Ownership structure, organizational reform and corporate reputations

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Abstract

We examine how delegated management affects corporate reputation formation. We show that, even in a very restricted compensation contracting environment, delegated "professional" management can support socially efficient reputable firm behavior in cases where owner management cannot. However, because delegated management transfers rents to managers, firm value may still be higher under owner management. Thus, control changes that convert professionally-managed firms to owner-managed firms, e.g., leveraged buyouts, can be profitable even if they are socially inefficient. The owner-management structure is even more problematic when reform mechanisms exist to restore damaged reputations. Increasing the efficacy of reform mechanisms lowers firm value by adversely impacting owner-manager incentives. In contrast, it can increase both firm value and social efficiency under delegated management.

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1 Introduction

Management researchers and practitioners uniformly assert corporate reputations are valuable. By some estimates, reputation accounts for more than 60% of firm value (Gaines-Ross [2008a,b]). Reputation is valuable since it enables firms to 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]).

Economists have developed many sophisticated models of reputation formation (Milgrom and Roberts [1982, 1986], Allen [1984], Maksimovic and Titman [1991], and Noe et al. [2012]). In most models, reputation is tied to specific characteristics of an agent. This agent's actions affect the reputation. The agent bears the entire cost of maintaining the reputation and is also its sole beneficiary. In some economic models, (e.g., Tirole [1996] and Cremer [1986]) agents are organized into teams, and each team captures the benefits and costs of its collective reputation. In this case, reputation adheres to specific qualities of the agents who make up the team. Changing the team will change the team's reputation. Thus, standard economic models clearly fit reputation acquisition and loss when reputation adheres to the specific set of agents employed by the firm (e.g., owner-managed firms, professional firms, investment banks, mutual funds, etc.).

In the standard economic model, the reputation of an organization is a aggregation of the reputations of the individual members. However, to practitioners and management consultants "reputation" has a very different meaning. This difference in meaning best illustrated by considering prototypical cases of "corporate reputation loss" advanced in the management literature. In these cases, the corporation's reputation is not an aggregation of the reputations of its employees. Instead, the reputation of the corporation adheres to institutions which control the behavior of anonymous "reputationless" agents. A specific example of "reputation" used in this sense is provided by Lululemon Athletica. Lululemon is a Canadian firm with a reputation for high-quality athletic clothing. In 2013, Lululemon suffered a "reputation crisis," when consumers discovered that yoga pants made from their signature fabric, Luon, became far too sheer when stretched out during yoga exercise. The problem was traced to factory-level managers who purchased substandard quality fabric. Lululemon's stock price and revenues dropped sharply as a result of the crisis. In response, Lululemon's board announced a reform package which included (a) a new system of factory oversight, and (b) a new cross-functional organizational structure. Immediately after the board met, CEO Christine Day announced that she was leaving the company for personal reasons. Although the guilty factory managers were almost certainly dismissed, neither their dismissals nor the CEOs departure were even mentioned in the board's press release which focused entirely on reforming Lululemon's control structures.

While the crisis was precipitated by the actions of factory managers, the resulting economic consequences were borne primarily by Lululemon's investors. Moreover, replacing the offending managers with managers having better reputations clearly was not part of the firm's reform strategy. Neither the old nor the replacement factory managers had reputations with either consumers or Wall-street analysts. The CEO's departure was also not triggered by any CEO actions that directly reduced the quality of Lululemon yoga pants. Rather, the natural interpretation of this case, and the one universally adopted in journalistic analysis, was that the reputation lost by Lululemon was a reputation for having a control structure (or equivalently from

the perspective of our analysis a "corporate culture") ensuring high quality output. The reform steps taken by the board were aimed at increasing consumer and investor confidence in this structure. Lululemon's lost reputation was the reputation of a structure and not an aggregation of the reputation of the individuals (factory managers) responsible for sourcing quality inputs. Lululemon's reputation did not relate to an inherent characteristic of individuals but rather to alterable structural and organizational traits of the firm. In fact, much of the literature on corporate reform focuses on making these sorts of structural changes in response to reputation crises.[1]

In this paper, we model the management/practitioner concept of corporate reputation in a rational-choice economic framework. Our model departs from the traditional economic models of reputation in two ways. First, we focuses on the viability of a firm's reputation that is based on its structural characteristics rather than the characteristics of its employees. Second, we compare two ownership/management regimes: an owner-manager versus delegated management. Under delegated management, the agents whose actions affect the reputation do not bear the entire cost of maintaining the reputation nor are they its sole beneficiaries. These departures enable us to answer the following questions: How can a firm maintain a reputation that is tied to its structural characteristics? How does the separation between ownership and management affect a firm's ability to maintain its reputation and its value? Is it possible to restore reputations through organizational reform?

In our delegated management model, a firm's owner delegates operating decisions to a professional manager. The manager's characteristics are common knowledge and there exists a pool of managers who are perfect substitutes for the chosen manager. When the manager is hired, the firm commits to an employment contract that compensates the manager based on firm revenue, which is assumed to be verifiable. The actual quality of goods produced is observable but not verifiable, and thus not contractible. This assumption restricts the efficiency of delegated management significantly. Relaxing this restriction would increase the likelihood that delegated management is optimal. However, our aim is to show that, even in a very restrictive contracting environment, delegating management can be optimal. Employment is hire-at-will, with the owner having the option to replace the manager at any date. Replacement, however, does not relieve the owner of the obligation to make contracted payments.

The firm has in place a governance mechanism to control the manager's actions, which we will henceforth refer to as the "control structure." While the owner and the firm's customers are unsure of the effectiveness of the control structure, the manager knows its true effectiveness. If a control structure is not "secure," the manager can exploit weaknesses in the structure to implement risky low-cost production strategies. The

[1]There are many examples of "reputation" being assigned this meaning: Gaines-Ross [2008a] clearly attributes reputation loss to organizational failure, citing dozens of examples of reputations lost and reputations rebuilt through governance, structure, organization and culture. Reputation restoring structural changes can be targeted as high as board level oversight or as low as factory worker behavior. Barclays established a "Brand and Reputation Committee" to review any issues that might negatively affect reputation (Gaines-Ross [2008a, p. 136]). Toyota developed the "Toyota Way" in which all employees are required to identify and fix problems that might affect Toyota's reputation for quality (Gaines-Ross [2008a, 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 [2008a, p. 140]). What these examples have in common is the structural control aspect of reputation management independent of the specific agents managing the companies.

failure of low-cost strategies results in low quality goods which reveal an insecure control structure and alter consumers' beliefs about future product quality. Thus, the firm's reputation is based on consumers' perceptions about the effectiveness (security) of its control structure and not the characteristics of its manager. However, the manager's actions affect the consumer's beliefs about the control structure and hence the firm's reputation.

In order to compare delegated management with owner management, we assume that when the firm is owner managed the owner also assumes the management role and, thus, chooses production quality knowing the efficacy of the control structure. We first make this comparison in the contact of a fixed control structure that cannot be modified. We then extend the analysis and compare owner and delegated management under the assumption that firms invest in "corporate reforms" after a loss in reputation. Reform aims to increase the control structure's effectiveness, but does not always work.

Our model's conclusions are largely consistent with the stylized conclusions of the management literature. For example, replacing delegated managers who act disreputably is optimal but is never sufficient for repairing reputation. Long-term back-loaded compensation for delegated managers maximizes reputation maintenance. In fact, the optimal compensation design resembles Supplemental Executive Retirement Plans (SERPs) under which the firm provides deferred compensation funded out of firm cash flows. Like a company-funded SERPs, these payments are contingent on firm revenue and back-loaded. In some cases, like a SERP, the contracted payments are made at the end of the managers tenure. However, for some model parameters, the contracted payment is made before the end of the manager's tenure. In all cases, only one payment is made and this payment ensures reputable behavior by the manager at all dates preceding payment. Thus, under the optimal contract, managers are "bureaucrats" whose variable compensation only depends on the firm having a viable revenue stream a future date, usually close to or at the end of their tenure.

In addition to rationalizing the use of termination combined with low-powered compensation as optimal contracting mechanisms, the analysis produces a number of new insights on the ownership structure and reputation. First, somewhat surprisingly, the sort of bureaucratic delegated management which we model is not only effective for maintaining reputation, it is also sometimes more effective than entrepreneurial owner-management. Because delegating management can lead to more reputable behavior, it may increase both firm value and social welfare. Second, when organizational reform is possible, increasing the efficiency and effectiveness of reform increases the advantage of delegated management relative to owner management.

Second, we highlight the differences in the reputational tradeoffs faced by owner-managers and delegated managers. If the organizational structure is insecure, both can "harvest" short-run benefits of a good reputation by acting opportunistically at the expense of costs related to the firm's future reputation. An owner-manager who reaps these short-run benefits must also bear long-run reputational costs. A delegated manager reaps different short-run benefits from harvesting but faces the risk of being fired. These different reward structures create different incentives to protect reputation. We show that owner managers have the strongest incentive to protect reputations when the control system is unlikely to be insecure (and thus permit opportunistic behavior). In contrast, because the owner only needs to compensate a delegated manager to

maintain a firm reputation when the control system is insecure, the gains from ensuring reputation are highest under delegated management when the control system is likely to be insecure. In this case, delegated management leads to more reputable behavior and higher social value than owner management. However, assuring reputation imposes a cost on owners: increased managerial compensation. Thus, even when social value is higher under delegated management, firm value may be lower. In such cases, delegated-management firms are vulnerable to management buy outs which are socially suboptimal but firm-value maximizing.

Third, because reputation is tied to the organizational structure of the firm, we can study the possibility of reforming structure to restore reputation. We find that the effect of the option to reform varies greatly with ownership structure. Allowing reform actually lowers the ex ante incentives to behave reputably for owner-managers while improving incentives under delegated management. Thus, delegated management frequently maximizes firm value when reform is both fairly effective and not too expensive, and the future economic rents generated by the firm are modest. This result suggests that, for mature "value-firms," with modest market to book ratios, delegated management by professional managers may dominate hands-on control by owners with "skin in the game." Consequently, in environments where effective corporate reform technologies have been developed, we predict that, when firms mature and transit from growth to value, the separation of ownership and management will naturally emerge even without diversification gains or capital constraints.

The remainder of the paper is organized as follows: We describe the central features of our model in Section 2. In Section 3, we compare reputation equilibria when the firm is managed by an owner-manager with equilibria when the owner and manager are separate. In Section 4, we examine reputation formation when the owner can attempt structural reform. In Section 5 we assess the relation between the value of firm and its reputation, reform possibilities and ownership structures. We conclude the paper in Section 6 with a brief discussion and summary of our results. Proofs of all claims are presented in the Appendix.

2 Model

2.1 Assumptions

Consider an economy populated by risk-neutral agents and one firm. These agents are "patient" and do not discount future cash flows.[2] Time is indexed by a finite set of dates, $\mathscr{T} = \{0, 1, \ldots T\}$. We refer to the interval of time between adjacent dates $t-1$ and t in this index set $\mathscr{T}$ as "period t." There is no storage technology. Thus, any cash flow received in a period must be consumed in that period, and any good produced in a period must be consumed during the period.

The firm has a single owner. We focus on the case where the owner delegates operating decisions to a professional non-owner manager. To highlight the effect of separating ownership and control, we also consider the case where the firm's owner is also its manager and performs all tasks performed by the manager

[2]We have chosen to assume a zero discount rate to improve exposition. Our results are robust to changes in this assumption.

when ownership and management are separate. To maintain tractability, we assume that the incumbent and replacement managers have identical characteristics.[3]

When the owner delegates to a manager, at the start of each period in which the owner wants the firm to operate, she has to invest $\$I$ directly in assets. The owner has to give the manager additional funds to finance the firm's operations. If the owner does not want the firm to operate in the period, she does not invest or allocate operating funds. The firm does not produce output in any period in which it does not operate. In each period, the manager chooses a production technology for the period after the owner's funding decision. The production technology affects the quality of the firm's output for the period. The manager can choose between a safe technology and a risky technology. The safe technology costs $c \in (0,1)$ per period, while the per-period cost of the risky technology is 0. To simplify notation, we define e as the per-period expense the owner has to bear to allow the manager to implement the safe technology, i.e., $e = I + c$. Both technologies produce one unit of a good whose quality can be either high, h, or low, l. The safe technology always produces a high-quality good. The risky technology produces a high-quality good with probability $\delta \in (0,1)$ and low-quality good with probability $1-\delta$. In each period, all agents observe the owner's asset investment and allocation of operating funds to the manager. Only the manager observes his technology choice.

The manager may be able to divert unused operating funds for personal consumption. The amount he diverts is unobservable. The firm has a control structure that limits the manager's ability to divert funds. By limiting diversion, the control structure constrains the manager's technology choice. The control structure is either "secure," type-S, or "insecure," type-I. If the control structure is insecure, the manager can divert all the operating funds. If the control structure is secure, the manager cannot divert any funds. Therefore, if the control structure is secure and the owner supplies at least e to fund production, the manager will always choose the safe technology. The manager privately observes whether the control structure is secure. Customers and the owner do not know the control structure's type. At date 0, the beginning of the first period, both the customers and the owner share a prior belief that the control structure is type S with probability ρ_1. To improve exposition, when customers and the owner assess a high (low) probability to the control structure being secure, we capture their beliefs by referring to the control structure as robust (fragile). Thus, the owner and customers make decisions without knowing whether the firm's control structure is secure, and without observing the manager's production and diversion decisions.

Since goods cannot be stored, a good is sold in the same period that it is produced. Each good is sold to a continuum of customers through Bertrand competition. For convenience, we refer to the good produced and sold in period t as the "period t" good. The price customers pay is common knowledge as are their preferences. All customers assess a value of \$1 to a high-quality good and \$0 to a low-quality good. Customers do not know the good's quality when they purchase it. However, all agents learn the good's quality after it is purchased and thus its quality is common knowledge at the start of the subsequent period.

[3]Since the manager has to be replaced by one with identical characteristics, replacing the manager cannot be motivated by its effect on the firm's operations. Instead, the only motivation for replacing the manager is the effect it has on his ex ante incentives.

While a good's quality is observable, we assume that it is not verifiable for contracting purposes.[4] Figure 1 provides a snapshot of the timing of decisions in each period.

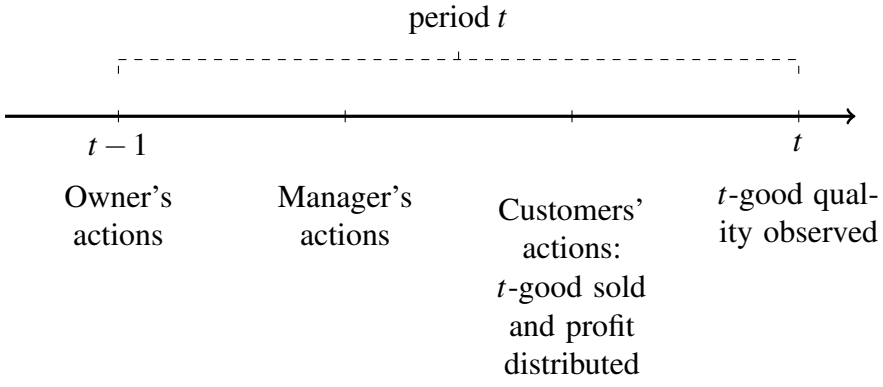


Figure 1: *Time Line*. This figure presents the sequence of actions within each time period.

The owner can offer the manager an employment contract. The owner sets the terms of the contract at the start of the game, the beginning of period 1. Contracted payments at date t depend on the revenue realized at date $t-1$ [5] We restrict our attention to contracts that specify payments which are non-decreasing in revenue. We also assume that the manager has limited liability and thus the payments are always non-negative. These restrictions are standard in the contracting literature (see, for example, Innes [1990], Nachman and Noe [1995] and DeMarzo and Duffie [1999]).[6] In summary, our compensation contracting environment is restrictive: compensation must be a non-decreasing function of past firm revenue. Directly contracting on output or net profit is not permitted. In a sense, or framework is the most restrictive contracting environment consistent with any dependence between compensation and performance.

In each period, the owner shares firm revenue with the manager according to the manager's employment contract. 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.

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

[5]We 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 Lemma 3, the owner's welfare cannot be increased by contracting payments at date t dependent on revenues realized before $t-1$. The restriction to dependence only on the previous date is simply imposed to simplify the definition of non-decreasing contracts required below.

[6]The 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 customers, 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.

Thus, the owner has all of the bargaining power in compensation negotiations.[7]

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 risky 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 customers believe that the manager will always divert operating funds and choose the risky technology under an insecure control structure, consumers will bid a sufficiently high price to ensure production in period 1 is profitable for the owner. Assumption 2 ensures that the risky technology always produces a high-quality good with positive probability, but if the control structure is revealed to be insecure, the probability of producing a high-quality good is too low for production to be profitable for the owner. It also ensures that it is suboptimal for the owner to allocate less than $e = I + c$ to the manager; if the owner allocates less than e to the manager, customers will know that the manager cannot choose the safe technology. Therefore, they will set the good's price equal to $\delta < I$. Because is pointless for the owner to provide funding in excess of e, we assume that the owner allocates precisely e to the manager if the owner chooses to fund the firm in a given period.

When the owner also manages the firm, her information set is the combination of the information sets of the owner and the manager under delegated management. Moreover, the owner chooses the production technology and decides whether to consume funds she allocated for production. Customers cannot observe the owner's technology and diversion choices. Therefore, as is the case under delegated management, customers 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 resources funds if the control structure is secure.

2.2 Solving the model

We solve for the model's Bayesian Nash equilibria using backward induction, starting in the last period, T. In these equilibria, in each period, each agent plays a best response to the other agents' expected actions. In equilibrium, each agent's expectations about the other agents' actions is correct. When possible, beliefs are updated using Bayes' rule. The manager's optimal action in each period is determined by the firm's control structure and the expected future price path for goods. The owner's optimal action in each period is based on her expectation about the good's price in the period and the manager's expected action. The customers' optimal actions are dependent on their assessment of the firm's control structure and the manager's expected action. Thus, for a given period, only the information that fixes the good's current-period price is relevant,

[7] By assuming a zero reservation wage, we ensure that all compensation paid to the manager is incentive compensation.

that is, the customers' and owner's common beliefs about the firm's control structure and their beliefs 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 structure, ρ_t, and the period in which the decision is made, t. For ease of exposition, we will refer to histories before low-quality output is observed as *unrevealed* histories. We will refer to histories after low-quality output is observed as *revealed* histories.

3 Ownership structure, firm reputation, and firm value

We first establish the effects of the separation of ownership and management on the firm's reputation. We also provide a detailed characterization of the optimal incentive contract for the manager. We then establish the conditions for reputation formation under owner management. We conclude the section by comparing the likelihood of reputation formation and firm value under delegated and owner management.

3.1 Reputation under delegated management

Incentive compensation is essential for the firm to maintain its reputation when the owner delegates to a professional manager. To see this, suppose the owner does not offer the manager incentive compensation. If the control structure is insecure, the manager can raise his payoff in a period by diverting resources. 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 resources. However, since the manager's only avenue to a higher payoff is to divert operating funds, both delaying diversion and eschewing it are suboptimal. Thus, it follows from straightforward backward induction that the owner's threat is never sufficiently strong to deter the manager from diverting. Consequently, the manager will divert resources whenever the control structure is insecure, which will jeopardize the firm's reputation in every period it operates.[8]

While incentive compensation is essential if the firm is to maintain its reputation, it cannot deter the manager from diverting in period T or once the control structure has been revealed as insecure. The reason compensation is ineffective in period T is straightforward. Since customers cannot observe the manager's technology choice, a period t good's price cannot vary with the manager's period t technology choice. Thus, the manager's technology choice in period t, including period T, cannot be influenced by a payment tied to period t's revenue. Since the firm does not operate after period T, the manager's compensation cannot be tied to revenue in any subsequent period. Moreover, incentive payments in prior periods cannot influence the manager's period T decisions.

The underlying reason why incentive compensation cannot deter the manager from diverting once the control structure has been revealed to be insecure is frequently encountered in reputation models—*unraveling*. Since the manager cannot be incentivized in period T, if customers know that the control

[8] We 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.

structure is insecure in period T, they will price the period T good as if the manager will divert. Now suppose that the control structure has been revealed as insecure before period $T-1$. Since the period T revenue is fixed, any incentive payment made in period T will not vary with the manager's period $T-1$ actions. Therefore, incentive compensation in period T will be ineffective in deterring the manager from diverting in period $T-1$. Moreover, customers will price the period $T-1$ good as if the manager will divert with certainty. Repeating this argument extends this result to earlier periods where it is known that the control structure is insecure.

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

After the firm has been revealed, the ineffectiveness of incentive compensation ensures that the firm will not operate. Because incentive compensation is ineffective, customers know that the manager will always divert if the firm operates after an insecure control structure is revealed. Given this, customers will set a price of δ for any good the firm produces in every subsequent period. By assumption (2), production is unprofitable at this price. Therefore, the owner will withhold funding in every period after the control structure has been revealed to be insecure. We formalize this result in the following lemma:

Lemma 2. *The firm will shut down after it is revealed, i.e., if the firm' control structure is revealed to be insecure, the owner will not fund the firm's operation in any subsequent period.*

As long as the control structure remains unrevealed, the owner will want to operate the firm even if she has not contracted to make incentive payments to the manager in any future period. To see this note that, if the manager does not expect future incentive payments, he will divert if the firm's control structure is insecure. When customers assess probability ρ to the control structure being secure and conjecture that the manager will divert if the control structure is insecure, the good's price will be

$$P = \rho + (1-\rho)\delta. \tag{1}$$

Note that P is also the probability that the firm will remain unrevealed until the subsequent period even if the manager diverts when the control structure is insecure. Moreover, since P is a one-to-one function of the customer's and owner's assessment of the control structure's security, ρ, it captures the same information. In the interest of clearer exposition, hereafter, we employ P to capture the history instead of ρ. Define the function $\Gamma : [\delta, 1] \to [\delta, 1]$ as follows:

$$\Gamma[p] = 1 + \delta - \frac{\delta}{p}. \tag{2}$$

By Bayes' rule, after customers observe high quality output in the current period, the good's price in the subsequent period, P', is given by $P' = \Gamma[P]$, and the next period's expected price for the good equals:

$$PP' + (1-P)\,\delta = P. \tag{3}$$

Equation (3) indicates that the current period's price equals the expected price in the next period, i.e., the 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. Because the owner can shut down production, she can limit the influence of the price decline following low-quality output on her payoff. Consequently, as we demonstrate in the next Lemma, the owner prefers to operate the firm as long the control structure has not been revealed as insecure.

Lemma 3. *If no incentive payments are contracted by the firm after period s, then the firm never shuts down if unrevealed for all* $t \in \{s, s+1, \ldots T\}$.

Since incentive payments are ineffective once the firm is revealed, they will only be contracted for histories where the firm is unrevealed. Moreover, since the firm will operate in every period so long as it remains unrevealed, each history of the game where the firm is unrevealed is preceded by a single sequence of revenues. Therefore, without loss of generality, we can assume that incentive payments contracted by the owner are simply fixed payments conditioned on reaching a given unrevealed history.

Let $v_M(t)$ represent the manager's value function when the firm has not been revealed up to period t, i.e., up until period t the firm has never produced low-quality output. Let $b(t) \geq 0$ represent the payment to the manager in period t if the firm is unrevealed up to period t. Then:

$$v_M(t) = b(t) + \max\left(v_M(t+1), \delta\, v_M(t+1) + c\right). \tag{4}$$

The first term in the maximum expression on the right hand side of equation (4) reflects the manager's payoff from choosing the safe technology in period t. The second term reflects the manager's gain from diverting, c, and choosing the risky technology as well as the resulting reduced probability of continuation as an unrevealed firm. Since:

$$v_M(t) = b(t) + \max\left(v_M(t+1), \delta\, v_M(t+1) + c\right) \geq \max\left(v_M(t+1), \delta\, v_M(t+1) + c\right) \geq v_M(t+1), \tag{5}$$

$v_M(t)$ is weakly decreasing in t. $v_M(t)$ declines with each passing period because the manager has fewer periods in which he can expect to receive a payoff before the terminal period, T.

From expression (4) it is clear that the manager will choose the safe technology in period t if and only if $(1-\delta)\, v_M(t+1) \geq c$, and will choose the risky technology if and only if $(1-\delta)\, v_M(t+1) < c$. If the manager chooses the risky technology in period t, he will always choose the risky technology in subsequent periods because $v_M(t)$ is weakly decreasing in t. That is, the set of periods at which the manager chooses the risky technology is an upward directed order interval. This set is not empty since it always contains $t = T$. Let t^+ denote the last period in which the manager chooses the safe technology. For ease of exposition we refer to t^+ as the *reputation cutoff period*. Note that, by Lemma 1, $t^+ < T$. We interpret $t^+ = 0$ as representing the case where the manager always chooses the risky technology.

Each vector of contracted incentive payments at unrevealed histories $b = (b(2), b(3), \ldots b(T))$ generates a reputation cutoff period $t^+(b)$. The following two lemmas establish that the optimal incentive contract

always concentrates all incentive payments one period after the reputation cutoff period, i.e., in period $t^+(b)+1$. The manager receives no incentive payment other than in period $t^+(b)+1$. The first of the two lemmas establishes that the manager will not receive any incentive payments after period $t^+(b)+1$ under the optimal contract. The intuition is straightforward. Since the manager chooses the risky technology in every period subsequent to $t^+(b)+1$, incentive payments after period $t^+(b)+1$ are wasted and thus it is optimal for the owner to eliminate these payments.

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

The next lemma demonstrates that it is not optimal for the owner to make incentive payments before $t^+(b)+1$. Once again, the intuition is straightforward. As we have previously argued, an incentive payment in period t has no effect on the manager's incentives in period t itself or in subsequent periods. However, deferring the incentive payment by a period improves the manager's incentives for one more period. Thus, by concentrating all payments at $t^+(b)+1$ the owner effectively defers all incentive payments and maximizes the effectiveness of the incentive compensation.

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

Together, Lemma 1 through Lemma 5 enable us to characterize the optimal employment contract and the manager's optimal technology choices. We collect these results in the following proposition. An optimal contract allows for only one incentive payment to the manager in period $t^+ + 1$. This payment is made conditional on the firm remaining unrevealed until period $t^+ + 1$. The manager does not divert in any prior period, i.e., $t \leq t^+$, and diverts in all periods starting with period $t^+ + 1$ in which he is paid. We define the optimal compensation policy in which the owner contracts to make the incentive payment in period $t^+ + 1$ as a t^+-policy. When $t^+ = 0$, the policy induces the manager to divert in every period t. Clearly, when $t^+ = 0$ it is optimal to set $b(t) = 0$ in all periods.

Proposition 1. *The optimal employment contract always specifies a single incentive payment to the manager in period $t^+(b)+1$, where $t^+(b) \in \{1, 3 \ldots T-1\}$. When the control structure is insecure, the manager never diverts on or before $t^+(b)$ and always diverts after $t^+(b)$.*

Next we determine the level of the single compensation payment identified in Proposition 1. Note that we are determining the ex ante optimal policy so expectations are taken relative to the beginning of period 1. Given Proposition 1, determining the optimal t^+-policy is simple. Subsequent to period $t^+ + 1$, the manager's only payoff results from diversion. In earlier 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 under a t^+-policy is given by:

$$v_M(t) = \begin{cases} b(t+1) + \frac{c\left(1-\delta^{T-t^+}\right)}{1-\delta} & \text{if } t \leq t^+ + 1 \\ \frac{c\left(1-\delta^{T-(t-1)}\right)}{1-\delta} & \text{if } t > t^+ + 1. \end{cases} \tag{6}$$

To ensure that the manager does not divert in period t^+, $b(t+1)$ must be set to satisfy the incentive condition, $(1-\delta)\,v_M(t^+ + 1) \geq c$. Clearly, to maximize the owner's value, this constraint must bind. Using (6) to solve $(1-\delta)\,v_M(t^+ + 1) = c$ gives the optimal payment at $t^+ + 1$. We denote this payment by $b^*[t^+](t^+ + 1)$. Then:

$$b^*[t^+](t^+ + 1) = \frac{c\,\delta^{T-t^+}}{1-\delta}. \tag{7}$$

From Lemmas 4 and 5, it follows that $b^*[t^+](t) = 0$ if $t \neq t^+ + 1$. Equation (7) implies that the cost of reputation-assuring compensation increases with δ. Since δ captures the noisiness of output quality under the risky technology, a higher δ implies that an opportunistic manager can expect to remain undetected longer and thus enjoy a longer expected run of profitable diversion. The optimal incentive payment is also increasing in t^+. The reason is clear. If the control structure is revealed insecure, the firm cannot operate in future periods, which denies the manager the opportunity for future diversion. Current diversion raises the chance of revealing an insecure control structure. Therefore, the manager faces an opportunity cost when he diverts. This cost falls with each passing period and the incentive payments have to rise to compensate for the this fall. Evaluating the manager's continuation value when the firm is insecure at the optimal t^+ policy, which we represent by $v_M[t^+](\cdot)$, yields:

$$v_M[t^+](\cdot) = \begin{cases} \frac{c}{1-\delta} & \text{if } t \leq t^+ + 1 \\ \frac{c\left(1-\delta^{T-(t-1)}\right)}{1-\delta} & \text{if } t > t^+ + 1. \end{cases} \tag{8}$$

To identify the optimal payment period, consider the consequence of "t^+-shifts": incrementing 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. First consider the change in the manager's compensation. Because the single incentive payment is always made under the manager's induced response, the change in expected compensation is simply the difference in total contingent compensation under $b^*[t^+]$ and $b^*[t^+ + 1]$. This difference is given by

$$c\,\delta^{(T-t^+)-1}. \tag{9}$$

Thus, to increase the number of periods over which the manager does not divert, the owner must bear a higher compensation cost. This results from the manager's falling opportunity cost of diversion as time passes. Expression (9) also implies that the incremental cost of incentivizing the manager falls with T, the owner's horizon. This results from the higher opportunity cost of diversion for the manager as the horizon T increases.

Now consider the effect of a t^+-shift on the revenue stream. For ease of exposition, we will use the term *gross firm profit* to refer to the total cash inflow to the owner in a specific period gross of any incentive payment to the manager in the period. We will use the term *gross firm value* to refer to the value of the owner's claim gross of any payments to the manager. Under both the t^+ and $t^+ + 1$ policies the manager will not divert when $t \leq t^+$. Thus, for $t \leq t^+$, under both policies, the good's price in each period equals 1 and the owner's gross profit under both policies is $1 - e$. Since the manager diverts in all periods after t^+

and does not divert in any period before t^+ under the t^+-policy, the good's price under the t^+-policy is given by $P[t^+](\cdot)$, where:

$$P[t^+](t) = \begin{cases} 1 & t \leq t^+ \\ \Gamma^{(t-(t^++1))}(P_1) & t > t^+ \end{cases}, \tag{10}$$

$P_1 = \rho_1 + \delta(1-\rho_1)$, and $\Gamma^{(n)}$ is defined as:

$$\Gamma^{(n)}(p) = \frac{(p-\delta)+(1-p)\delta^{t+1}}{(p-\delta)+(1-p)\delta^t}. \tag{11}$$

Note that $\Gamma^{(n)}$ is the n-fold composition of the Bayes' operator defined in equation (2). It represents the expected probability that the good's quality is high in the current period given the probability of a high-quality good in the previous period if the manager diverts when the control structure is insecure. Following a t^+-shift, the good's price, and thus the owner's gross profit, will follow the process described by (10) and (11) with a one period delay. Thus, the change in gross firm value caused by the t^+-shift is given by:

$$\begin{aligned} 1-e-&\left[\frac{(P_1-\delta)(1-e)-(1-P_1)(e-\delta)\delta^{T-t^+-1}}{1-\delta}\right] \\ &= \frac{(1-P_1)(1-e)+(1-P_1)(e-\delta)\delta^{T-t^+-1}}{1-\delta} > 0. \end{aligned} \tag{12}$$

Consequently, gross firm value increases with the t^+-shift. The amount of the increase rises with the owner's 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 by (9)) and its effect on gross firm value (given by (12)). It is:

$$\frac{(1-P_1)(1-e)+((1-P_1)(e-\delta)-c)\delta^{T-t^+-1}}{1-\delta}. \tag{13}$$

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. If so, the cost of compensating the manager to prevent diversion in every period is lower than the resulting increase in gross profit. Therefore, when the firm's initial reputation is sufficiently low, the owner defers compensation until period T, ensuring no diversion through period $T-1$. In contrast, expression (13) is negative for values of t^+ approaching T when P_1 approaches one. Thus, when the firm's initial reputation is sufficiently high, the cost of deferring the incentive payment becomes prohibitively high close to period T. Thus, the owner will make the manager's incentive payment before period T, meaning that the manager will divert in at least one period. Expression (13) also implies that the cost of incentivizing the manager falls as the owner's horizon, T, increases. 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 2. *Reputation formation under delegated management has the following characteristics:*

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

$$P_1 < 1 - \frac{c\,\delta}{1-e+\delta}, \tag{14}$$

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 structure is insecure, the manager will not divert in any period before T.

(ii) Whenever initial firm reputation is sufficiently high, the owner will never offer the manager a bonus payment conditioned on remaining unrevealed by period T and, when the structure 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 until at least period 1.

This analysis of firm reputation under delegated management provides three primary insights. First, a firm can maintain its reputation even when its ownership and management are separate. Second, when a firm's control structure is fragile, it is optimal for the firm's owner to bear the cost of incentive payments to reassure customers about the quality of the firm's products. In contrast, when the control structure is robust, it is optimal for the owner to eschew incentive compensation, and instead rely on the control structure to maintain product quality. The longer the owner's horizon, the greater the likelihood that she will pay the manager incentive compensation to maintain product quality.

3.2 Reputation under owner management

To explore the implications of unifying firm ownership and management, we assume the owner 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 the switch to owner management alters the incentive to maintain the firm's reputation.

First consider the owner-manager's technology choice in period T. The good's price will reflect customers' beliefs regarding the firm's control structure and the owner-manager's technology choice conditional on an insecure control structure. Since the technology choice itself is unobservable, it cannot affect the good's price. Moreover, since the firm cannot produce in the future, the technology choice does not have any reputational consequences. The absence of reputational consequences means that, in equilibrium, the owner-manager will always choose the risky technology to maximize period T profit if the control structure is insecure. The owner-manager's technology choices also nave no reputational implications once the firm's control structure is revealed as insecure. As a result, the owner will choose the risky technology in every period after the firm is revealed. Recognizing the owner's incentives, customers will set a price that will make production unprofitable and the owner will halt production.

Lemma 6. *Every equilibrium under owner management has the following characteristics:*

(i) If the control structure is insecure, the owner will choose the risky technology in period T.

(ii) Once it is common knowledge that the firm is insecure, the firm will cease production and the owner's payoff will equal 0 in all future periods.

Before period T, the reputational benefits can be strong enough that the owner-manager always picks the safe technology. To see this, consider the owner's choice in period $T-1$ when (1) consumers expect a high-quality good in the period, (2) the firm is not revealed as insecure, and (3) the control structure is actually insecure. The owner's expected payoff from choosing the safe technology in period $T-1$ equals $1-e+P(t)-I$. If she chooses the risky technology instead, the firm's organizational structure will be revealed insecure with probability $1-\delta$. In this event, the firm will shut down in the final period (see Lemma 6). Therefore, the owner-manager's expected payoff from choosing the risky technology in period $T-1$ is $1-e+\delta(P(t)-I)+c$. It follows that the owner will choose the safe technology in period $T-1$ if and only if:

$$(1-\delta)(P(t)-I) \geq c. \tag{15}$$

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 safe technology in period $T-1$ whenever the firm's initial reputation P_1 is sufficiently high.

In expression (15), $(1-\delta)(P(t)-I)$ represents the owner's opportunity cost of selecting the risky technology 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 choosing the risky technology in a given period remains fixed at c. Thus, if the owner finds it profitable to eschew the risky technology in a period, she will also find this optimal in every prior period. Consequently, when the firm's initial reputation is high enough to satisfy condition (15), the owner-manager will eschew the risky technology in every period until period T. That is, when the firm's control structure is robust, there exist only reputation equilibria. Moreover, since the owner's opportunity cost of choosing the risky technology rises along with the remaining horizon, successively weaker conditions on the firm's reputation ensure that the owner-manager will eschew the risky technology in earlier periods.

Proposition 3. *Under owner management,*

(i) At any date t, the firm will produce high quality whenever

$$c \leq (P(t)-I)\left(1-\delta^{T-t}\right). \tag{16}$$

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

$$\frac{c}{1-\delta} < (P_1 - I). \tag{17}$$

(iii) If

$$\frac{c}{1-\delta} \geq \max_{s=\{0,1,\ldots T-t\}} (1-I-c)s + \frac{(1-I)\left(1-\delta^{T-t-s}\right)}{1-\delta} \tag{18}$$

then, at date t, the firm produces low quality.

Proposition 3 demonstrates that owner-managed firms can maintain reputations. Owner-managed firms are likely to do so when their control structures are robust. These firms are also more likely to ensure product quality when their owners' horizons are long.

3.3 Reputation formation

Proposition 2 demonstrated that an owner who delegates will pay incentive compensation to protect the firm's reputation when her firm's control structure is fragile. When the control structure is robust, incentive compensation is no longer optimal. This will jeopardize the firm's reputation. In contrast, Proposition 3 demonstrates that an owner-managed firm protects its reputation when its control structure is robust. Thus, a fragile control structure means a firm will maintain its reputation only if it delegates management. When the control structure is robust, only owner management can ensure the firm will maintain it reputation.

Corollary 1. *(i) If P_1 is sufficiently small, i.e., if*

$$P_1 < \min\left[\frac{e(1-\delta)+c\,\delta}{1-\delta}, 1-\frac{c(1-\delta)}{e-\delta}\right], \tag{19}$$

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

(ii) If P_1 is sufficiently large, then owner management supports reputation equilibria and delegated management does not.

What drives the effect of management structure on reputation formation? Suppose that the firm's control structure is fragile. The owner manager's decision problem is one of optimal harvesting. If she harvests the profits from reputation in the current period by opportunistically selecting the risky technology, she may reveal the firm's control structure as insecure. This would eliminate future gains accruing from the reputation. Since customers believe that the firm's control structure is relatively insecure, the future gains from reputation are small relative to the current gain from opportunism. Thus, the owner manager is unlikely to maintain the firm's reputation. Under delegated management the owner cannot capture the gains from opportunism because she has to maintain funding at the level necessary for the safe technology to be able to sell any goods. The only option the owner has to boost her payoff is to compensate the manager to ensure the firm's reputation. Because the owner does not know whether the control structure is secure, she has to pay this compensation even when the control structure is actually secure and the compensation is irrelevant. With a fragile control structure, the compensation is relatively small but effectively guarantees product quality. Thus, the owner will be willing to pay to guarantee the firm's reputation.

This reverses under a robust control structure. 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. On the other hand, the firm's control structure alone is likely to be effective making it likely the

compensation is unneeded. Thus, the owner will avoid using incentive compensation and risk the firm's reputation instead.

Management structure changes also impact firm value. This impact depends how customers perceive the firm's control structure. Suppose customers believe that the control structure 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 the owner finds a period T incentive payment to be optimal, the firm will earn the same expected profits through period $T-1$. In period T it will earn a lower profit because the manager must be paid. Thus, firm value is lower under delegated management when the firm's reputation is ensured under both owner and delegated management. Firm value under delegated management is also lower when the incentive payment is made in period t where $t < T$. 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 has to be made under owner management, (2) the firm's revenues in periods subsequent to $t+1$ are never lower than under delegated management, and (3) under owner management the owner does not have to contribute c towards the firm's operating expenses in every period that diversion occurs.

When customers believe that the control structure 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 structure is fragile, a switch to delegated management can both improve product quality and increase firm value.

Proposition 4. *The relation between ownership structure and firm value satisfies the following characterizations:*

(i) If owner management supports reputation formation, i.e., (17) *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 indicates that firm reputation can be preserved under both owner management and delegated management. However, owner management best ensures reputable behavior when the control structure is robust. In contrast, delegated management best ensures reputable behavior when the control structure is fragile. Consequently, a firm with a strong reputation can enhance its value by switching to owner management, while a firm with a weak reputation can sometimes raise its value by delegating management to a professional. Value will increase if increased revenue generated by the increased probability of reputable behavior more than offsets the rents captured by the professional manager.

4 The effect of reform on reputable behavior

Firms often reform their control structures to repair damaged reputations. Attempts at reform are widely advertised and include revising board and management responsibilities, changing reporting channels and responsibilities within the firm, changing firm culture, changing accounting and reporting procedures, and other aspects of control structures. Thus, to align our model more closely with reality, we introduce reform into our model. We preserve the most salient features of real world reform. Specifically, we assume that reform is costly and publicly observable, and its success is uncertain. We examine how these changes affect firm reputation and value.

Introducing reform complicates the analysis. Moreover, we 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 and these mixed strategies vary across periods. Characterizing mixed-strategy equilibria for an arbitrary number of periods is awkward. Therefore, we simplify our model by focusing on the case where the firm operates only over two periods, period 1 and period T.

In period 1 under delegated management, the owner decides whether to offer incentive compensation. If the control structure allows it, the manager will always divert resources in period T. The interesting compensation question is whether to compensate the manager in period T to deter diversion in period 1. Thus, we only focus on employment contracts that pay the manager in period T. If period 1 reveals an insecure control structure, the owner can also reform the control structure before period T. Without reform, Lemma 2 implies the firm will not operate. Reform transforms an insecure control structure into a secure structure with probability $r \in (0,1)$. Reform costs the owner $\$R$ in addition to the costs of investment and the firm's operations. Only the manager observes whether reform succeeds. Therefore, the owner and customers believe that the post-reform control structure is secure with the commonly known probability r.

If reform is unsuccessful, the manager will always divert in period T since incentive compensation is ineffective in period T. Therefore, following reform, customers and the owner will believe that the period T good is high quality with probability $r+(1-r)\delta$. Let P_r represent the good's price following reform in period T. It follows that $P_r = r+(1-r)\delta$. We assume that period T reform is profitable, i.e.,

$$P_r - I - c - R > 0. \tag{20}$$

4.1 Reform and employment policy

With or without the possibility of reform, there is no reason to replace the manager so long as the firm produces high quality goods and remains unrevealed. Without the possibility of reform, the firm ceases operations once its control structure is revealed as insecure. The manager's employment with the firm is, in effect, terminated once the firm is revealed. Thus, 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, the firm can continue operating after being revealed by attempting reform. Consequently, the owner must choose between retaining the incumbent manager and replacing him after the firm is revealed.

Suppose the owner retains the manager following reform. If reform fails, the manager will divert in period T and earn a period T payoff of c plus any contracted incentive payment contingent on revenue 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 along 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 7. *A professional manager will be terminated if the owner chooses to reform the firm's control structure.*

Lemma 7 demonstrates that, once a firm's reputation is threatened by a manager's actions, it is optimal to replace him. 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 allows the group to repair its reputation by bringing more reputable agents into the group. In our model, the incumbent and replacement managers are identical in characteristics and incentives. Replacement acts only as a penalty for deviant behavior, which maximizes the manager's ex ante incentives to eschew diversion.

4.2 Reform vitiates incentive compatibility

Absent a reform option, incentive compensation is only effective in supporting the firm's reputation because it ensures that the manager's payoff varies with the firm's reputation. To see this suppose the manager is offered a period T incentive payment. If the firm produces a low quality period 1 good, the owner will shut down the firm in period T and the manager will not receive the incentive payment. In contrast, if the firm remains unrevealed in period 1, the manager receives the incentive payment in period T. Thus, the manager's expected payoff falls along with firm revenue, tying the manager's payoff to his actions.

Designing incentive compensation is more complex with reform. Now the design has to account for the effect of reform on firm revenue. In a reputation equilibrium, the optimal contract implies the manager receives a single period T payment if the firm is unrevealed in period 1. Since consumers do not learn anything about the firm in period 1, the good's price in period T must be P_1. Thus, the manager must be paid if the period T good's price is at least P_1. The owner's option to reform can render this compensation design ineffective. To see this suppose the firm produces a low-quality good in period 1 revealing the control structure as insecure. The firm will only produce in period T if it reforms. Following reform, the period T good's price will be P_r. Following production of a high-quality good in period 1, the period T good's price will be P_1. It follows that, if reform is highly effective such that $r \geq \rho_1$, the firm's period T revenue will be higher if the firm produces low-quality output in period 1. Since the manager's contractual payment is non-decreasing in firm revenue, the manager's 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 5. *When the likelihood the reform will succeed, r, is sufficiently high, i.e.,*

$$P_r \geq P_1, \tag{21}$$

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

4.3 When is paying incentive compensation optimal?

When the condition presented in Proposition 5 is not satisfied, 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 will be paid only if the period T price at least equals P_1. The manager will be replaced and will not receive an incentive payment after reform to maximize his opportunity cost of diversion. We now characterize the optimal incentive contract when reform is possible.

Consider a period T incentive payment of b_T. The payment $b_T > 0$ if $P(T) \geq P_1$ and $b_T = 0$ if $P(T) < P_1$. If the manager chooses the safe technology in period 1 and diverts in period T, his expected payoff equals:

$$b_T + c. \tag{22}$$

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 to diverting in period 1 is:

$$c + \delta(b_T + c). \tag{23}$$

The optimal incentive payment, $b^*(T)$, is the payment that leaves the manager indifferent to diversion and is obtained by equating expressions (23) and (22), i.e.,

$$b_T^* = \frac{c\,\delta}{1-\delta}. \tag{24}$$

If the owner offers the manager a period T incentive payment equal to b_T^*, the manager will choose the safe technology in period 1 and will divert in period T if and only if the control structure is insecure. Thus, the owner's expected payoff is:

$$1 - c - I + P_1 - I - c - b_T^*. \tag{25}$$

If instead, the owner does not offer incentive compensation, the manager will divert in period 1 if the structure is insecure. If diversion results in the production of a low-quality good, the owner will reform and terminate the manager in period T. If the firm produces a high-quality good despite the manager's diversion, customers use Bayes' Rule to update the probability that the structure is secure. It follows that the owner's expected payoff if she does not offer the manager a bonus contract in period $T-1$ is given by:

$$P_1 - I - c + (1-P_1)(P_r - I - c - R) + P_1\left(\Gamma(P_1) - I - c\right). \tag{26}$$

The owner will find incentive compensation optimal when her payoff from using incentive compensation, given by expression (25), is greater than her payoff from not paying incentive compensation, given by expression (26). This will be the case when the prior assessment of the control structure's security, P_1, is relatively low. Since the cost of incentive compensation rises with the funds the manager can divert, c, 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 6. *If*

$$P_r < P_1 < 1 - \frac{c\delta}{(1-\delta)(1+\delta-(P_r-R))}, \tag{27}$$

then the owner will offer an incentive payment in period T, and the firm will use the safe technology and produce high-quality goods in period 1 with certainty. 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 (27) indicates that an increase in the effectiveness of reform, P_r, or a fall in its cost, R, lowers the likelihood that a firm with delegated management will attempt to protect its reputation via incentive compensation. The intuition is straightforward. More effective and less costly reform options decrease the owner's expected loss from managerial diversion. Therefore, the owner is less willing to pay the manager the rents needed to implement effective incentive contracting.

Figure 2 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 structure, 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 6. In the region labeled **Comp NotOpt**, condition (27) is violated; the higher prior assessment of the firm's control structure 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 5, 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.

4.4 Ownership structure, reputation and reform

Clearly the option to reform limits reputation equilibria under delegated management. Reform may also limit reputation equilibria under owner management. For this reason, it is no longer clear whether delegated management and owner management still support reputation equilibria for different sets of parameter values. Next, we ask whether our earlier result on the difference in management structure on reputation survives introducing reform.

Note that, in a reputation equilibrium, the good's price will equal 1 in period 1. If the period 1 good is high quality, the period T price will equal P_1. Otherwise, the owner will reform and the period T good's

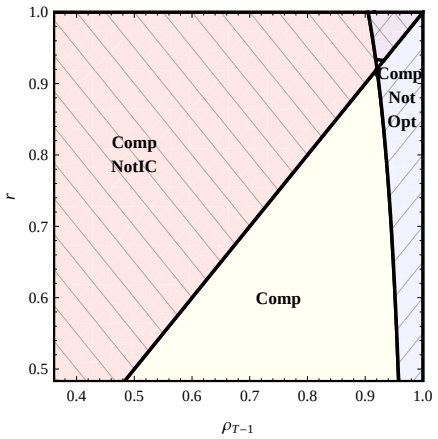


Figure 2: *Incentive compensation and the option to reform.* In the figure, the region in which incentive employment contracts do not exist is shaded, hatched and labeled "Comp NotIC"; the region in which incentive compatible employment contracts exist but are not optimal is shaded, hatched in the opposite direction, and labeled "Comp NotOpt"; the region were incentive compensation will be used by the owner is shaded, unhatched, and labeled "Comp." The horizontal axis in the graph represents the $T-1$ probability that the structure is secure, ρ_{T-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 $R = 0.20$, $I = 0.2$, $c = 0.16$, $\delta = 0.15$

price will equal P_r. When the control structure is insecure, the owner-manager always chooses the risky technology in period T. Thus, choosing the safe technology in period 1 yields an expected payoff of:

$$1 - c - I + P_1 - I. \tag{28}$$

If she chooses the risky technology instead, her expected payoff equals:

$$\begin{aligned} 1 - I + \delta\,(P_1 - I) + (1-\delta)\Big(r(P_r - I - c) + (1-r)(P_r - I) - R\Big) \\ = 1 - I + \delta\,(P_1 - I) + (1-\delta)\Big(P_r - I - R - rc\Big). \end{aligned} \tag{29}$$

The owner will prefer the safe technology when it generates a higher expected payoff than the risky technology. This gives the following necessary and sufficient condition for the existence of reputation equilibria under owner management.

Proposition 7. *The necessary and sufficient condition for a reputation equilibrium when the firm is controlled by an owner-manager is*

$$(1-\delta)(P_1 - I) \geq c + (1-\delta)(P_r - I - R - rc). \tag{30}$$

Condition (30) demonstrates that a robust control structure will lead to reputation equilibria under owner management even following the introduction of the reform option. The right hand side of the reputation

equilibrium existence condition (30) is increasing in the effectiveness of reform r and decreasing in its cost R. Thus, as with delegated management, increased effectiveness of reform 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 6: the ability to reform lowers the cost of reputation loss and thus encourages opportunistic behavior. Raising the profitability of reform provides even greater encouragement for 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 6 and 7 combined show the effect of ownership structure on reputation equilibria. Figure 3 illustrates the effect. Consistent with Propositions 2 and 3 (with no reform option), owner management supports reputation equilibria when the control structure is robust while delegated management supports reputation equilibria when the control structure 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.

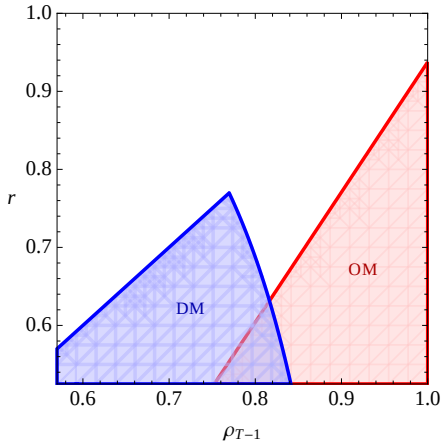


Figure 3: *The option to reform and reputation equilibria under different ownership structures.* In this figure, we illustrate parameter regions that support reputation equilibria under the two alternative ownership structures we consider. The blue shaded region, labeled "DM," represents parameter values supporting reputation equilibria when ownership and management have been separated, and the red region, labeled "OM," represents reputation equilibria when they are combined. The purple 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 $R = 0.05$.

5 Ownership structure, reform and value of control structures

Thus far, we have assumed that the effectiveness of both the firm's control structure and of reform are exogenous. In reality, firms can influence both these characteristics. To specify a complete model of the endogenous determination of control structures, we have to specify cost functions for the integrity of control structures and the effectiveness of reform. Any results we obtain from such an exercise will be highly

dependent on the specific cost functions we choose. Because there is scant evidence on what these functions should be, we opt for a more modest approach: We simply determine the marginal value of the control structure under each ownership regime. We leave specifying the cost of control structure and reform, optimization and objective value determination to future research.

Since changes in control structures will change the nature of the equilibrium solution under both delegated and owner management, we need to characterize equilibrium behavior under all parameterization of our model. We have already fully characterized the firm's value under delegated management. However, thus far we have only considered reputation equilibria under owner management. To examine the marginal value of the control structure and reform under owner management, we now complete our characterization of equilibrium solutions under this firm ownership structure.

5.1 Other equilibrium outcomes with an owner manager

When the prior probability of a secure control structure is not high enough to support reputation equilibria (i.e., it is too fragile), there exist two alternative types of equilibria in which the owner manager either (1) randomizes between picking the high- and low-quality technologies or (2) diverts with probability one. We call the first equilibrium type a "mixed equilibrium" and the second type a "cheating equilibrium."

5.1.1 Mixed equilibrium

First consider a mixed equilibrium. Suppose the owner-manager diverts with probability η when the control structure is insecure. She will be willing to randomize only when her expected payoff from picking the safe technology and diverting are equal. The owner's expected payoff from picking the safe technology equals:

$$P_1^* - e + P_T^* - I, \tag{31}$$

where P_1^* and P_T^* are the equilibrium prices in periods 1 and T, respectively. The owner's expected payoff from diverting and picking the risky technology equals:

$$P_1^* - I + \delta\,(P_T^* - I) + (1-\delta)(P_r - I - R - r\,c). \tag{32}$$

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

$$P_T^* = \frac{\rho_1}{P_1^*} + \left(1 - \frac{\rho_1}{P_1^*}\right)\delta. \tag{33}$$

Equating the two expected payoffs, (31) and (32), and using (33), we obtain the following equilibrium prices:

$$P_1^* = \frac{(1-\delta)^2\rho_1}{(1-\delta)(P_r - R - \delta) + c(1-(1-\delta))r}, \quad P_T^* = P_r - R + \frac{c(1-(1-\delta)r)}{1-\delta}. \tag{34}$$

Since the owner's expected payoff is the same regardless of her technology choice in period $T-1$, when computing the firm's value we can assume that the owner chooses the safe technology. Therefore, firm value in the mixed equilibrium is given by:

$$\rho_1 \left(P_1^* - e + P_T^* - e\right) + (1-\rho_1)\left((P_1^* - e) + (P_T^* - I)\right) = P_1^* + P_T^* - 2e + (1-\rho_1)c. \tag{35}$$

5.1.2 Cheating equilibrium

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 $\Gamma(P_1)$. Therefore, firm value in the cheating equilibria is given by:

$$\rho_1 \left(P_1 - e + \Gamma(P_1) - e\right) + (1-\rho_1)\Big(P_1 - I + \delta\left(\Gamma(P_1) - I\right) + (1-\delta)(P_r - I - R - rc)\Big) \tag{36}$$

The cheating equilibrium exists if and only if diversion is optimal in period 1 given the equilibrium price P_1, i.e.,

$$P_r - R - rc \geq 1 + \delta - \frac{\delta}{P_1} - \frac{c}{1-\delta}. \tag{37}$$

Condition (37) implies that cheating equilibria will exist when reform is extremely effective which minimizes the gain from maintaining a reputation. Mixed equilibria arise when neither condition (37) nor condition (30) from Proposition 7 hold.

5.2 Reform and the marginal value of control structures

Regardless of the equilibrium, the firm always chooses the risky technology when its control structure is insecure in period T. However, producing a high-quality good is first best. Therefore, a stronger control structure increases the firm's period T gross profit by increasing the likelihood that the firm will adopt the safe technology in period T. Consequently, a stronger control structure raises firm value in period T.

How strengthening the control structure affects overall firm value depends on the firm's equilibrium behavior. In a reputation equilibrium, regardless of the strength of its control structure, the firm produces a high-quality good in period 1. Consequently, varying control structure strength only affects firm value through its effect on the firm's period T profit. In any other equilibrium, the risky technology is used with positive probability in period 1 when the firm's control structure is insecure. By increasing the likelihood that the firm will adopt the first-best technology, strengthening the control structure increases the firm's period 1 gross profit. This implies that the marginal value of strengthening the control structure is highest when the firm is not in a reputation equilibrium and sometimes behaves opportunistically in period 1.

Overall, strengthening the control structure raises the firm's value regardless of its equilibrium behavior. This is true under both owner management and delegated management. Figure 4 illustrates the positive marginal value of strengthening the control structure under both management structures. The figure also

illustrates the effect of management structure. An owner-managed firm is likely to be in a reputation equilibrium only when the control structure is robust. In contrast, a firm with delegated management is likely to be in a reputation equilibrium only when its control structure is fragile. Therefore, under owner management, the marginal value of increasing the strength of the control structure is highest when the firm's control structure is fragile while, under delegated management, the marginal value is highest when the firm's control structure is robust.

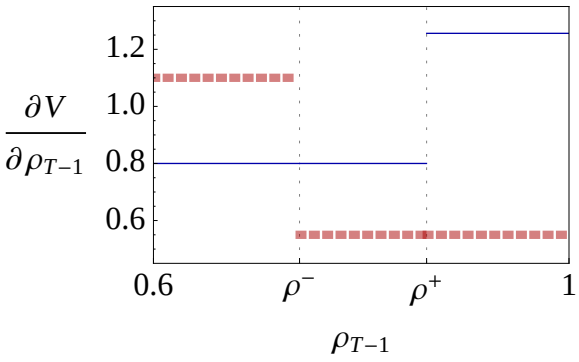


Figure 4: *The marginal value of strengthening the control structure.* On the horizontal axis, we plot the initial quality of the control structure, ρ_{T-1}. On the vertical axis, we plot the marginal effect of a change in the initial quality of the control structure on firm value, $\partial V/\partial \rho_{T-1}$. In the figure, the following parameters are fixed: $R = 0.05$, $I = 0.25$, $c = 0.32$, $\delta = 0.20$. The thick red dashed line represents the marginal value under owner management and the blue line represents the marginal value under delegated management. Under owner management, if the quality of the control structure at $T-1$, satisfies $\rho_{T-1} < \rho^-$, the owner plays a mixed strategy randomizing between high and risky technology at $T-1$; for $\rho_{T-1} > \rho^-$ the owner always selects the safe technology. Under delegated management, if $\rho_{T-1} < \rho^+$, the owner offers the manager incentive compensation to deter diversion at $T-1$; if $\rho_{T-1} > \rho^+$, the owner pays no incentive compensation and thus the manager diverts when the control structure is insecure.

As with the control structure, the marginal value of increasing the effectiveness of reform, r, varies with the firm's equilibrium behavior. Reform only occurs in period T and only after the firm produces a low-quality good in period 1. In a reputation equilibrium, there is no reform because the control structure is never revealed insecure before the final period T. Hence, the marginal value of the increasing reform effectiveness is zero. In other equilibria, the firm will produce a low quality period 1 good with positive probability. This reveals an insecure control structure. Period T reform is optimal in these instances. Increasing the reform effectiveness will increase the price in period T. Therefore, enhancing the effectiveness of reform will affect the firm's value in any non-reputational equilibrium. The direction of this effect will depend on the firm's ownership structure.

When the firm is owner managed, reform weakens the owner's incentive to produce a high-quality good in period 1 by reducing her expected cost from opportunistically choosing the risky technology. Recognizing the owner's weakened incentives, customers lower the period 1 good's price. Since the safe technology is first best, this period 1 good's price drop more than offsets the cost savings from adopting the risky

technology and can lower firm value. The effect of increasing reform's effectiveness is very different when the owner delegates management. Reform is useful only when the manager picks the risky technology in period 1. He always does unless offered a period T incentive payment. Thus, reform is only useful when the manager is committed to the risky technology, and the manager's behavior is not affected by the increased effectiveness of reform. The only effect of increasing the effectiveness of reform is to raise the period T good's price and thus firm value.

As demonstrated previously, an owner-manager plays a reputation equilibria only when the control structure is robust, while a non-owner manager plays a reputation equilibrium only when the control structure is fragile. Therefore, 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. These results are illustrated in Figure 5.

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.

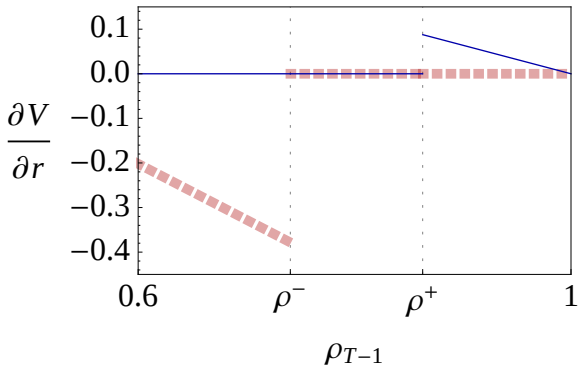


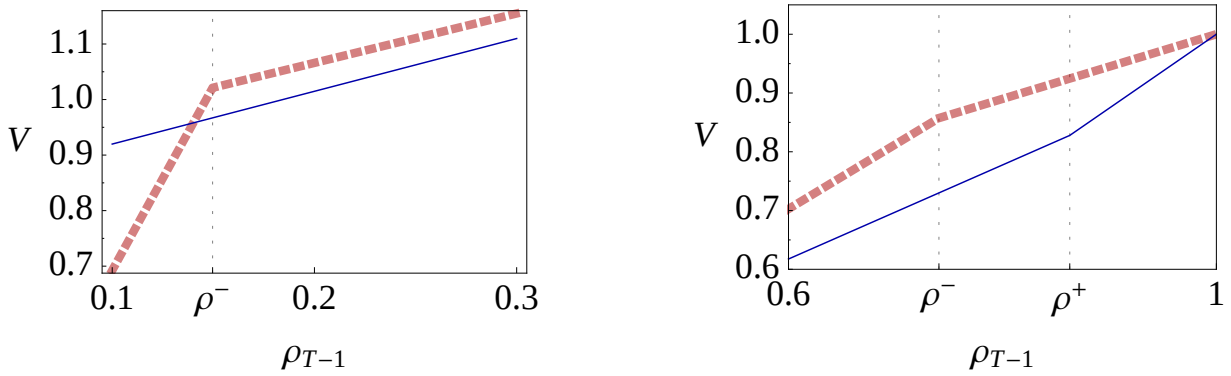
Figure 5: *The marginal value of reform.* On the horizontal axis we plot the initial quality of the control structure, ρ_{T-1}. On the vertical axis, we plot the marginal effect of the changes in the efficacy of reform, $\partial V/\partial r$. In the figure, the following parameters are fixed: $R = 0.05$, $I = 0.25$, $c = 0.32$, $\delta = 0.20$. The thick red dashed line represents the derivative under owner management and the blue line represents the derivative under delegated management. Under owner management, if the quality of the control structure at $T-1$ satisfies $\rho_{T-1} < \rho^-$, the owner plays a mixed strategy randomizing between high and risky technology at $T-1$; for $\rho_{T-1} > \rho^-$ the owner always selects the safe technology. Under delegated management, if $\rho_{T-1} < \rho^+$, the owner opts to hire the manager and offer incentive compensation to deter managerial diversion at $T-1$; if $\rho_{T-1} > \rho^+$, the owner pays no incentive compensation and thus the manager diverts when the control structure is insecure.

5.3 Ownership structure and the value of firm reputation

Figures 4 and 5 illustrate how firm value changes with effectiveness of reform (r), cost of reform (R) and prior expectations about the control structure (embedded in P_1). These factors interact with the firm's ownership structure. Understanding the combined effects is key to understanding how the locus of control impacts firm value. We illustrate this in Figure 6.

Consider a situation where the control structure 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. Owner-management cannot support reputation equilibria. In fact, under these circumstances, owner management produces a high probability of opportunistic behavior in period 1. In contrast, under the same circumstances, delegated management produces reputation equilibria and, thus, higher total welfare. However, 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 structure 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.



Panel A. Panel B.

Figure 6: *Ownership structure and firm value.* On the horizontal axis, we plot the initial quality of the control structure, ρ_{T-1}. On the vertical axis, we plot the value of the firm, V. The thick red dashed line represents firm value under owner management and the blue line represents the derivative under delegated management. Under owner management, if the quality of the control structure at $T-1$, satisfies $\rho_{T-1} < \rho^-$, the owner plays a mixed strategy randomizing between high and risky technology at $T-1$; for $\rho_{T-1} > \rho^-$ the owner always selects the safe technology. Under delegated management, if $\rho_{T-1} < \rho^+$, the owner opts to hire the manager and offer incentive compensation to deter managerial diversion and ensure high quality at $T-1$; if $\rho_{T-1} > \rho^+$, the owner pays no incentive compensation and thus the manager diverts when the control structure 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 $R = 0.01$, $I = 0.051$, $r = 0.10$, $c = 0.06$, and $\delta = 0.05$.

6 Conclusion and extensions

In this paper, we developed a theory of reputation formation that assumes separate ownership and control of reputation. We showed that professional delegated management can support socially-efficient reputable firm behavior in cases where owner management cannot. Owner-management is even more problematic when reform mechanisms exist to restore damaged reputations. In fact, increasing the efficacy of reform mechanisms lowers firm value by adversely impacting owner managers' incentives. In contrast, with delegated management, it can increase both firm value and social efficiency. We also showed that firms can protect their reputations both through compensation policy and through corporate reform, i.e., investments in strengthening internal control structures. The interaction between control and incentives is somewhat subtle. For a compensation policy to work, a firm's stakeholders must believe that its control structure is viable. However, possibility of reform after a loss of reputation can make it impossible to motivate managers through monetary rewards. 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 this 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.

Another possible extension would be to increase the information available to owners by assuming that owners know whether the structure is secure. In many cases, such information would have the obvious effect of permitting more efficient owner interventions. However, because customers would still not know whether the structure was secure and would now use owner intervention as another signal for inferring security, the presence of informed owners might generate the perverse consequence of discouraging intervention to reform insecure structures. Reforming both reveals insecurity and, thus, lowers customers' assessments, and increases intrinsic security and, thus, raises assessments. When the success of reform is uncertain, the net effect of reform would be to lower the market's assessment of security if firms only reformed insecure structures. When the relation between security and good-quality is also fairly stochastic, this adverse revision in customer assessments could provide owners with and incentive to "continue and pretend," eschewing reform to maintain the illusion that reform is not beneficial because the structure is already secure.

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.

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Appendix

Proof of Lemma 1. Suppose that the manager is contracted to receive an incentive payment $b(T)$ in period T. To see that manager will always divert in period T if the control structure 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 structure has been revealed as insecure. □

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 choose the risky technology whenever the control structure is insecure. Now note that at histories where $\rho = 0$, the control structure is insecure with probability 1. Thus, only the risky technology will be used. By Assumption 2, known production with the risky technology is not profitable. Thus, if the control structure is know to be insure in period T, the firm will shut down. Now, suppose that the assertion is true in period t. At a node where the control structure is revealed to be insecure in period t, the manager knows that next period's history will also be a revealed node. Thus, by the induction hypothesis 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. □

Proof of Lemma 3. We first prove by induction that, if no bonus payments are contracted by the firm after period s, revelation after period s is valuable, i.e., for all $t \in [s,T)$, $Pv_O(P',t+1)+(1-P)v_O(\delta,t+1) \geq v_O(P,t+1)$, where $v_O(P(\rho),t)$ represents the owner's value function at history (ρ,t). First consider $T-1$. As shown in Lemma 2, when $P=\delta$, the firm shuts down. Therefore, when $t=T-1$,

$$Pv_O(P',t+1)+(1-P)v_O(\delta,t+1) = Pv_O(P',T).$$

Using the updating operator defined by (2), we see that

$$Pv_O(P',T) = (1-P)(e-\delta)+(P-e).$$

If $t=T-1, v_O(P,t+1) = P-e$. Because $e>\delta$, it follows that the result holds when $t=T-1$.

Now suppose the result holds at t, then at $t-1$, the assertion is that

$$Pv_O(P',t)+(1-P)v_O(\delta,t) = Pv_O(P',t) \geq v_O(P,t).$$

Using the recursion relation, we can express the two sides of the inequality as follows:

$$P\,v_O(P',t) = P(P'-e) + P\,P'\,v_O(P'',t+1) \text{ and}$$
$$v_O(P,t) = (P-e) + P v_O(P',t+1).$$

The induction hypothesis implies that $P'\,v_O(P'',t+1) > v_O(P',t+1)$ and the same argument as given above shows that $P(P'-e) > P-e$. Thus the first claim is established.

Now we establish the claim in the Lemma. If the firm contracts no bonus payments after s, it pays no bonus after $s+1$. If the firm shuts down at any unrevealed history, (P,t) where $t > s+1$, the current payoff to the firm will be 0 and the firm will transit to history $(P,t+1)$. If the firm operates, it will earn $P-e>0$ in the current period and will transit to (P',t) with probability P and (δ,t) with probability $1-P$. The first result we have established in this proof shows that this expected future value from operating is higher than the expected future value from not operating. □

Proof of Lemma 4. Suppose the optimal compensation policy is given by the payment vector b. Consider the alternative compensation policy b' of eliminating all payments to the manager after period $t^+(b)+1$ and adding the sum of the these payments discounted by the probability that the manager receives the payments under an insecure control structure, i.e.,

$$b'(t) = \begin{cases} b(t) & \text{if } t < t^+(b)+1 \\ b(t) + \sum_{s=1}^{T-(t^+(b)+1)} \delta^s\, b\,(t^+(b)+1+s) & \text{if } t = t^+(b)+1 \\ 0 & \text{if } t > t^+(b)+1. \end{cases} \tag{38}$$

Under b', the manager receives no incentive payments after period $t^+(b)+1$ and thus will clearly choose the risky technology 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, $t <= t^+$ 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 the b. The expected payments to the manager conditioned on an insecure control structure will also be the same under both compensation schemes. However, the payments will be strictly lower under b' conditioned on a secure control structure 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 structure are strictly lower under b' than under b. It follows that, taking expectations over possible control structures, the expected payments to the manager are strictly lower under b'. Because the manager's diversion policy is the same under both policies, the owner's payoff must be higher under b'. This contradiction establishes the result. □

Proof of Lemma 5. Given Lemma 4 we can restrict attention to policies that make no payments to the manager after $t^+(b)+1$. Consider the policy b that makes no payments after $t^+(b)+1$ but which makes positive payments at some date before $t^+(b)+1$. Consider the alternative policy, 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.,

$$b'(t) = \begin{cases} 0 & \text{if } t < t^+(b)+1 \\ b(t) + \sum_{s=1}^{t^+(b)} b(s) & \text{if } t = t^+(b)+1 \\ 0 & \text{if } t > t^+(b)+1. \end{cases} \tag{39}$$

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

$$v_M\left(t^+(b)+1\right) \geq \delta\, v_M\left(t^+(b)+1\right) + c \tag{40}$$

At date $t^+(b)+1$, any payment made before $t^+(b)+1$ has no effect on the unrevealed managers value at $t^+(b)$. Thus, the effect of the change from b to b' is to increase the unrevealed manager's value at $t^+(b)$. It follows that the managers value is higher under b' at $t^+(b)$ than under b, implies when combined with inequality (40) that

$$v'_M\left(t^+(b)+1\right) > \delta\, v'_M\left(t^+(b)+1\right) + c, \tag{41}$$

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

$$b_\lambda(t^+(b)+1) = b'(t^+(b)+1) - \lambda, \quad b_\lambda(t) = b'(t) = 0 \text{ if } t \neq t^+(b)+1 \tag{42}$$

Expression (41) implies that we can choose $\lambda > 0$ so that

$$v_M^\lambda\left(t^+(b)+1\right) \geq \delta\, v_M^\lambda\left(t^+(b)+1\right) + c \text{ and } v_M^\lambda\left(t^+(b)+2\right) < \delta\, v_M^\lambda\left(t^+(b)+2\right) + c, \tag{43}$$

where v_M^λ represents the manager's value under b_λ. Equation (43) implies that $t^+(b) = t^+(b_\lambda)$. Hence, the manager's diversion policy is the same under both policies. Because contingent bounus 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 implies than under b implies that the total expected cost of compensation is stricly lower. Since the 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. □

Proof of Proposition 1. The proposition follows directly from Lemmas 1 through 5. □

Proof of Proposition 2. 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 remained 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

$$\bar{\pi}[t^+](t) = (P[t^+](t) - e) \prod_{s=0}^{t-1} P[t^+](s), \quad t = \{1, 2, \ldots T\} \tag{44}$$

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 telscoping sum and this is given by

$$\bar{\pi}[t^+](t^+) - \bar{\pi}[t^+](T) = (1-e) - \bar{\pi}[t^+](T). \tag{45}$$

Using equations (10), (11), and (44), we see that

$$\bar{\pi}[t^+](T) = \frac{(P_1-\delta)(1-e) - (1-P_1)(e-\delta)\delta^{T-t^+-1}}{1-\delta} \tag{46}$$

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

$$(1-e) - \frac{(P_1-\delta)(1-e) - (1-P_1)(e-\delta)\delta^{T-t^+-1}}{1-\delta} = \frac{(1-P_1)(1-e) + (1-P_1)(e-\delta)\delta^{T-t^+-1}}{1-\delta}. \tag{47}$$

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

$$\frac{(1-P_1)\,(1-e) + ((1-P_1)\,(e-\delta) - c)\,\delta^{T-t^+-1}}{1-\delta}. \tag{48}$$

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 least $t^+ \in \{0,1,\ldots T-1\}$ such that the effect of a t^+ shift is to lower the owner's value, or, if all t^+ shifts increase owner value, then $t^+_* = T-1$. □

Proof of Lemma 6. : The owner's period T payoff from choosing the risky technology is $P(T) - I$, which is higher than his payoff from choosing the safe technology, $P(T) - e$ since $I \leq e$. Therefore, in period T, the owner will always choose the risky technology 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 choose the risky technology 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 choose the risky technology 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 choose the risky technology 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 choose the risky technology without incurring any change in her future expected payoff, making the risky technology 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

safe technology in any period subsequent to the revelation that the firm is insecure. Moreover, consumers will pay only δ blocking production in every period. □

Proof of Proposition 3. The owner will choose the safe technology in period t in a given equilibrium whenever

$$c + \delta v_O(t+1) < v_O(t+1), \tag{49}$$

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 choose the risky technology in all periods subsquent 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, $\underline{v}_O(t+1)$, where

$$\underline{v}_O(t+1) = \sum_{j=1}^{s} \delta^{j-1} \left(P(t) - I\right) = \frac{\left(P(t) - I\right)\left(1 - \delta^{T-t}\right)}{1-\delta} \tag{50}$$

Thus,

$$v_O(t+1) \geq \underline{v}_O(t+1) = \frac{\left(P(t) - I\right)\left(1 - \delta^{T-t}\right)}{1-\delta}. \tag{51}$$

It follows that if

$$c \leq \left(P(t) - I\right)\left(1 - \delta^{T-t}\right), \tag{52}$$

at any date t, then condition (49) 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 $\delta < 1$, $\delta \leq \delta^{T-t}$ for all $t \leq T-1$. Therefore, condition (49) is satisfied for all periods whenever (17) is satisfied. This establishes claim (ii).

The owner manager will choose the risky technology in period t whenever

$$\frac{c}{1-\delta} > v_O(t+1) \tag{53}$$

An upper bound on the owners's payoff is given by the owners 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 $s \in \{0, 1, \ldots T\}$. The owner's payoff from the policy of choosing the safe technology up to and including s periods after t is given by

$$\sum_{j=1}^{s} (1 - I - c) + \sum_{j=s+1}^{T-t} \delta^{j-s-1} (1 - I) = (1 - I - c)\, s + \frac{(1-I)\left(1 - \delta^{T-t-s}\right)}{1-\delta} \tag{54}$$

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

$$\bar{v}_O(t+1) = \max_{s=\{0,1,\ldots T-t\}} (1-I-c)\,s + \frac{(1-I)\left(1-\delta^{T-t-s}\right)}{1-\delta} \tag{55}$$

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

$$\frac{c}{1-\delta} > \bar{v}_O(t+1) \tag{56}$$

Claim (iii) follows. □

Proof of Corollary 1. This result follows directly from the conditions for reputation equilibria in Propositions 2 and 3. □

Proof of Proposition 4. 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 management structures. Moreover, under both management structures, the firm invests I in each period and spends c in every period through period $T-1$. The only difference between cash flows under the two management structure 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 management structures. However, the 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 undiscovered. 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 undiscovered. Once the firm is discovered, its future payoff is 0 regardless of its ownership structure. Since the likelihood of being discovered 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) this result 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 (11). Applying this rule to the initial price $P(1)=0.80$ yields, $P(2)=0.825, P(3)=0.851\bar{5}$. Verification of the equilibrium consists of showing that at each date, $t\in\{1,2,3\}$, (53) 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 14 is satisfied. It is then relatively straightforward to demonstrate that firm value is higher under delegated management. □

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

Proof of Proposition 5. The proof follows directly from the discussion preceding the statement of the proposition. □

Proof of Proposition 6. The proof for Condition (27) 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 (20). □

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