria. Firm value under delegated management is also lower when the optimal incentive payment is made in period $t < T$. The timing of this payment ensures that the manager will not divert till period t and will divert in every subsequent period. While feasible, this strategy is suboptimal under owner management when owner management ensures a reputation equilibrium. Moreover, this strategy is more profitable under owner management than delegated management for the following reasons: (1) no incentive payment is paid under owner management, (2) the firm's revenues after period $t + 1$ are never lower than under delegated management, and (3) under owner management the owner does not have to contribute c toward the firm's expenses in every period that diversion occurs.

When consumers believe that the control system is fragile, an owner-manager will sacrifice the firm's reputation in search of a short-term gain. Under delegated management however, the owner will guarantee product quality via incentive compensation. The resulting increase in firm revenue can offset the cost of compensation. Thus, when the control system is fragile, delegated management can support higher product quality and firm value.

Proposition 5. *The relation between ownership structure and firm value satisfies the following characterizations:*

- (i) *If owner management supports reputation formation, i.e., condition (19) is satisfied, then firm value is*

higher under owner management.

(ii) *If owner management does not support reputation formation, then firm value may be higher under delegated management.*

Our analysis thus far establishes that both owner management and delegated management can preserve firm reputation. Owner management ensures reputable behavior when the control system is robust. In contrast, delegated management ensures reputable behavior when the control system is fragile. Whenever delegated management supports a reputation equilibrium and owner management does not, the owner-manager can increase her wealth simply by selling the firm to outside investors while retaining the management role, thereby converting the firm to delegated management. This follows because the sum of managerial rents and firm value equals total value and total value is always higher under the no-diversion, high-quality production strategy followed in reputation equilibria. In some cases, even if the owner relinquishes managerial control, the owner can still increase her wealth by selling the firm to outside owners. In these cases, the revenue increase generated by the higher probability of reputable behavior is so large that it more than offsets the rents paid to a professional manager.

6 Information, reform and reputation with delegation

We now consider, under delegated management, the effect of modifying our assumptions about the information environment and opportunities to “reform” a firm after it is revealed. We investigate several variations. First, we loosen the assumption that the terms of compensation contracts are observable by all agents. Instead, we adopt another extreme view of the information environment: consumers cannot observe and condition their demand on compensation contracts. Second, we dispense with the assumption that the manager has an information advantage over the owner. Instead, we assume an “inside” owner who also observes whether the control system is insecure. Finally, instead of assuming that the security of the control system is fixed, we examine a real-world feature of control systems: the firm can reform its control systems to repair damage to its reputation.

To facilitate a relatively straightforward discussion of these extensions, we simplify our analysis by focusing on the case where the firm operates over only two periods, period 1 and period T .¹² Our earlier results translate into this modified time-line in a straightforward manner: If the control system is insecure, the manager will always divert in period T . To deter period 1 diversion, under the optimal reputation-ensuring contract, the manager will receive a payment of $\frac{\delta c}{1-\delta}$ in period T if the period- T good’s price equals P_1 . If the firm produces a low quality good in period 1, the firm shuts down and the manager receives a period T payment of 0.

¹²We would like to explicitly characterize firm behavior and value when reputation equilibria are not sustainable. Agents may play mixed strategies in some of these equilibria. Since these mixed strategies vary across periods, characterizing mixed-strategy equilibria for an arbitrary number of periods is awkward.

6.1 Unobservable compensation policy

From an ex ante perspective, an observable compensation policy is in the owner's best interest since it assures consumers about product quality even in periods before optimal quality-assuring compensation payments are made. In the context of modern corporate governance standards, which aim for transparency, it is natural to assume that consumers observe management compensation. All that is needed is a mechanism to verify an owner's report of compensation policy. Accounting systems can and do perform this function in most developed economies. However, there are environments with underdeveloped or corrupt accounting systems. In such situations, it may be difficult to verify owner reports of compensation policy, which opens up the possibility that an owner may misreport compensation to manipulate consumer expectations. Thus, it is worthwhile exploring reputation under delegated management when compensation policy is not observable.

Changing our assumption about the observability of compensation policy has no effect on the manager's information set or his diversion strategy. Thus, based on the results developed earlier in Section 4, the optimal reputation-ensuring compensation is a period T payment of $\frac{\delta c}{1-\delta}$ if the period T good's price equals P_1 . However, by limiting the information available to consumers, our changed assumption influences the owner's incentive to pay reputation-ensuring compensation. In a reputation equilibrium, consumers will correctly conjecture that the owner will pay reputation-ensuring compensation and thus will set a price of 1 for the period 1 good. It follows that the owner's payoff from paying incentive compensation in a reputation equilibrium is given by

$$(1 - I - c) + \left(P_1 - I - \frac{c}{1 - \delta} \right).$$

Since compensation is unobservable, the owner can deviate from the candidate equilibrium policy by refraining from compensating the manager. This deviation saves the owner the compensation cost. However, she faces the possibility that the low-quality technology will reveal the firm with probability $1 - \delta$ and force it to shut down in period T . Because the owner's deviation is unobservable, the price of the period 1 good will remain unchanged and the owner's expected payoff is

$$(1 - I - c) + P_1 (P_1 - I - c).$$

A necessary and sufficient condition for a reputation equilibrium under unobservable compensation is that the owner's expected payoff is higher if she pays incentive compensation. Algebraic simplification shows that this condition is satisfied if and only if

$$\frac{(P_1 - I) (1 - P_1) (1 - \delta) - c (1 - P_1 (1 - \delta))}{1 - \delta}.$$

This condition is harder to satisfy than condition (15), which ensures reputation equilibria with observable compensation. However, for a large range of model parameters, the incentive to pay reputation-assuring compensation remains intact. We illustrate this assertion in Figure 2. We see from the figure that non-observability attenuates the owner's incentive to pay reputation-ensuring compensation most when P_1 , the initial reputation, is either large or small. This result follows because, under non-observability, the entire

benefit of reputation-ensuring compensation derives from continuation payoffs. When the control system is fragile, i.e., P_1 is small, the period T price is low. Thus, even though the increase in the probability of continuation induced by paying reputation-ensuring compensation, given by $1 - P_1$, is large, this increased probability is multiplied by a small continuation payoff, leading to a small expected payoff increase. Similarly, when the control system is very robust, continuation payoffs are large but the increase in the probability of receiving the continuation payoff caused by paying reputation-ensuring compensation is small. Again, under non-observability the owner will eschew such compensation. At intermediate degrees of robustness, continuation gains are still fairly large and compensation has a significant effect on the likelihood of receiving these gains. Thus, even without observability the owner will pay reputation-ensuring compensation.

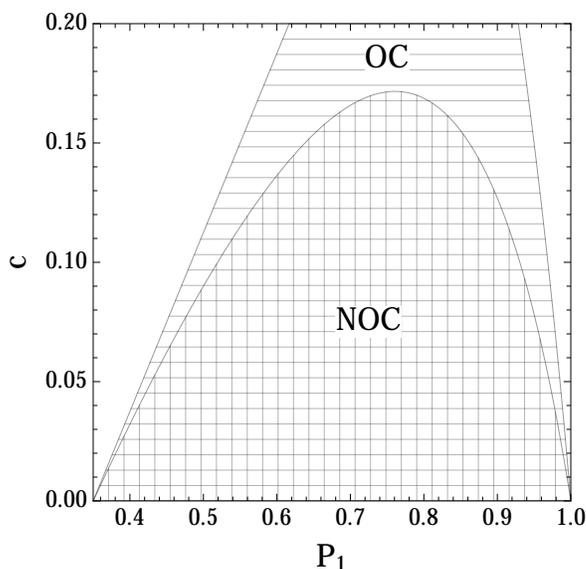


Figure 2: *Effect of unobservable compensation.* The horizontal axis represents P_1 , the good's period 1 price if consumers conjecture that the reputation ensuring compensation payment will not be made by the firm. The vertical axis represents, c , funds subject to diversion. The horizontally hatched region labeled "OC" represents the region that supports reputation formation under delegated management when compensation is observable. The vertically hatched region labeled "NOC" represents the region that supports reputation formation under delegated management model when compensation is not observable. The fixed parameters in the graph are $I = 0.35$ and $\delta = 0.25$

If we interpret the verifiability of reported compensation as transparency, we see from Figure 2 that transparency increases the effectiveness of delegated management for maintaining firm reputation. However transparency is not essential for delegated management to lead to reputable firm behavior.

6.2 Reputation with an “insider” owner

We have assumed that, under delegated management, the separation between ownership and management is both operational and informational: while the manager observes the effectiveness of the control system, the owner, like an outsider, does not. This setup approximates a firm controlled by an outsider board and managed by a professional non-owner manager. We now return to observable compensation, but allow for an “insider non-managing owner.” To do so, we assume that both the owner and the manager know the security of the control system.

At a technical level, characterizing equilibria with an insider non-managing owner is complex. Because the owner has private information, in addition to affecting the manager’s incentives, the owner’s compensation policy choice also has an “inferential effect”—consumers can use the owner’s compensation choice to infer her private information. Thus, we have a signaling game where compensation policy is the “message” sent by the informed insider whose “type” is the state of the control system. The price of the good is the uninformed consumers’ response. Signaling games usually generate many equilibria, some of which are intuitively implausible. There is an extensive literature on refining the set of equilibria in static signaling games in which the informed agent’s message space and type space are finite. In order to rely on this literature, we restrict the insider owner’s message space to the following three alternatives: (i) operating and not offering incentive compensation, NC, (ii) operating and offering the optimal incentive contract derived in Section 4, C, or (iii) shutting the firm down, SH. Because, in period T , compensation is ineffective and managerial incentives are not affected by consumer beliefs, we are left with a static single period signaling game. In this setting, we use the perfect Bayesian equilibrium (PBE) as our solution concept and refine the set of equilibria using the standard D1 refinement.

The technical details of this development are tedious, and we defer them to the appendix. However, our basic result is both striking and quite intuitive: insider ownership completely eliminates the ability of the delegated management structure to sustain corporate reputations.

Proposition 6. *Suppose that governance is exercised by an owner who is privately informed about the security of the control system. Then in any perfect Bayesian equilibria satisfying the D1 refinement*

- (i) *The manager will never receive incentive compensation.*
- (ii) *The manager will always choose the low-quality technology in period 1 when the control system is insecure.*

The logic behind Proposition 6 is transparent. For compensation to ensure reputation, it must be sensitive to the period T good’s price. However, if the insider owner only offers incentive compensation when the control system is insecure, by offering incentive compensation the owner will reveal that the control system is insecure and fix the period T good’s price at δ . Thus, incentive compensation will not prevent diversion. It follows that no equilibrium can exist in which the insider owner only pays reputation-ensuring compensation when the control system is insecure. Consequently, if reputation ensuring compensation is offered it must be offered with positive probability both when the control system is secure and when it is insecure.

When the structure is secure, incentive payments have no effect on the manager’s technology choice.

Therefore, the owner will only offer incentive pay to positively influence consumer beliefs. This is possible if consumers believe that a firm that does not offer incentive compensation has an insecure control system. In this case, if the owner does not offer incentive pay, consumers will set a price for the period 1 good to δ , which will ensure a negative profit for the firm. Under these beliefs, consumers would attribute a high quality period 1 good to a lucky draw from the low-quality technology and set the period T good's price to δ as well. Given these beliefs, even the inside owner of a secure firm would pay incentive compensation, and PBE do exist in which reputation assuring compensation is offered. In these equilibria, not paying incentive compensation is off the equilibrium path and thus the resulting consumers' beliefs are not regulated by Bayes' rule. However, the belief that incentive compensation signals that the firm is secure even though security implies that such compensation has no fundamental purpose is clearly unreasonable. Not surprisingly, under the D1 restriction on off-the-equilibrium-path beliefs, no perfect Bayesian equilibria exist in which the insider-owner offers reputation-ensuring compensation.

Proposition 6 shows that, for delegated management to support firm reputation, owners have to exercise control as outsiders. Insider control combined with delegation never supports reputation formation, and simply permits managers to extract rents. Thus, delegation combined with insider control results in a lower payoff to owners as well as lower social welfare than simple owner management. Consequently, outsider control is an essential feature of effective delegated management.

6.3 The effect of reform on reputable behavior

Firms typically reform their control systems to repair damage to their reputations. Attempts at reform, though not always successful, are widely advertised. Control system reform involves revising board and management responsibilities, changing reporting channels and responsibilities within the firm, changing firm culture, and changing accounting and reporting procedures. To align our model more closely with reality, we introduce an option for the outside owner to attempt reforming the control system, and examine how this change affects firm reputation and value. We preserve the most salient features of real world reform by assuming that reform is costly and publicly observable, and its success is uncertain.

Specifically, we assume that if the firm is revealed by the period 1 good's quality, the owner can reform the control system before period T . Without reform, Lemma 2 implies the firm will not operate. Reform transforms an insecure control system into a secure structure with probability $r \in (0, 1)$ at a cost of $R > 0$ to the owner. Only the manager observes whether reform succeeds. The owner and consumers share the belief that the post-reform control system is secure with probability r . Since incentive compensation is ineffective in the final period, the manager will always divert in period T if reform is unsuccessful. Therefore, following reform, consumers will believe that the period T good is high quality with probability $r + (1 - r)\delta$, and the good's price $p(T) = r + (1 - r)\delta$. Let $P_r = r + (1 - r)\delta$. We assume that reform is profitable, i.e.,

$$P_r - I - c - R > 0. \tag{22}$$

6.3.1 Manager turnover and compensation restrictions with reform

When reform is not possible, replacing the manager is suboptimal so long as the firm remains unrevealed. Since the firm shuts down once its control system is revealed, in equilibrium, managerial turnover is indistinguishable from and a direct consequence of the owner's decision to shut down the firm. When reform is possible, it continues to be suboptimal to replace the manager while the firm remains unrevealed. However, after it is revealed, the firm can reform and continue operating. Consequently, the owner must choose between retaining and replacing the incumbent manager.

Suppose the owner retains the manager. If reform fails, the manager will earn a period T payoff of c by diverting plus any contracted incentive payment contingent on the price being equal to P_r . If reform succeeds, the manager will receive only the contracted incentive payment. In contrast, if reform triggers the manager's termination, while his contract payment is unchanged, he will be denied the opportunity to divert in period T . Since termination coupled with reform lowers the manager's payoff contingent on the firm being revealed, it maximizes the manager's opportunity cost of diverting. Thus, it is optimal for the owner to terminate the manager if the firm is revealed in period 1.

Lemma 4. *A professional manager will be terminated if the owner reforms the firm's control system.*

Lemma 4 demonstrates that, it is optimal to replace a manager once his actions damage the firm's reputation. However, the reason is not to try for a "better" manager ex post. The reason is to create stronger ex ante incentives for the incumbent manager. Thus, the factors driving this result differ dramatically from Tirole [1996] and Cremer [1986]. In these papers, groups of agents share a reputation and it is optimal to terminate agents whose actions damage the group's reputation. Termination repairs the group's reputation by bringing more reputable agents into the group. In our model, the incumbent and replacement managers have identical characteristics and preferences. Thus, replacement has no ex post beneficial effect. Replacement only penalizes diversion, which maximizes the manager's ex ante incentives to preserve the firm's reputation.

Reform makes compensation design more complex. Now the owner must account for the effect of reform on output prices. In a reputation equilibrium, consumers do not learn anything about the firm in period 1 and thus the good's price in period T must be P_1 . Under the optimal contract, the manager receives a single period T payment if the good's period T price is P_1 . The owner's option to reform can render this compensation design ineffective. To see this, suppose the firm is revealed in period 1 and thus can only produce in period T if it reforms. Following reform, the period T good's price will be P_r . The post-reform price will be higher than P_1 if reform is highly effective, i.e., $r \geq \rho_1$. Since the manager's contractual payment is non-decreasing in the good's price, his period T payoff will be higher if the firm produces low-quality output in period 1. Hence, there will not exist a compensation contract that blocks diversion.

Proposition 7. *When the likelihood that reform will succeed, r , is sufficiently high, i.e.,*

$$P_r \geq P_1, \tag{23}$$

there do not exist incentive contracts that ensure the manager protects the firm's reputation.

6.3.2 Optimal incentive compensation with reform

When the condition presented in Proposition 7 is violated, the owner can design incentive contracts that will incentivize the manager to protect the firm's reputation. As was the case without reform, under these contracts, the manager is paid only if the period T price at least equals P_1 . After reform, to maximize the manager's opportunity cost of diversion, he is replaced and does not receive an incentive payment.

To see this, consider a period T incentive payment of b_T , where $b_T > 0$ if $p(T) \geq P_1$ and $b_T = 0$ if $p(T) < P_1$. If the manager chooses the high-quality technology in period 1 and diverts in period T , his expected payoff equals

$$b_T + c. \quad (24)$$

If he diverts in period 1, the firm produces a high quality good with probability δ . With probability $1 - \delta$, the firm produces a low-quality good resulting in $p(T) = P_r < P_1$. In this case, the owner will reform in period T and replace the manager. Therefore, the manager's expected payoff from diverting in period 1 is

$$c + \delta(b_T + c). \quad (25)$$

The optimal incentive payment, $b^*(T)$, leaves the manager indifferent to diversion and is obtained by equating expressions (24) and (25), i.e.,

$$b_T^* = \frac{c\delta}{1-\delta}. \quad (26)$$

When offered the optimal incentive payment b_T^* , the manager will choose the high-quality technology in period 1 and will divert in period T . Thus, the owner's expected payoff is

$$1 - c - I + P_1 - I - c - b_T^*. \quad (27)$$

If instead, the owner does not offer incentive compensation, the manager will divert in period 1. If diversion results in the firm being revealed, the owner will reform and terminate the manager in period T . If the firm remains unrevealed, consumers use Bayes' Rule to update the probability that the structure is secure. Consequently, the owner's expected payoff if she does not offer incentive compensation is given by

$$P_1 - I - c + (1 - P_1)(P_r - I - c - R) + P_1(\Gamma(P_1) - I - c). \quad (28)$$

The owner will find incentive compensation optimal when her payoff from paying incentive compensation, given by expression (27), is greater than her payoff from not paying incentive compensation, given by expression (28). This is the case when the prior assessment of the control system's security, P_1 , is relatively low. Since the cost of incentive compensation rises with c , the funds the manager can divert, the threshold for P_1 below which incentive compensation is attractive falls as c rises. The profitability of reform, $P_r - R$, has the same effect.

Proposition 8. *If*

$$P_r < P_1 < 1 - \frac{c\delta}{(1-\delta)(1+\delta-(P_r-R))}, \quad (29)$$

then the owner will offer an incentive payment in period T , and the firm will use the high-quality technology in period 1. Otherwise the owner will not offer incentive compensation, and the manager will divert in period 1 whenever the structure is insecure. If diversion is detected, the firm will reform in period T otherwise the firm will continue operations without reforming in period T .

Condition (29) indicates that an increase in P_r , the effectiveness of reform, or a fall in R , its cost, lowers the likelihood that a firm with delegated management will attempt to protect its reputation. The intuition is straightforward: More effective and less costly reform decrease the owner's expected loss from managerial diversion, lowering the owner's willingness to pay the manager the rents needed to forgo diversion.

Figure 3 clearly illustrates the effect of introducing the option to reform on the owner's use of incentive compensation. There are three regions in the figure. Incentive contracting is optimal only in the region labeled **Comp**. In this region, the prior assessment of the security of the control system, P_1 , is moderately high and the effectiveness of reform, r , is relatively low. Only this region satisfies the two conditions for the use of compensation presented in Proposition 8. In the region labeled **Comp NotOpt**, condition (29) is violated; the higher prior assessment of the firm's control system implies that the owner's gain from offering the manager an incentive contract is smaller than the cost of the contract. The region labeled **Comp NotIC** captures the effect of introducing the option to reform. In the absence of this option, the owner would find incentive compensation optimal. However, when reform is possible, as demonstrated in Proposition 7, the owner can no longer devise a contract that will align the manager's incentives. This region expands as the effectiveness of reform, captured by r , rises.

7 Ownership structure, reputation, firm value and the value of reform

Clearly lower transparency and insider ownership limit reputation equilibria under delegated management. Since these changes do not affect owner management, they make delegated management less attractive relative to owner management. The option to reform also limits reputation equilibria under delegated management. However, reform may also limit reputation equilibria under owner management. Consequently, it is unclear whether delegated management and owner management still support reputation equilibria for different sets of parameter values when reform is possible. Therefore, we now reexamine our earlier result on the effect of ownership structure on reputation and firm value in the presence of the option to reform. We also examine how the marginal value of the control system and reform vary with ownership structure.

We start by examining the effect of reform on owner management. Note that, in a reputation equilibrium, the period 1 good's price will equal 1. If the period 1 good is high quality, the period T good's price will equal P_1 . Otherwise, the owner will reform and the period T good's price will equal P_r . Since, the

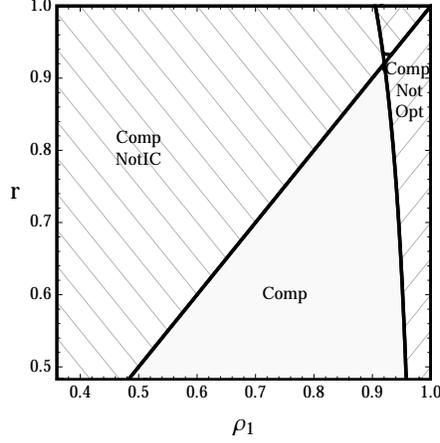


Figure 3: *Incentive compensation and the option to reform.* In the figure, the region in which incentive compensation contracts do not exist is shaded, hatched and labeled “Comp NotIC”; the region in which incentive compatible compensation contracts exist but are not optimal is shaded, hatched in the opposite direction, and labeled “Comp NotOpt”; the region where incentive compensation will be used by the owner is shaded, unhatched, and labeled “Comp.” The horizontal axis in the graph represents the period 1 probability that the structure is secure, ρ_1 , and the vertical axis represents the likelihood that an insecure structure will be rendered secure by reform, r . The fixed parameters for the example are $R = 0.20$, $I = 0.2$, $c = 0.16$, $\delta = 0.15$

owner-manager always diverts in period T when the control system is insecure, choosing the high-quality technology in period 1 yields an expected payoff to the owner of

$$1 - c - I + P_1 - I. \quad (30)$$

If the owner diverts in period 1 instead, her expected payoff equals

$$\begin{aligned} & 1 - I + \delta (P_1 - I) + (1 - \delta)[r(P_r - I - c) + (1 - r)(P_r - I) - R] \\ & = 1 - I + \delta (P_1 - I) + (1 - \delta)[P_r - I - R - rc]. \end{aligned} \quad (31)$$

The owner will prefer the high-quality technology when it generates a higher expected payoff than diverting. This yields the necessary and sufficient condition for the existence of reputation equilibria under owner management in the following proposition:

Proposition 9. *The necessary and sufficient condition for a reputation equilibrium when the firm is controlled by an owner-manager is*

$$(1 - \delta)(P_1 - I) \geq c + (1 - \delta)(P_r - I - R - rc). \quad (32)$$

Condition (32) demonstrates that, as with delegated management, increased effectiveness or a lower cost of reform make it more difficult to satisfy the existence condition for reputation equilibria. The intuition

behind the result is the same as the intuition behind Proposition 8: reform lowers the cost of reputation loss and thus encourages opportunistic behavior. Raising the profitability of reform further encourages opportunism. Therefore, when reform is more effective, the owner will only refrain from diversion when she faces a higher opportunity cost, i.e., when her potential reputational loss is greater.

Propositions 8 and 9 together illustrate the effect of ownership structure on reputation equilibria. Figure 4 illustrates the effect. Consistent with Propositions 3 and 4 (with no reform option), owner management supports reputation equilibria when the control system is robust while delegated management supports reputation equilibria when the control system is fragile. Reform limits the range of reputation equilibria for both owner management and delegated management. The limitations become stronger as the likelihood of successful reform, r , increases.

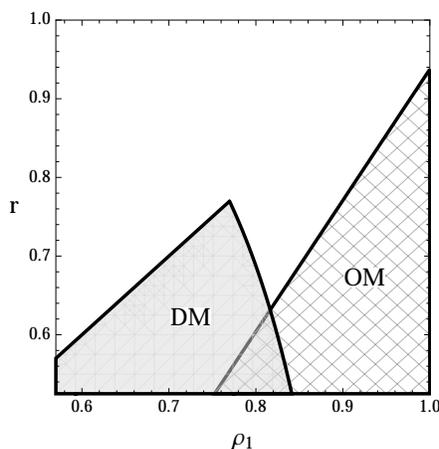


Figure 4: *The option to reform and reputation equilibria under different ownership structures.* In this figure, we illustrate parameter regions that support reputation equilibria under delegated management and owner management. The medium shaded region, labeled “DM,” represents parameter values supporting reputation equilibria under delegated management, and the lightly shaded and cross hatched region, labeled “OM,” represents reputation equilibria under owner management. The overlapping region represents parameter values that support reputation equilibria under both ownership structures. To generate this figure, we assume $c = 0.32$, $I = 0.25$, $\delta = 0.2$ and $R = 0.05$.

7.1 Other equilibria under owner management

Thus far we have only considered reputation equilibria under owner management. To examine the marginal value of the control system and reform under owner management, we must first characterize two other equilibrium types supported by owner management. In these equilibria, the owner-manager either (1) randomly diverts or (2) diverts with probability one. We call the first equilibrium type a “mixed equilibrium” and the second type a “cheating equilibrium.”

First consider a mixed equilibrium. Suppose the owner-manager diverts with probability η when the control system is insecure. She will be willing to randomize only when her expected payoff from picking

the high-quality technology and diverting are equal. The owner's expected payoff from picking the high-quality technology equals

$$P_1^* - e + P_T^* - I, \quad (33)$$

where P_1^* and P_T^* are the equilibrium prices (and the total probability of high quality production) in periods 1 and T , respectively. The owner's expected payoff from diverting equals

$$P_1^* - I + \delta(P_T^* - I) + (1 - \delta)(P_r - I - R - rc). \quad (34)$$

The posterior probability of a secure control system in period T conditioned on high quality being observed in period 1 equals $\frac{\rho_1}{P_1^*}$. Since beliefs and, thus, prices conform to Bayes' rule, the period T price conditioned on a high quality period 1 good equals

$$P_T^* = \frac{\rho_1}{P_1^*} + \left(1 - \frac{\rho_1}{P_1^*}\right) \delta. \quad (35)$$

Equating the expected payoffs given by (33) and (34), and using (35), we obtain the following equilibrium prices:

$$P_1^* = \frac{(1 - \delta)^2 \rho_1}{(1 - \delta)(P_r - R - \delta) + c(1 - (1 - \delta)r)}, \quad P_T^* = P_r - R + \frac{c(1 - (1 - \delta)r)}{1 - \delta}. \quad (36)$$

Since the owner's expected payoff is the same regardless of her technology choice in period $T - 1$, we can denote the firm's value by assuming that the owner chooses the high-quality technology, i.e., firm value in the mixed equilibrium is given by

$$\rho_1(P_1^* - e + P_T^* - e) + (1 - \rho_1)((P_1^* - e) + (P_T^* - I)) = P_1^* + P_T^* - 2e + (1 - \rho_1)c. \quad (37)$$

In a cheating equilibrium where the owner diverts with probability one, characterizing prices and firm value is straightforward. Since the price in each period equals the total probability of high quality production, the equilibrium price in period 1 is P_1 , and the price in period T is $\Gamma(P_1)$ if the firm remains unrevealed. Therefore, firm value in the cheating equilibria is given by

$$\rho_1(P_1 - e + \Gamma(P_1) - e) + (1 - \rho_1)\left(P_1 - I + \delta(\Gamma(P_1) - I) + (1 - \delta)(P_r - I - R - rc)\right). \quad (38)$$

These equilibria exist if and only if diversion is optimal in period 1 given the equilibrium price P_1 , i.e.,

$$P_r - R - rc \geq 1 + \delta - \frac{\delta}{P_1} - \frac{c}{1 - \delta}. \quad (39)$$

Condition (39) implies that cheating equilibria will exist when reform is extremely effective. Mixed equilibria arise when neither condition (39) nor condition (32) from Proposition 9 hold.

7.2 Ownership structure, reform and value of control systems

Firm owners can alter both the robustness of control systems and the effectiveness of reform. To specify a complete model of the endogenous determination of control systems, we have to specify cost functions for the robustness of control systems and the effectiveness of reform. Any results we obtain from such an exercise will be highly sensitive to the specific cost functions we choose. Because there is little evidence to guide our choice of cost functions, we opt for a more modest approach: We simply determine the marginal value of the control system under each ownership regime. We leave specifying the cost of the control system and reform, optimization and objective value determination to future research.

7.2.1 The marginal values of control systems and reform

Regardless of the equilibrium, in period T , the manager always diverts when the control system is insecure. However, producing a high-quality good is first best. Therefore, by increasing the likelihood that the firm will adopt the high-quality technology in period T , a stronger control system increases the firm's period T gross profit. The effect of a stronger control system on overall firm value also depends on the firm's period 1 equilibrium behavior. In a reputation equilibrium, regardless of the strength of its control system, the firm produces a high-quality good in period 1. Consequently, varying control system strength only affects firm value through its effect on the firm's period T profit. In any other equilibrium, the manager diverts with positive probability in period 1 when the firm's control system is insecure. Therefore, a stronger control system increases the firm's period 1 gross profit. Consequently, the marginal value of strengthening the control system is highest when the firm is not in a reputation equilibrium.

Figure 5 illustrates the positive marginal value of strengthening the control system under both ownership regimes. The figure also illustrates how the marginal value of the control system varies with ownership structure. An owner-managed firm is likely to be in a reputation equilibrium only when the control system is robust, while a firm with delegated management is likely to be in a reputation equilibrium only when its control system is fragile. Therefore, under owner management, the marginal value of increasing the strength of the control system is highest when the control system is fragile, and under delegated management the marginal value is highest when the control system is robust.

As with the control system, the marginal value of increasing the effectiveness of reform, r , varies with the firm's equilibrium behavior and its ownership structure. Reform only occurs in period T and only after the firm produces a low-quality good in period 1. Hence, in a reputation equilibrium, because the control system is never revealed in period 1, the marginal value of the increasing reform effectiveness is zero. In other equilibria, the firm produces a low quality period 1 good with positive probability, which makes period T reform optimal. Since increasing reform effectiveness increases the period T good's price, it will affect the firm's value in any non-reputational equilibrium. Therefore, under owner management reform affects firm value when the control system is fragile, and under delegated management it affects firm value when the control system is robust. The direction of each effect depends on the firm's ownership structure.

When the firm is owner managed, reform strengthens the owner's incentive to divert in period 1 by

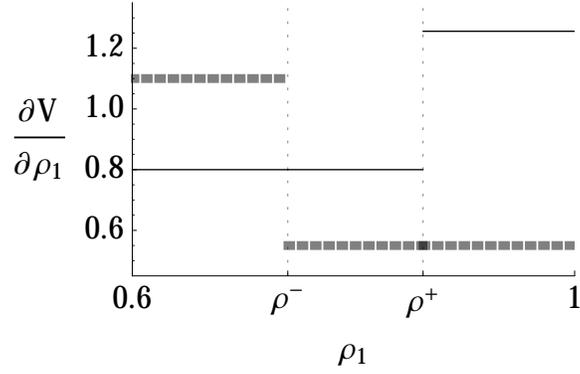


Figure 5: *The marginal value of strengthening the control system.* On the horizontal axis, we plot the initial quality of the control system, ρ_1 . On the vertical axis, we plot the marginal effect of a change in the initial quality of the control system on firm value, $\partial V/\partial \rho_{T-1}$. In the figure, the following parameters are fixed: $R = 0.05$, $I = 0.25$, $c = 0.32$, $\delta = 0.20$. The thick dashed gray line represents the marginal value $\partial V/\partial \rho_{T-1}$ under owner management and the thin black line represents the marginal value under delegated management. Under owner management, if the quality of the control system in period 1, satisfies $\rho_1 < \rho^-$, the owner plays a mixed strategy randomizing between high-quality technology and diverting in period 1; for $\rho_1 > \rho^-$ the owner always selects the high-quality technology. Under delegated management, if $\rho_1 < \rho^+$, the owner offers the manager incentive compensation to deter diversion in period 1; if $\rho_1 > \rho^+$, the owner pays no incentive compensation and thus the manager diverts when the control system is insecure.

reducing her expected cost from diverting. Recognizing the owner's weakened incentives, consumers lower the period 1 good's price. Since the high-quality technology is first best, the period 1 good's price drop more than offsets the cost savings from the low-quality technology and can lower firm value. Increasing reform's effectiveness has a very different effect under delegated management. Reform is useful only when the manager diverts in period 1, which he does if he is not offered a period T incentive payment. Thus, reform is only useful when the manager is committed to diverting. In this case, the manager's behavior is not affected by the increased effectiveness of reform, and its only effect is to raise the period T good's price and thus firm value.

Figure 6 illustrates the marginal value of reform. It shows that, for low values of P_1 , increasing the effectiveness of reform lowers value under owner management and has no effect on value under delegated management. For high values of P_1 , increasing the effectiveness of reform increases firm value under delegated management and does not affect value under owner management. The same forces that determine the effect of increasing the effectiveness of reform, r , also determine the effect of increasing the cost of reform, R . Thus, for low values of P_1 , increasing the cost of reform, R , increases value under owner management and has no effect on value under delegated management; for high values of P_1 , increasing the cost of reform lowers firm value under delegated management and does not affect value under owner management.

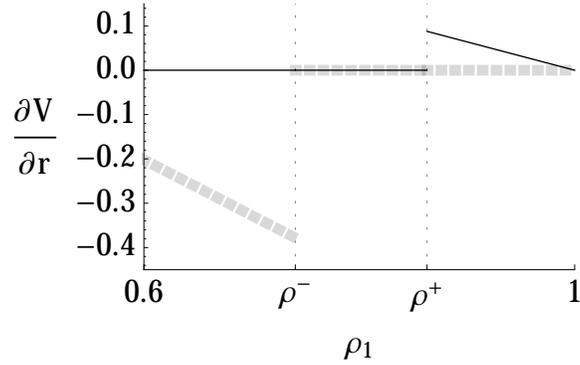


Figure 6: *The marginal value of reform.* On the horizontal axis we plot the initial quality of the control system, ρ_1 . On the vertical axis, we plot the marginal effect of the changes in the efficacy of reform, $\partial V/\partial r$. In the figure, the following parameters are fixed: $R = 0.05$, $I = 0.25$, $c = 0.32$, $\delta = 0.20$. The thick gray dashed line represents the derivative $\partial V/\partial r$ under owner management and the thin black line represents the derivative under delegated management. Under owner management, if the quality of the control system in period 1 satisfies $\rho_1 < \rho^-$, the owner plays a mixed strategy randomizing between high-quality technology and diverting in period 1; for $\rho_1 > \rho^-$ the owner always selects the high-quality technology. Under delegated management, if $\rho_1 < \rho^+$, the owner opts to hire the manager and offer incentive compensation to deter managerial diversion in period 1; if $\rho_1 > \rho^+$, the owner pays no incentive compensation and thus the manager diverts when the control system is insecure.

7.2.2 Ownership structure and the value of firm reputation

Figures 5 and 6 illustrate how firm value changes with prior expectations about the control system (ρ_1), the effectiveness of reform (r), and the cost of reform (R). The figures also show that these effects are tied to the firm's ownership structure. Understanding the combined effects is key to understanding how a firm's ownership structure impacts its value. We illustrate these effects in Figure 7.

Consider a situation where the control system is fragile and reform is very attractive because it is both inexpensive and sufficiently effective to increase security after opportunism to a level close to P_1 . In this situation, owner-management cannot support reputation equilibria. In fact, owner management produces a high probability of opportunistic behavior in period 1. In contrast, under these circumstances, delegated management produces reputation equilibria and, thus, higher total welfare. In these equilibria, the manager earns a rent proportional to the scope for managerial diversion, c , via his bonus contract. When this rent is relatively small, as is the case when the scope for managerial diversion is small, delegated management also supports a higher firm value than owner management. This case is depicted in Panel A where, for sufficiently low levels of P_1 , delegated management produces higher firm value than owner management.

The increase in efficiency under delegated management cannot compensate for the increased rents paid to the manager when the control system is robust, reform is less attractive, and the scope for diversion is higher. Under these circumstances, owner management always yields higher firm values even when it produces lower social welfare. Panel B illustrates this result.

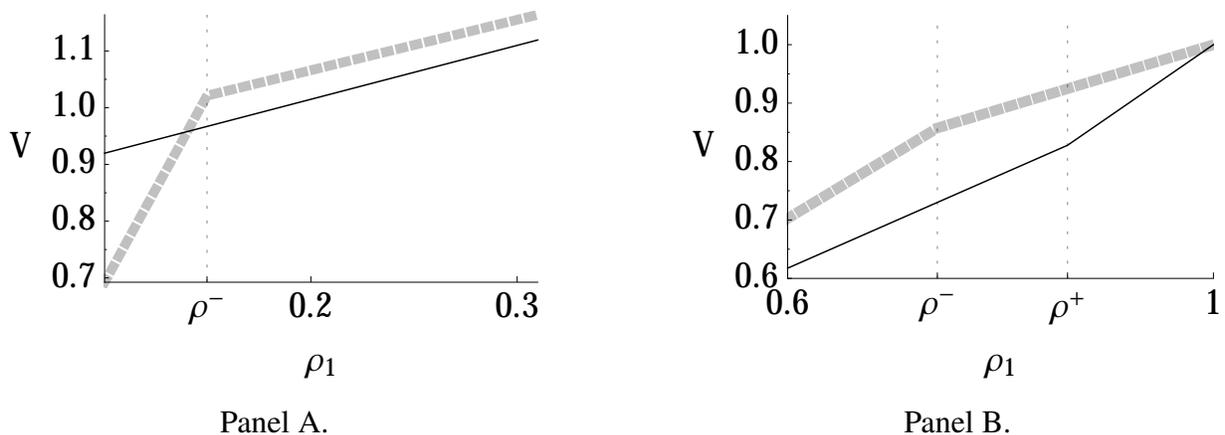


Figure 7: *Ownership structure and firm value.* On the horizontal axis, we plot the initial quality of the control system, ρ_1 . On the vertical axis, we plot the value of the firm, V . The thick gray dashed line represents firm value under owner management and the thin black line represents the value under delegated management. Under owner management, if the quality of the control system in period 1, satisfies $\rho_1 < \rho^-$, the owner plays a mixed strategy, randomizing between high-quality technology and diverting in period 1; for $\rho_1 > \rho^-$ the owner always selects the high-quality technology. Under delegated management, if $\rho_1 < \rho^+$, the owner offers incentive compensation to deter managerial diversion in period 1; if $\rho_1 > \rho^+$, the owner pays no incentive compensation and thus the manager diverts when the control system is insecure. In Panel A, the parameters are $R = 0.01$, $I = 0.051$, $r = 0.10$, $c = 0.06$, and $\delta = 0.05$; in Panel B, the parameters are $R = 0.05$, $I = 0.25$, $r = 0.60$, $c = 0.25$, and $\delta = 0.20$.

8 Conclusion and extensions

In this paper, we develop a model in which a firm's reputation is based solely on its organizational and institutional structure, and the control and ownership of its reputation can be separated. Our model extends the standard reputation framework where reputation is instead based entirely on perceived characteristics of agents who both control the firm's reputation and enjoy all the costs and benefits of the reputation. We find that professional delegated management, which separates ownership and control of reputation, can support socially-efficient reputable firm behavior even in an environment where contracting is restricted and a weak disclosure regime makes firms relatively opaque. For a firm to successfully maintain its reputation under delegated management, its ownership must rest with arms-length outsiders. We find that delegated management can support reputable behavior even in cases where owner management, which unifies ownership and control of reputation, cannot. Sometimes, despite the cost of incentivizing delegated managers, delegated management may also yield a higher firm value. This explains why owner managers can benefit from liquidating their ownership stakes.

The difference between delegated and owner management persists when we consider the possibility of reforming a firm's reputation through structural changes in governance (i.e., the control system). The opportunity to reform has an adverse effect on owner-managers' reputation incentives, and increasing the efficacy of reform can decrease firm value, reputation and social efficiency. In contrast, under delegated

management, reform possibilities can increase both firm value and social efficiency.

When firms can protect their reputations both through compensation policy and through structural reform of the control systems, the two remedies interact in a subtle way. For compensation to work, a firm's stakeholders must believe that its control system is viable. However, the possibility of reform after a loss of reputation can render compensation ineffective. This result offers an alternative explanation to the well-known crowding out theory for the incompatibility between using monetary rewards and other means of eliciting honest behavior. This explanation does not rely on intrinsic employee motivation or employee shame.

There are a number of potential directions for extending our work. One direction is to allow for heterogeneous agents who have private information regarding their own degree of honesty. If we also assumed a competitive labor market that valued honesty, these agents would have an motivation to build a reputation for being honest even if they were not and this motivation could discourage opportunism. Corporate reputation reform activities might also crowd out this motivation. Because such reform activities make honest behavior a weaker signal of agents' internal preference for honesty by strengthening external control, they would lower the returns from employee reputation building.

Extensions aimed at enriching the informational complexity of the model are not the only potential directions for extension. It is also possible to extend the analysis to allow for alternative property-right allocations. Assuming that employees are capital constrained but can accumulate compensation, such compensation could be used to buy the firm from the owner. Such a buyout would unify reputation and ownership and, thus, generate a welfare gain. Although this scenario might not be realistic in many cases, when the scale of the revenue produced by the operation is not too much larger than the scale of employee rents, buyouts could occur in equilibrium after a sufficiently long spell of high-quality output.

References

- Franklin Allen. Reputation and product quality. *The RAND Journal of Economics*, 15(3):311–327, 1984.
- John Armour, Colin Mayer, and Andrea Polo. Regulatory sanctions and reputational damage in financial markets. Oxford Legal Studies Research Paper, 2010.
- Matthew T. Billett, Zhan Jiang, and Lopo Rego. Glamour brands and glamour stocks. Indiana University working paper, 2012.
- Jacques Cremer. Cooperation in ongoing organizations. *Quarterly Journal of Economics*, 101(1):33–49, 1986.
- Peter DeMarzo and Darrell Duffie. A liquidity-based model of security design. *Econometrica*, 67(1):65–99, 1999.
- Alex Edmans. Does the stock market fully value intangibles? employee satisfaction and equity prices. *Journal of Financial Economics*, 101:621–640, 2011.

- Leslie Gaines-Ross. *Corporate Reputation: 12 Steps to Safeguarding and Recovering Reputation*. John Wiley & Sons, Inc., Hoboken, NJ, 2008.
- Edward L. Glaeser and Andrei Shleifer. Not-for-profit entrepreneurs. *Journal of Public Economics*, 81(1): 99 – 115, 2001.
- Sanford J. Grossman and Oliver D. Hart. The costs and benefits of ownership: A theory of vertical and lateral integration. *The Journal of Political Economy*, 94(4):691–719, 1986.
- Oliver Hart and John Moore. Property rights and the nature of the firm. *Journal of Political Economy*, 98 (6):1119–1158, 1990.
- Robert D. Innes. Limited liability and incentive contracting with ex-ante action choices. *Journal of Economic Theory*, 52(1):45–67, 1990.
- Michael C Jensen and William H Meckling. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4):305–360, 1976.
- David M Kreps and Robert Wilson. Reputation and imperfect information. *Journal of economic theory*, 27 (2):253–279, 1982.
- Jonathan Levin and Steven Tadelis. Profit sharing and the role of professional partnerships. *The Quarterly Journal of Economics*, 120(1):131–171, 2005.
- Vojislav Maksimovic and Sheridan Titman. Financial policy and reputation for product quality. *Review of Financial Studies*, 4(1):175–200, 1991.
- Paul Milgrom and John Roberts. Predation, reputation, and entry deterrence. *Journal of Economic Theory*, 27(2):280–312, 1982.
- Paul Milgrom and John Roberts. Price and advertising signals of product quality. *The Journal of Political Economy*, 94(4):796–821, 1986.
- David C. Nachman and Thomas H. Noe. Operating efficiency and output insensitive employment contracts for capital management. *Economic Theory*, 5(2):315–335, 1995.
- Leonard I Nakamura. Intangible assets and national income accounting: measuring a scientific revolution. Federal Reserve Bank of Philadelphia Working Paper, 2009.
- Thomas H. Noe, Michael J. Rebellio, and Thomas A. Rietz. Product market efficiency: The bright side of myopic, uninformed, and passive external finance. *Management Science*, 58(11), 2012.
- Peter W. Roberts and Grahame R. Dowling. Corporate reputation and sustained superior financial performance. *Strategic Management Journal*, 23(12):1077–1093, 2002.

Rajendra K. Srivastava, Thomas H. McInish, Robert A. Wood, and Anthony J. Capraro. Part IV: How do reputations affect corporate performance?: The value of corporate reputation: Evidence from the equity markets. *Corporate Reputation Review*, 1 and 2(1):62–68, 1997.

Steven Tadelis. What's in a name? reputation as a tradeable asset. *The American Economic Review*, 89(3): 548–563, 1999.

Jean Tirole. A theory of collective reputations (with applications to the persistence of corruption and to firm quality). *Review of Economic Studies*, 63:1–22, 1996.

Appendix

Proof of Lemma 1. Suppose that if, the firm is unrevealed and the t -good's price is P , the manager is contracted to receive an incentive payment $B_T(P)$ in period T . To see that the manager will always divert in period T if the control system is insecure, note that the period T good's price and thus both the firm's revenue and the manager's incentive payment are unaffected by his technology choice. However, if the manager diverts, he receives an additional c . Therefore, the manager maximizes his payoff in period T by diverting. The argument regarding unraveling preceding the statement of the lemma establishes the result that the manager will always divert once the control system has been revealed as insecure. \square

Proof of Lemma 2. The proof is by induction. First note that the firm will not operate after period T and thus revelation in period T is not consequential. Therefore, in period T , the manager will divert whenever the control system is insecure. Now note that at histories where $\rho = 0$, the control system is insecure with probability 1. Thus, by Lemma 1, the manager will always divert. By Assumption 2, certain diversion is not profitable. Therefore, if the control system is known to be insecure in period T , the firm will shut down. Now, suppose that the assertion is true in period t . At a node where the control system is revealed in period t , the manager knows that next period's history will also be a revealed node. Consequently, by induction, the firm will shut down at $t + 1$ and revenue will equal a constant, 0. It follows that the manager's bonus at $t + 1$ cannot vary with the technology decision. Hence, even if he is offered a bonus contract, the manager will divert. This implies that shutdown is optimal at t . \square

We present the proof Proposition 1 after establishing the following three Lemmas:

Lemma A-1. *The set of periods in which the owner funds production and the manager does not divert even when the control system is insecure is either empty or an interval of the form $\{1, 2, \dots, t^+\}$, $t^+ < T$.*

Proof of Lemma A-1. For any given compensation contract, B^* , let $v_M(t)$ represent the manager's value function when the control system is insecure and the firm has not been revealed up to period t , i.e., until period t the firm has never produced a low-quality good. Let $b^*(t) \geq 0$ represent the payment specified by the compensation contract in period t given that the unrevealed price of the good in period t is $p^*(t)$, i.e., $b^*(t) = B_t^*(p^*(t))$. If the manager does not divert in period t , then it must be the case that the manager's payoff from diversion is no greater than the payoff from not diverting. The manager's payoff from diverting in period t is

$$b^*(t) + c + \delta v_M(t^+ + 1). \quad (\text{A-1})$$

The manager payoff from not diverting is

$$b^*(t) + v_M(t + 1). \quad (\text{A-2})$$

Thus, not diverting is incentive compatible if and only if

$$(1 - \delta)v_M(t + 1) \geq c. \quad (\text{A-3})$$

Next note that the value function is non-increasing in t . This follows because, in period t , the manager can always secure a value of

$$b^*(t) + v_M(t+1)$$

by not diverting. Because the manager chooses the optimal policy in period t

$$v_M(t) \geq b^*(t) + v_M(t+1) \geq v_M(t+1). \quad (\text{A-4})$$

Thus, if equation A-3 is satisfied at t , it is satisfied for $s < t$. □

Lemma A-2. *Under a simple contract the firm will operate in every period in which it unrevealed.*

Proof of Lemma A-2. First note that Bayes' rule implies that the price of the good at least equals P_1 in all periods if the firm is unrevealed, and is always less than P_1 if the firm is revealed. Thus, under a simple contract the manager receives a bonus in period t if and only if the firm is unrevealed in period t . For all periods $t \leq t^+$, the manager does not divert. If the firm shuts down or if the manager does not divert when the control system is insecure, the firm's output provides no information about the security of the control system. Therefore, both cases will yield the same market assessments about the control system at the start of the next period. Consequently, regardless of whether the firm shuts down or operates, the continuation value will be the same. By Assumption 1, the current reward for operating always exceeds the reward for shutting down. It follows that, for $t \leq t^+$, the owner will never shut down the firm.

Next consider $t > t^+$. In each period the manager diverts when the control system is insecure. Thus, the decision to operate in period t affects consumer beliefs along the unrevealed path in the next period and thus the owner's continuation value. Consequently, the proof that the firm will not shut down is somewhat more involved. Suppose the firm is unrevealed. Let $v_O(P, t)$ be the owner's value in period t conditioned on the period, t , and state variable, P . Because, the manager diverts in all periods $t > t^+$, the good's price equals P . We prove the hypothesis though induction on the following statements: in each period $t > t^+$

- (a) the optimal policy for the firm is to shut down when revealed and operate if unrevealed, and
- (b) $Pv_O(\Gamma[P], t) > v_O(P, t)$.

Consider $t = T$. Assertion (a) is trivially true because the payoff from operating is positive, the payoff from shutting down is 0, and the period T bonus is not affected by operate/not operate decision. Next, note that

$$Pv_O(\Gamma[P], T) - v_O(P, T) = P(\Gamma[P] - e - b(T)) - (P - e - b(T)) = (1 - P)(e - \delta) > 0. \quad (\text{A-5})$$

Thus, assertion (b) is also satisfied for $t = T$.

Suppose that the assertions are true for $t = t' + 1$. First note that Lemma 2 implies that, if the firm is revealed at $t' + 1$, it will shut down. Therefore, the payoff from operating at t' is given by

$$(P - e - b(t')) + Pv_O(\Gamma[P], t' + 1). \quad (\text{A-6})$$

Similarly, the payoff from shutting down at t' is

$$-b(t') + v_O(P, t' + 1). \quad (\text{A-7})$$

Given $P > e$ (given Assumption 1) and the induction hypothesis, the payoff from operating at t is higher than the payoff from shutting down. Thus, the firm will operate at t if unrevealed, confirming assertion (a). Next, note that, if the firm operates at t' when unrevealed, then

$$\begin{aligned} P v_O(\Gamma[P], t') &= P(\Gamma[P] - e - b(t')) + \Gamma[P] v_O(\Gamma^2[P], t' + 1) \\ v_O(P, t') &= (P - e - b(t')) + P v_O(\Gamma[P], t' + 1). \end{aligned} \quad (\text{A-8})$$

Using (A-8) yields

$$\begin{aligned} P v_O(\Gamma[P], t') - v_O(P, t') &= \\ &= \left(P(\Gamma[P] - e) - (P - e) \right) + P \left(\Gamma[P] v_O(\Gamma^2[P], t' + 1) - v_O(\Gamma[P], t' + 1) \right). \end{aligned} \quad (\text{A-9})$$

The first term in parenthesis is positive for the same reasons as A-5. The second term is positive by induction, establishing that

$$P v_O(\Gamma[P], t') - v_O(P, t') > 0. \quad (\text{A-10})$$

This confirms assertion (b) when $t = t'$. Thus, both (a) and (b) are established. \square

Lemma A-3. *Given any general compensation contract B , there exists a simple replacement contract, b which produces at least as high of a date 0 owner payoff as B . Moreover, if the owner shuts down production in any period under the general contract, B , the simple replacement contract produces a strictly higher date 0 owner payoff.*

Proof. Lemma A-2 shows that the firm will operate in every period when unrevealed. From the ex ante date 0 perspective, operating in every period is optimal because, by Assumption 1, operating even when the manager diverts under the insecure structure generates positive profits. Thus, any replacement simple contract ensures that the first-best operating policy is followed. Moreover, ceteris paribus, switching from shutting to operating always increases the manager's payoff weakly. Increasing the manager's continuation payoff relaxes the incentive compatibility condition for managerial non-diversion when the control system is insecure. Thus, holding the payment to the manager on the unrevealed path constant, switching from shutting down to operating, weakly increases the set of dates at which the manager will not divert, this effect also weakly increases the owner's period 0 value.

Under the general contract, some bonus payments might not be paid to the manager even along the unrevealed path because the good's price required to trigger the payment is higher than the good's actual price. Call such payments "ineffective." For a given general contract, consider the following replacement simple contract: Under the replacement scheme set the bonus payment to the manager at t to 0 whenever no payment was promised or an ineffective payment was promised under the general scheme. Replace all

effective positive payments with payments of the same amount but conditioned simply on a t -good price weakly greater than P_1 . In every period, the expected value of the contracted payment is the same under the general and simple replacement contracts. If, under the general contract, the manager receives a bonus payment at t even though the owner shuts down the firm in this period, the manager's payoff in that period will be higher under the replacement scheme if diversion is optimal in that period. However, in no period will the manager's payoff be lower. Thus, the manager's continuation value is weakly higher under the replacement scheme, which implies that the set of unrevealed periods in which the manager will divert is smaller under the replacement scheme as discussed above. By Assumption 1 switching from shutting down to operating at any date increases expected date 0 total firm value and the set of dates where the manager does not divert weakly expands. Thus, firm value weakly increases. It strictly increases if under the general contract the firm shuts down in any unrevealed period. Since, the expected payments to the manager are the same under both policies, owner value is weakly higher under the replacement contract and strictly higher if the firm shuts down in any unrevealed period under the general contract. \square

Proof of Proposition 1. Lemmas A-1, A-2, and A-3 establish the proposition. \square

Lemma A-4. *If b is an optimal compensation policy, and $t > t^+(b) + 1$, then $b(t) = 0$.*

Proof of Lemma A-4. Suppose b is an optimal simple compensation contract. Consider an alternative contract, b' , defined as follows: eliminate all payments to the manager after period $t^+(b) + 1$ and add the sum of these payments, discounted by the probability that the manager receives the payments under an insecure control system, to payments received at $t^+ + 1$, i.e.,

$$b'(t) = \begin{cases} b(t) & \text{if } t < t^+(b) + 1 \\ b(t) + \sum_{s=1}^{T-(t^+(b)+1)} \delta^s b(t^+(b) + 1 + s) & \text{if } t = t^+(b) + 1 \\ 0 & \text{if } t > t^+(b) + 1. \end{cases} \quad (\text{A-11})$$

Under b' , the manager receives no incentive payments after period $t^+(b) + 1$ and, thus, will clearly divert in all periods starting with $t^+(b) + 1$. These choices will be identical to those under b for $t > t^+(b)$. Because the probability that the firm will remain unrevealed s periods after $t^+(b) + 1$ under b' is δ^s , the manager's value in periods, $t \leq t^+$ is exactly the same under b' as it is under b . Thus, $t^+(b') = t^+(b)$, i.e., the manager's diversion policy choices under b' will be exactly the same as under b . The expected payments to the manager conditioned on an insecure control system will also be the same under both compensation schemes. However, the payments will be strictly lower under b' conditioned on a secure control system since, in this case, the manager never diverts and, thus, receives the payments $b(t)$ in periods $t > t^+ + 1$ with probability 1. Thus, expected payments conditioned on a secure control system are strictly lower under b' than under b . It follows that, taking expectations over possible control systems, the expected payments to the manager are strictly lower under b' . Because the manager's diversion policy is the same under both payment policies, the owner's payoff must be higher under b' . This establishes the result. \square

Lemma A-5. *If b is an optimal policy, and $t < t^+(b) + 1$, then $b(t) = 0$.*

Proof of Lemma A-5. Given Lemma A-4 we can focus on policies that make no payments to the manager after $t^+(b) + 1$. Consider a contract b that makes no payments after $t^+(b) + 1$, but which makes positive payments at some date before $t^+(b) + 1$. Consider the alternative contract, b' that eliminates all payments before $t^+(b) + 1$ and instead adds the sum of these payments to the payment made at $t^+(b) + 1$, i.e.,

$$b'(t) = \begin{cases} 0 & \text{if } t < t^+(b) + 1 \\ b(t) + \sum_{s=1}^{t^+(b)} b(s) & \text{if } t = t^+(b) + 1 \\ 0 & \text{if } t > t^+(b) + 1. \end{cases} \quad (\text{A-12})$$

By the definition of $t^+(b)$,

$$v_M(t^+(b) + 1) \geq \delta v_M(t^+(b) + 1) + c \quad (\text{A-13})$$

Under policy b , any payment made before $t^+(b) + 1$ has no effect on the unrevealed manager's value at $t^+(b)$. Thus, the change from b to b' increases the unrevealed manager's value at $t^+(b)$. It follows that the manager's value is higher under b' at $t^+(b)$ than under b . When combined with inequality (A-13), this implies that

$$v'_M(t^+(b) + 1) > \delta v'_M(t^+(b) + 1) + c, \quad (\text{A-14})$$

where v'_M represents the manager's value under b' . Now consider the family of policies b_λ defined by

$$b_\lambda(t^+(b) + 1) = b'(t^+(b) + 1) - \lambda, \quad b_\lambda(t) = b'(t) = 0 \text{ if } t \neq t^+(b) + 1. \quad (\text{A-15})$$

Expression (A-14) implies that we can choose $\lambda > 0$ so that

$$v_M^\lambda(t^+(b) + 1) \geq \delta v_M^\lambda(t^+(b) + 1) + c \text{ and } v_M^\lambda(t^+(b) + 2) < \delta v_M^\lambda(t^+(b) + 2) + c, \quad (\text{A-16})$$

where v_M^λ represents the manager's value under b_λ . Equation (A-16) implies that $t^+(b) = t^+(b_\lambda)$. Hence, the manager's diversion policy is the same under both payment policies. Because contingent payments b made on or before $t^+(b) + 1$ are paid with probability 1 and under both b and b_λ , the fact that the sum of the payments under b_λ is smaller than under b implies that the total expected cost of compensation is strictly lower. Since the diversion policy followed by the manager is the same under both b_λ and b the owner's value must be higher under b_λ , contradicting b being an optimal policy. \square

Proof of Proposition 2. The proposition follows directly from Lemmas 1 through A-5. \square

Proof of Proposition 3. If the firm is unrevealed, let $p(t)$ represent the price consumers are willing to pay for the good in period t . Note that $p(t)$ also represents the probability that the firm will remain revealed until period $t + 1$. The owner's expected gross profit in period t under the t^+ -policy, which we represent by $\bar{\pi}[t^+](\cdot)$, equals

$$\bar{\pi}[t^+](t) = (p[t^+](t) - e) \prod_{s=0}^{t-1} p[t^+](s), \quad t = \{1, 2, \dots, T\} \quad (\text{A-17})$$

and the owner's gross value is simply a sum of these gross profits across all periods. Since the good's price under both the t^+ and $t^+ + 1$ policies equals 1 when $t \leq t^+$, $\bar{\pi}[t^+ + 1](t) = \bar{\pi}[t^+](t)$ for all $t \leq t^+$. Since the Bayes' operator goes into effect with a one period delay under the $t^+ + 1$ -policy, $\bar{\pi}[t^+ + 1](t + 1) = \bar{\pi}[t^+](t)$ for $T > t > t^+$. Thus, the difference in gross value induced by a t^+ -shift is a telescoping sum given by

$$\bar{\pi}t^+ - \bar{\pi}[t^+](T) = (1 - e) - \bar{\pi}[t^+](T). \quad (\text{A-18})$$

Using equations (12), (13), and (A-17), we see that

$$\bar{\pi}[t^+](T) = \frac{(P_1 - \delta)(1 - e) - (1 - P_1)(e - \delta)\delta^{T-t^+-1}}{1 - \delta}. \quad (\text{A-19})$$

Thus, the effect on the gross value of the owner of a t^+ -shift is given by

$$(1 - e) - \frac{(P_1 - \delta)(1 - e) - (1 - P_1)(e - \delta)\delta^{T-t^+-1}}{1 - \delta} = \frac{(1 - P_1)(1 - e) + (1 - P_1)(e - \delta)\delta^{T-t^+-1}}{1 - \delta}. \quad (\text{A-20})$$

Combining the effects of a t^+ shift on compensation and gross firm value shows that the net effect on the owner is given by

$$\frac{(1 - P_1)(1 - e) + ((1 - P_1)(e - \delta) - c)\delta^{T-t^+-1}}{1 - \delta}. \quad (\text{A-21})$$

Thus, if $(1 - P_1)(e - \delta) - c \geq 0$, all t^+ -shifts increase the owner's value and the owner will set $t^+ = T - 1$. Otherwise, $(1 - P_1)(e - \delta) - c < 0$. In which case, the effect of a t^+ shift on the owner's value is strictly decreasing. Thus, the set of t^+ -shifts that increase the owner's value is a (possibly empty) downward directed order interval. The owner will pick the unique t^+ , which we denote by t_*^+ , which satisfies the following conditions: if some t^+ -shift lowers owner value, t_*^+ is the smallest $t^+ \in \{0, 1, \dots, T - 1\}$ such that the effect of a t^+ shift is to lower the owner's value, or, if all t^+ shifts increase owner value, then $t_*^+ = T - 1$. \square

Proof of Lemma 3. The owner's period T payoff from diverting is $p(T) - I$, which is higher than his payoff from choosing the high-quality technology, $p(T) - e$ since $I \leq e$. Therefore, in period T , the owner will always divert since this is the dominant strategy for period T .

If the owner does not produce, her payoff is zero. If consumers expect the owner to divert in every period she chooses to produce, the consumers' best response is to pay δ . Moreover, if consumers pay δ in each period, the owner's best response is not to produce. This establishes that there is an equilibrium for a subgame following the revelation that the firm is insecure in which the owner's payoff is 0.

Now we establish the uniqueness of this outcome. If the owner's future payoff is not sensitive to her technology choice, her best response is to divert if the current period's price is sufficiently high or not to produce when it is low. Therefore, the consumers' best response is to pay δ . Now consider the possibility that the price varies over time. It is a dominant strategy for the owner to divert in period T . Therefore, consumers will pay δ in period T , and the owner will not produce in the period. In period $T - 1$, the owner can divert without incurring any change in her future expected payoff, making diverting her best response to any price $p^* \geq I$ in period $T - 1$ and no production his best response to a lower price. It is clear that the

consumers' best response in period $T - 1$ is to pay δ , which will block production. By induction, it is clear that the owner will not choose the high-quality technology in any period subsequent to the revelation that the firm is insecure. Moreover, consumers will pay only δ blocking production in every period. \square

Proof of Proposition 4. The owner will choose the high-quality technology in period t in a given equilibrium whenever

$$c + \delta v_O(t+1) < v_O(t+1), \quad (\text{A-22})$$

where the owner's continuation value, $v_O(t+1)$ is based on an optimal continuation strategy. A feasible strategy for the owner is to divert in all periods subsequent to t . All updating rules consistent with Bayes' rule produce $p(s) > p(t)$ for $s > t$. Thus a lower bound on the owner's continuation payoff is given by, $v_O(t+1)$, where

$$v_O(t+1) = \sum_{j=1}^s \delta^{j-1} (p(t) - I) = \frac{(p(t) - I) (1 - \delta^{T-t})}{1 - \delta}. \quad (\text{A-23})$$

Consequently,

$$v_O(t+1) \geq v_O(t+1) = \frac{(p(t) - I) (1 - \delta^{T-t})}{1 - \delta}. \quad (\text{A-24})$$

It follows that if

$$c \leq (p(t) - I) (1 - \delta^{T-t}), \quad (\text{A-25})$$

at any date t , then condition (A-22) is satisfied and the owner-manager will choose high quality. This establishes claim (i).

Note that because equilibrium beliefs are updated according to Bayes' rule, $p(t) \geq P_1$. Moreover, since $\delta < 1$, $\delta \geq \delta^{T-t}$ for all $t \leq T - 1$. Therefore, condition (A-22) is satisfied for all periods whenever (19) is satisfied. This establishes claim (ii).

The owner-manager will divert in period t whenever

$$\frac{c}{1 - \delta} > v_O(t+1). \quad (\text{A-26})$$

An upper bound on the owner's payoff is given by the owner's payoff when $P = 1$ and the owner optimally chooses in each period whether to produce high or low quality. The value function associated with this policy is increasing in the number of remaining periods because the per period payoff is positive moreover the cost of investing high quality is fixed while the benefit of high quality, the increase the probability of being unrevealed, is proportional to continuation value. Thus, assuming the upper bound $P = 1$ in every period, the owner's optimal technology choice will be to produce high quality for the first s periods after t and low quality for the remainder, with $s \in \{0, 1, \dots, T\}$. The owner's payoff from the policy of choosing the high-quality technology up to and including s periods after t is given by

$$\sum_{j=1}^s (1 - I - c) + \sum_{j=s+1}^{T-t} \delta^{j-s-1} (1 - I) = (1 - I - c)s + \frac{(1 - I) (1 - \delta^{T-t-s})}{1 - \delta}. \quad (\text{A-27})$$

Thus, an upper bound on the payoff to the continuation payoff of the owner, $\bar{v}_O(t+1)$ is given by

$$\bar{v}_O(t+1) = \max_{s=\{0,1,\dots,T-t\}} (1-I-c)s + \frac{(1-I)(1-\delta^{T-t-s})}{1-\delta}. \quad (\text{A-28})$$

Because, $\bar{v}_O(t+1)$ is an upper bound for $v_O(t+1)$, a sufficient condition for low quality production at date t is that

$$\frac{c}{1-\delta} > \bar{v}_O(t+1). \quad (\text{A-29})$$

Claim (iii) follows. □

Proof of Corollary 1. This result follows directly from the conditions for reputation equilibria in Propositions 3 and 4. □

Proof of Proposition 5. First consider firm value when both owner and delegated management support reputation equilibria. It is clear that firm revenue in every period is identical under both ownership structures. Moreover, under both ownership structures, the firm expends $I+c$ in each period through period $T-1$. The only difference between cash flows under the two ownership structures arises because of the payment of management compensation of $\frac{\delta c}{1-\delta}$ in period T under management control. Thus, firm value is lower under management control.

Now compare firm value under owner management in a reputation equilibrium with firm value under delegated management in any other equilibrium. Consider firm value under owner management if the owner adopts the same strategy as the manager adopts under delegated management. Thus, the owner will have to choose high quality up to some period t' and then choose low quality. Up to period t' , firm revenue, investment expense and investment in quality will be identical under the two ownership structures. However, under delegated management, the firm will incur the additional expense of management compensation in period $t'+1$ to ensure quality until period t' . Under owner management, firm revenue and investment in every subsequent period will be 1 and I , respectively so long as the firm remains unrevealed. Under delegated management, firm revenue and investment in every period subsequent to t' will equal $P < 1$ and I so long as the firm remains unrevealed. Once the firm is revealed, its future payoff is 0 regardless of its ownership structure. Since the likelihood of being revealed under owner management is the same as under delegated management, expected cash flows and thus firm value are higher under owner management. Since the reputational behavior through period $T-1$ is optimal and thus must generate even higher expected cash flows, firm value under owner management must be higher than firm value under delegated management. Thus we have established claim (i).

We establish claim (ii) by constructing an example of a case where firm value is higher under delegated management. Let $T=3, \delta=0.7, I=0.725, P_1=0.8, c=0.06$. Thus, $\rho_1=0.3\bar{3}$. We claim that under owner management the firm will produce low quality in all three periods. This implies prices given by the price revision rule (13). Applying this rule to the initial price $p(1)=0.80$ yields, $p(2)=0.825, p(3)=0.85\bar{15}$. Verification of the equilibrium consists of showing that at each date, $t \in \{1,2,3\}$, (A-26) holds. Now consider the same parameters under delegated management. We claim that the equilibrium under

delegated management will involve the firm hiring the manager and paying the manager a bonus in period T conditioned on $T - 1$ revenue. The bonus will equal $(\delta c)/(1 - \delta) = 0.14$. This policy is optimal and the bonus is incentive compatible, since the reputation equilibrium condition (16) is satisfied. It is then relatively straightforward to demonstrate that firm value is higher under delegated management. \square

Preamble to proof of Proposition 6. Many features of the baseline model are unaffected by the change in the information structure. The size of the optimal incentive payment, b^* , which in a two period case of the baseline model is $c \frac{\delta}{1-\delta}$, remains unchanged as the manager's incentives are only affected by his contract and, thus, are not directly affected by consumer or owner beliefs. Moreover, except in a degenerate case discussed below, conditioning the incentive payment on the good's price in period T exceeding δ is still sufficient to ensure that the incentive payment will be made if and only if output quality in the previous period is high.

To interpret the model as a signaling game, we can view the owner as an informed first-mover who sends one of three messages, $m \in \mathcal{M} = \{C, NC, SH\}$, where message C denotes that the owner chooses an optimal contract, NC represents the decision not to pay incentive compensation, and SH represents the decision to shut down the firm in period 1. The owner's type is $\theta \in \Theta = \{S, J\}$. Consumers are uninformed responders. Their response is a price for the period 1 good. Let v_O represent the owner's payoff function at the start of the game, the beginning of period 1. A strategy for the owner, $\sigma(\cdot|\theta)$, is a probability measure over \mathcal{M} conditioned on the owner's type. Consumers' beliefs are represented by the function $\rho : \mathcal{M} \rightarrow [0, 1]$, where $\rho(m)$ represents their assessment of the probability the firm is secure conditioned on message m . Let $p^* : \mathcal{M} \rightarrow [\delta, 1]$ represent the period 1 good's price when quality is not assured by compensation. A Perfect Bayesian Equilibrium (PBE) is a triple, (σ^*, ρ^*, p^*) satisfying the following conditions:

- i. If $\sigma^*(m|\theta) > 0$, then m is a best response for type θ , i.e.,

$$v_O(m, p^*(m), \theta) = \max_{m \in \mathcal{M}} v_O(m, p^*(m), \theta).$$

- ii. Prices are based on beliefs, i.e. $p^*(m) = \rho^*(m) + (1 - \rho^*(m)) \delta$.
- iii. Whenever, under σ^* , a message m is selected with positive probability, ρ^* is consistent with Bayes' rule.

To complete the description of the signaling game, we have to define the owner's payoff function. The need to redefine the owner's payoff function arises because of complications that arise when consumers have a very low assessment of a good's quality. If they believe that a given compensation policy signals that the control system is insecure with probability 1, then high quality output will not lead them to revise their assessment. Consequently, the period T good's price will equal δ regardless of the quality of the period 1 good. It follows that incentive compensation will not motivate the manager. As long as consumers' assess a non-zero probability to the control system being secure, a high quality period 1 good will result in a strictly higher period T good price than a low quality period 1 good. However, the period T price might still be less than the cost of production, so the firm will shut down in period T . Accounting for these cases, we obtain

the following payoff function for the owner:

$$v_O(m, p, \theta) = \begin{cases} (p - I - c) + \delta \max[\Gamma(p) - I - c, 0] & \text{if } m = \text{NC} \ \& \ \theta = \mathcal{J}, \\ (p - I - c) + \max[\Gamma(p) - I - c, 0] & \text{if } m = \text{NC} \ \& \ \theta = \mathcal{S}, \\ (1 - I - c) + \max[\Gamma(p) - I - c, 0] - b^* & \text{if } m = \text{C} \ \& \ p > \delta, \\ 0 & \text{if } m = \text{C} \ \& \ p = \delta, \\ 0 & \text{if } m = \text{SH}, \end{cases} \quad (\text{A-30})$$

where $\Gamma(p) = 1 + \delta - \frac{\delta}{p}$ and $b^* = c \frac{\delta}{1-\delta}$. □

Lemma A-6. *In any D1-PBE in which incentive compensation is offered with positive probability, choosing to not provide incentive compensation, NC is on the equilibrium path.*

Proof. Suppose instead that $m = \text{NC}$ is off the equilibrium path in a D1-PBE in which $m = \text{C}$ is on the equilibrium path. Note that expression (A-30) shows that

$$v_O(m, p, \mathcal{S}) = v_O(m, p, \mathcal{J}), \quad m = \text{C} \ \text{or} \ m = \text{SH}. \quad (\text{A-31})$$

Because $m = \text{NC}$ is off the equilibrium path, this implies that the equilibrium payoff v_O^* of $\theta = \mathcal{J}$ equals equilibrium payoff of $\theta = \mathcal{S}$, i.e.,

$$v_O^*(\mathcal{S}) = v_O^*(\mathcal{J}). \quad (\text{A-32})$$

Next note that expression (A-30) shows that

$$\begin{aligned} v_O(\text{NC}, p, \mathcal{S}) &\geq v_O(\text{NC}, p, \mathcal{J}) \\ \text{and if } \Gamma(p) > I + c &\Rightarrow v_O(\text{NC}, p, \mathcal{S}) > v_O(\text{NC}, p, \mathcal{J}). \end{aligned} \quad (\text{A-33})$$

Expressions (A-32) and (A-33) imply that

$$\begin{aligned} v_O(\text{NC}, p, \mathcal{S}) - v_O^*(\mathcal{S}) &\geq v_O(\text{NC}, p, \mathcal{J}) - v_O^*(\mathcal{J}) \\ \text{and if } \Gamma(p) > I + c &\Rightarrow v_O(\text{NC}, p, \mathcal{S}) - v_O^*(\mathcal{S}) > v_O(\text{NC}, p, \mathcal{J}) - v_O^*(\mathcal{J}). \end{aligned}$$

If $\Gamma(p) \leq I + c$ then, because $p < \Gamma(p)$ when $p > \delta$ the payoff to both types from selecting NC is negative and thus less than the payoff from shutting down. So the set of market responses to NC that will induce either type to deviate is a subset of the set of responses, p , for which $\Gamma(p) > I + c$. Over this subset, $v_O(\text{NC}, p, \mathcal{S}) - v_O^*(\mathcal{S}) > v_O(\text{NC}, p, \mathcal{J}) - v_O^*(\mathcal{J})$ and $p \mapsto v_O(\text{NC}, p, \theta)$ is continuous. If consumers responded to the off equilibrium message NC with $p = 1$, then $v_O(\text{NC}, p, \mathcal{S}) - v_O^*(\mathcal{S}) > 0$. So the set of responses that will induce \mathcal{S} to deviate from the equilibrium is also not empty. Thus, the set of market responses p for which \mathcal{S} strictly gains from deviation to NC includes the set of consumer responses under which type \mathcal{J} weakly gains from deviating from the equilibrium. D1 then requires that market assign the belief that

$p^*(NC) = 1$ and thus $p^*(NC)$ equals 1. However, under this belief, the unique best response of type \mathcal{S} is to choose $m = NC$, contradicting the assumption that NC is off the equilibrium path \square

Lemma A-7. *In every DI-PBE, $\Gamma(p^*(NC)) > I + c$.*

Proof. Suppose not. First note that, if $\Gamma(p^*(NC)) \leq I + c$, then shutting down produces a strictly higher payoff than selecting $m = NC$ for both types. Lemma A-6 shows that $m = NC$ is played in equilibrium. Thus, because equilibrium strategies are best responses, it must be the case that $\Gamma(p^*(NC)) > I + c$. \square

Lemma A-8. *In every DI-PBE, the equilibrium payoffs received by types \mathcal{J} and \mathcal{S} are positive.*

Proof. Expressions (A-31), Lemma A-7, and (A-33), imply that in any equilibrium, whenever NC is a best response for type \mathcal{J} it is the unique best reply for type \mathcal{S} . Thus, the probability that type \mathcal{S} chooses NC is weakly higher than the probability that type \mathcal{J} plays NC . Lemma A-6 shows that NC is a best reply for some type. Thus, the probability that type \mathcal{S} chooses NC is weakly higher than the probability that type \mathcal{J} chooses NC and this probability is positive. Bayes' rule then implies that $p^*(NC) \geq P_1$. Expression (A-30) and Assumption 1 show that $p^*(NC) \geq P_1$ implies that the payoff from selecting NC is positive for both types. Thus because both types play best replies, the equilibrium payoff for both types must be positive. \square

Lemma A-9. *In every DI equilibrium in which the equilibrium payoff to both types is positive, $m = C$ is selected with zero probability.*

Proof. Suppose not. Note that it must be the case that type \mathcal{J} is selecting NC with positive probability. Otherwise choosing NC , by Bayes' rule, would reveal that the control system is secure and, thus, imply that $p^*(NC) = 1$. In which case, type \mathcal{S} would strictly prefer $m = NC$ to $m = C$. But if type \mathcal{S} strictly prefers NC over C , then C would only be selected by type \mathcal{J} . In which case selecting C would reveal the structure to be insecure and, thus, generate a payoff of 0, contradicting the payoff being positive for both types.

The hypothesis that C is played with positive probability combined with our result that type \mathcal{J} is selecting NC with positive probability imply that (a) NC is a best response for \mathcal{J} and that (b) C is a best response for some type. Expressions (A-31), Lemma A-7, and (A-33) imply that

$$v_O(NC, p^*(NC), \mathcal{S}) - v_O(C, p^*(C), \mathcal{S}) > v_O(NC, p^*(NC), \mathcal{J}) - v_O(C, p^*(C), \mathcal{J}). \quad (\text{A-34})$$

(a) and (b) and (A-34), imply that NC is the unique best response for \mathcal{S} . (b) then implies that C is a best response for type \mathcal{J} . Because NC is the unique best response for type \mathcal{S} . C is not a best response for type \mathcal{S} . Bayes' rule thus implies that $p^*(C) = \delta$ and thus $v_O(C, p^*(C), \mathcal{J}) = 0$, which is not possible given that C is a best response for type \mathcal{J} and type \mathcal{J} 's equilibrium payoff is positive. \square

Proof of Proposition 6. The proof follows from Lemmas A-6 through A-9. \square

Proof of Lemma 4. The proof follows directly from the discussion preceding the statement of the proposition. \square

Proof of Proposition 7. The proof follows directly from the discussion preceding the statement of the proposition. □

Proof of Proposition 8. The proof for Condition (29) follows directly from the discussion preceding the statement of the proposition. The proof of the claim about managerial diversion in the absence of incentive compensation follows directly from an argument similar to that used to prove Lemma 1—the manager’s only payoff comes from diversion and postponing diversion can only lower this expected payoff. The statement about the optimality of reform at date T following revelation follows directly from Assumption (22). □

Proof of Proposition 9. The proof follows directly from the discussion preceding the statement of the proposition. □