Firm reputation and agency: Information environments, corporate governance and its optics

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Abstract

Firms' reputations are founded on outsiders' (e.g., customers, suppliers) beliefs about the reputability of their managers' actions. These actions depend on governance policies owners choose to mitigate agency conflicts with managers. When governance is transparent, outsiders can draw inferences about managers' actions by observing governance decisions. The sort of inferences they draw depends on the information endowments of governance policy makers. Because of these inferences, firm reputation can depart significantly from the predictions of typical reputation models since they do not account for the owner-manager incentive conflict: Neither firm longevity, governance transparency, nor better informed governance policy makers unequivocally favor reputation formation.

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> The incentives of individuals not to milk the firm's reputation has not been clarified; it must be the case that somehow the incentives of the stock-holding layer trickles down through the rest of the hierarchy.
>
> –Holmstrom and Tirole (1989)

1 Introduction

The typical model of firm reputation has three elements:[1] First, the reputation is based on perceptions of agents outside the firm (outsiders) that the firm will implement "reputable" operating policies they favor. Second, the firm's owner is the sole beneficiary of its reputation and bears the entire cost of maintaining it. Third, the firm is a black box that faithfully implements the owner's preferred operating policies.

The typical principal-agent model of a firm supports a completely different conception of the link between operating policies a firm implements and its owner's preferences: Operating policies can diverge significantly from those the owner would choose. The reason is that a manager picks the operating policies; the owner only controls governance, which sets the manager's incentives.

Thus, if principal-agent models have any ability to explain firms' operating policies, there remains the need for firm reputation models that elaborate how "incentives of the stock-holding layer trickles down through the rest of the hierarchy," and what this implies for firm reputation. Such models will provide new insights into the large set of policies that firms implement to influence their reputations with outsiders. For example, corporate social responsibility (CSR) policy which, according to Bénabou and Tirole (2010), is inextricably linked with firm governance.

In this paper, we build a model that merges a standard principal-agent problem with the pioneering incomplete information reputation framework of Kreps and Wilson (1982a) and Milgrom and Roberts (1982) (KWMR), in which firm insiders privately know if their firm is a "type" that is committed to reputable operating policies, e.g., the "tough" monopolist type in Kreps and Wilson (1982a), or the type where the owner can strategically pick policies. Our model shows that agency conflicts between owners and managers can dramatically change firm reputation.

In our model, each period, a firm produces goods whose quality reflects the firm's operating policy for the period. The firm's customers favor "high quality" goods.[2] Owners control governance policies, which are represented by managerial compensation in our setting. Managers make operating decisions. Contracts cannot be written on quality. Owners' incentive to produce high quality goods arises solely from the desire to maintain a reputation with customers for commitment to high quality.

Mirroring the KWMR framework, the firm may be a "trustworthy type" or an "untrustworthy type." Managers of trustworthy firms always use a production technology that yields high quality goods. Managers of untrustworthy firms can opportunistically switch to an inferior, but cheaper, technology that sometimes

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

[2] Quality represents some aspect of goods or their production that matters to customers. For example, if the customers are other firms, the aspect could be reliability or adherence to these firms' supplier codes of conduct. Alternatively, if the customers are retail consumers, the aspect might be sustainable production practices or the goods' carbon footprint.

yields low quality goods. A variety of mechanisms can engender trustworthy firms: corporate culture (Kreps, 1996), managers who have pro-social preferences or value being perceived as being pro-social (Bénabou and Tirole, 2010), or internal monitoring mechanism that can deter managerial opportunism (Shleifer and Wolfenzon, 2002).

Firm insiders privately observe whether the firm is the trustworthy type. Outsiders do not know the firm's type. The manager is always an insider. In the baseline analysis, the owner is also an insider.[3] Later, we consider the the case where governance control rests with outsider institutional investors. Customers are outsiders. They observe quality after purchasing goods, and observe governance policy when it is transparent. Goods' prices reflect customers' beliefs about quality and measure the firm's reputation. Customers rationally update their beliefs based on the firm's actions they observe.

We characterize equilibria in which welfare is maximized. We refer to these equilibria as *reputation equilibria*. In a reputation equilibrium the owner adopts a governance policy that ensures reputable manager behavior. Such governance policies, which we refer to as *reputation-assuring* governance policies, are costly.

In our model there are two novel channels through which governance policy affects outsiders' beliefs: the *managerial behavior channel* and the *inference channel*. The managerial behavior channel captures the indirect effect of governance policy on outsiders' beliefs about the firm. The indirect effect arises because the compensation contract the owner chooses for the manager influences the manager's operating policy choice. In turn, the operating policy choice impacts outsiders' experiences with the firm and thus their beliefs. When governance policy is *transparent*, the inference channel also operates: outsiders observe the policy and draw inferences about the firm from directly observing governance policy decisions. The owner's governance policy choice is shaped by its anticipated effect of the policy on manager behavior and, when governance is transparent, also the (direct) effect of the policy on outsider beliefs.

When governance is *opaque*, so the inference channel does not operate, our model resembles the typical reputation model with an insider owner and customers who learn about the firm's type only from its operating policies. The only difference is that the owner sets governance policy not operating policy. We show that the cost of defection from reputation-assuring governance increases in the level of customer trust in the firm, i.e., their belief that the firm is the trustworthy type. Defection also becomes more costly as the firm's time horizon lengthens since it becomes more likely that customers will detect defection. Thus, reputation equilibria tend to exist when customer trust in the firm is high and the time horizon is sufficiently long. Importantly, when the time horizon is long, the condition on customer trust required to ensure the existence of reputation equilibria is the same in our setting, where operating decisions are delegated to managers, as it is in typical reputation models, where the owner directly controls the firm's operating policy and thus there is no principal-agent problem. Hence, the managerial behavior channel can support firm-reputation outcomes identical to ones in typical reputation models if the firm is long-lived.

[3] An informed owner fits both private firms like Cargill and Bechtel, and public ones like Oracle, Tesla, and Walmart that are controlled by "mavericks," blockholders whose wealth is concentrated in the firms, and who are likely to be intimately familiar with the firms' operations (Amel-Zadeh, Kasperk, and Schmalz, 2022).

What is the impact of the inference channel? For the channel to operate governance must be transparent so customers observe governance policy.[4] Now customers will try and infer the firm's type from its governance policy. Because reputation-assuring compensation is costly and is useful only when the manager can act opportunistically, customers will tend *not* to associate the firm with the trustworthy type if it adopts reputation-assuring governance. This encourages the owner to avoid such policies. Formally, we show that reputation equilibria cannot be sustained when the firm is sufficiently long-lived because a standard off-equilibrium belief refinement (D1 refinement, Cho and Kreps (1987)) forces customers to believe defection from candidate reputation equilibria signals that the firm is trustworthy. Thus, the inference channel undermines firm reputation and reputable behavior when the owner is an insider. In fact, reputation equilibria cannot exist if the firm's time horizon is long.

Does the inference channel always undermine reputation? In 90 percent of S&P500 firms, the largest shareholder is an institutional blockholder. On average, institutional blockholders own 83% of S&P500 firms' outstanding equity (Amel-Zadeh, Kasperk, and Schmalz, 2022). Although these institutions hold large positions in their portfolio companies, they are also diversified, and may own thousands of U.S. and global firms (BlackRock has ownership stakes in about 13,000 firms). At these institutions, small stewardship teams (BlackRock's team has around 70 members) are responsible for making governance decisions, e.g., share voting, for firms in their portfolios. Such teams are quite unlikely to possess private information about many of the hundreds or thousands of firms in their portfolios. Thus, it seems reasonable to conjecture that a significant fraction of firms are governed by institutions and that these institutions are not insiders.

We show that the effects of the inference channel are dramatically different if the owner is not an insider. Since the owner's actions are not informed by the firm's type, customers cannot draw the inference that the firm is not the trustworthy type if the owner adopts reputation-assuring compensation. They can only infer that the manager will act reputably *even* if the firm is not trustworthy. A governance policy that curbs opportunism will immediately raise goods' prices, and defection from reputation-assuring governance policies will immediately be impounded in prices. Hence, a long-time horizon is not necessary to ensure that defection is costly, and firm longevity is irrelevant for existence of reputation equilibria. Since a reputation-assuring governance policy is costly, adopting such a policy is never optimal for the owner when outsiders (including the owner) have a high level of trust in the firm. Therefore, reputation equilibria exist only when outsiders have a low level of trust in the firm. Importantly, the effects of both the time horizon and outsider trust for reputation formation are quite different from the effects in our baseline setting as well as the effects in typical reputation models.

In summary, we show that, when there is a principal-agent problem between the owner and manager,

[4] Customers must also pay attention to governance policy. This is likely to be the case if the goods are critical for customers. For example, when buying aircraft, airlines likely account for the incentives of managers at Boeing or Airbus to ensure that the aircraft they produce are safe to operate. Even typical retail consumers pay attention to governance. In a survey of typical retail consumers by Allianz, the insurance giant, 69% of respondents highlighted governance topics like transparency of business practices and finances or level of executive compensation as being significant in their decision making (Allianz, 2019). Moreover, when governance is transparent, governance decisions will affect product/firm ratings produced by entities like CSRHub (https://www.csrhub.com/csrhub-esg-data-schema), and through this channel, affect retail consumer demand.

the firm's reputation is inextricably linked with governance policy. The link is sensitive to the owner's information endowment, the ability of outsiders to observe governance policy, and the firm's time horizon. If governance policy is opaque and the firm's horizon is long, the firm's ability to sustain its reputation is not affected by the principal-agent problem. Governance transparency changes firm reputation dramatically. If the owner is an informed insider, transparency can completely undermine the owner's willingness to sustain the firm's reputation because outsiders associate governance policies that incentivize reputable manager behavior with the firm not being trustworthy. In stark contrast, if the owner is an uninformed outsider, governance transparency ensures that governance policies that incentivize reputable manager behavior, even when the firm is not trustworthy, will be factored into customers valuation of the firm's goods.. The firm is willing to make this commitment when outsiders doubt that the firm is trustworthy. The willingness to commit is independent of the time horizon. Thus, the firm is able to sustain its reputation under very different conditions than those developed in typical reputation models.

Related literature

Our approach to modeling reputation closely follows the hidden action/hidden information reputation literature (e.g., Kreps and Wilson, 1982a; Milgrom and Roberts, 1982; Maksimovic and Titman, 1991; Mailath and Samuelson, 2001; Cripps, Mailath, and Samuelson, 2004; Liu, 2011). Firm reputation is a "trans-individual" attribute as in Kreps (1996), Tadelis (1999), and Hakenes and Peitz (2007).

Our model of owner-manager agency conflict is a standard and elementary application of principal-agent theory when agents both take hidden actions and have private information (e.g., Myerson, 1982; Cole and Kocherlakota, 2001). There are reputation models of partnerships with agency conflicts. They focus on questions very different from the ones we consider: inter-generational rent transfers and effort allocation between partners (e.g., Cremer, 1986; Morisson and Wilhelm, 2004; Bar-Isaac, 2007) or the selection of new team members (e.g., Levin and Tadelis, 2005).

"Signal jamming" models also consider actions that cater to the beliefs of firm outsiders (Holmström and Costa, 1986; Gibbons and Murphy, 1992; Holmström, 1999). DeMarzo and Duffie (1995); Hirshleifer, Chordia, and Lim (2001); and Almazan, Suarez, and Titman (2009) consider the effects of transparency. Our model is different along three dimensions. First, in our model, an owner concerned with firm value caters to the beliefs of external actors, not managers with career concerns. Second, in our analysis the relevant outsiders are the firm's customers, not the managerial labor market. Third, in our analysis, the information environment has two dimensions (internal and external) because, in contrast to signal jamming models, we consider both internal (owner-manager) and external (owner-outsider) agency conflicts.

Prior research has shown that, in principal-agent models, revelation of information to the principal (in our setting, the owner) can be deleterious for the principal. In Holmström (1979) the channel for the deleterious effect is reduced agent effort incentives; in Crémer (1995) it is a weakened ability to commit to not renegotiate contracts; in Prat (2005) it is agents ignoring valuable private signals and instead conforming actions to the expectations created by the information. While our analysis also demonstrates that revealing information can harm principals, our definition of "transparency" is different and our channel for the harm is novel. Transparency in principal-agent models reflects the degree of asymmetry between the principal's and agent's information endowments, i.e., the "internal information environment" in our language. Our conception of transparency depends on the degree of asymmetry between the information endowments of firm-insider and external third-party agents, i.e., the "external information environment." The channel for the harmful effects of transparency in the principal-agent models is its effects on actions of agents. In our analysis, the harmful effects arise because principals change their actions out of concern about the impact of transparency on how third-parties interpret firm actions.

In this sense, our model is actually closer to models based on third-party effects such as in proprietary information models (e.g., Dye, 1986). In these models, transparency reveals information to competitors and thus weakens the firm's competitive position. Although proprietary information theories consider the external information environment, they do not consider the internal information environment like our model does. In our setting, the effects of transparency depend on the interaction between the external and internal information environments. Thus, there are no close analogues to our results in either the principal-agent or proprietary information literatures because papers in these literatures do not model both internal and external information environments.

More generally, our analysis relates to a growing literature in theoretical mechanism design on how principals can affect the behavior of strategic agents through the design of information environments and, thereby, induce outcomes that maximize welfare (e.g., Bergemann and Morris, 2016). Although our objectives are closely aligned with the objectives of this research, the structure of our analysis is quite different. We consider a specific setting, manager/shareholder conflicts in shareholder-owned firms, rather than a general Bayesian game. We assume a dynamic setting, as opposed to the static settings deployed in this literature. We consider two fixed information environments for uninformed third parties: transparency and opacity. We choose these environments based on observed disclosure regimes rather than attempting to derive the, perhaps stochastic, optimal information design for implementing reputation equilibria.

2 Model

Consider an economy with a risk free rate of zero that operates at dates $\mathscr{T} = \{0, 1, 2, \ldots T\}$, $\infty > T \geq 2$.[5] We refer to the interval of time between adjacent dates $t-1$ and t as "period t." The economy has one firm. If the firm operates in a period, it produces one unit of a good, which we refer to as the period t good. The firm sells each good for the numeraire good, "cash." There is no storage technology, thus cash and all goods must be consumed immediately.

Agents All agents in the economy are risk-neutral. The agents are a continuum of customers, a continuum of manager candidates, and a collection of shareholders who own the firm. The shareholders have sufficient cash in each period to fund all the firm's needs, including paying all the firm's financial obligations. One shareholder, "the blockholder," controls the firm by virtue of owning a large block of shares. The blockholder

[5]The finite time setting is a feature of the KWMR framework that facilitates a unique equilibrium. It allows us to examine the effect of longevity on reputation. Assuming a zero discount rate improves exposition. We would obtain identical results if all agents use the same positive discount rate.

maximizes expected firm value.[6] The utility or *payoff* for each customer is given by her expected future cash flows plus the expected value of the goods she purchases. The utility for each manager is given by his expected future cash flows and private benefits.

Manager The firm must have a manager. The blockholder selects one at date zero. All manager candidates have identical abilities and preferences, both of which are common knowledge, and the market for managers is competitive. Thus, managers cannot command rents because of their abilities or preferences. The per-period reservation wage for managers is zero, which lowers the minimum managerial compensation and thus increases the likelihood of managerial opportunism. We assume that the blockholder cannot replace the manager. In Section 6.1, we will show that this assumption has no effect on our conclusions.

Goods Each good the firm produces may be either high, h, or low, l, quality. Quality can represent any aspect of the good that customers value, from being fit-for-purpose to being environmentally friendly or the production technology being socially responsible (Kitzmueller and Shimshack, 2012). Quality is neither verifiable nor contractible. All agents observe the period t good's quality once a customer receives it. Hence, the period t good's quality is common knowledge at the end of period t.

Goods' prices and reputation Customers have identical preferences and their preferences are common knowledge. They assign a value of 1 to a high-quality good and 0 to a low-quality good. They engage in Bertrand competition for each good. The price customers set for the period t good represents a bid that will be filled if the good is produced.[7] Prices are verifiable and contractible. Consistent with Bertrand competition, we assume that the period t price equals customers' expected valuation of the period t good. This assumption rules out a "trivial" equilibrium in which customers believe the good is worthless and bid zero, the good is not produced and, because customers orders are never filled, Bayes rule cannot be applied to customer beliefs. Because goods' prices reflect customers' beliefs about their quality, the period t good's price measures firm reputation in period t.

Shut-down policy Each period, after observing the price set by customers, the blockholder chooses whether the firm will *operate* and produce a good or *shut down* and not produce. When the blockholder decides the firm will operate, shareholders supply capital worth e. When the blockholder shuts down production for the period, shareholders supply no capital. However, they cover any contracted financial obligations during the period.

Production technology The manager must invest all the shareholder-supplied capital, e, in a *reliable technology* that produces a high quality good with probability one or an *unreliable technology* that lowers product

[6]Shareholders neither extract private benefits nor exert personal effort on monitoring. So, assuming their collective interest is represented by the blockholder simply makes the analysis more compact and brings our model closer to the typical conceptionalization of the principal-agent problem.

[7]This timing for customer bids ensures that in each period there is a price for the good on which contracts can be written. If prices are set after production, in any period in which the firm does not produce, the good would not have a price and a contract based on the period's price would be ill defined. Our results would be unchanged if we assumed price setting after production and extended the definition of "price" to include the "null price," and specified contracts over this extended set. However, this would add to complexity without producing insight. Allen and Gale (1988) make a similar assumption.

quality with probability $1-\delta$, $0<\delta<1$. The manager's technology choice is unobservable. Unlike the reliable technology, the unreliable technology yields a private benefit of $c>0$ to the manager.

Given customer preferences, the unreliable technology produces goods with an expected value of δ, the probability the unreliable technology produces a high quality good, and increases the manager's payoff in the period by the private benefit, c. Thus, the expected benefit from adopting the unreliable technology in a period is $\delta+c$. We assume that this benefit is less than the cost of production, and thus operating the firm as a "low quality producer" is not socially efficient or economically viable.

Assumption 1. $e>c+\delta$.

Firm type Mirroring the KWMR framework, the firm may be a type that always adopts the reliable technology, or it may be a type which can adopt the unreliable technology. We can interpret the firm's type in several ways, each of which supports the results we will present later. Like typical reputation models, the firm being trustworthy might result from either firm culture or the manager's intrinsic preferences. For example, a trustworthy firm could result from a firm culture that imposes prohibitive non-pecuniary costs on managers who adopt inferior technologies that might result in shoddy products (Kreps, 1996). Alternatively, firms might be able to select managers with a strong preference for pro-social actions that overwhelms the private benefit from using the unreliable technology (Bénabou and Tirole, 2010).

The interpretation we adopt is that trustworthy firms are firms with effective quality control protocols. Specifically, we assume that a trustworthy firm has protocols specifying quality standards. The protocols are enforced by *monitoring*. Monitoring can be effective, type-$\mathcal{E}$, or ineffective, type-$\mathcal{I}$. If monitoring is ineffective, the manager can choose between the reliable and unreliable technologies. If monitoring is effective, the manager can only invest in the reliable technology.[8] For better exposition, we sometimes refer to the monitoring type as *firm type*. We refer to the manager's choice of the unreliable technology as *opportunism*. If, in a given period, the manager follows the strategy of choosing the reliable technology if and only if monitoring is effective, we will say that the manager *acts opportunistically* during the period. If no period qualification is used, acting opportunistically should be interpreted as acting opportunistically in all periods. If, in a given period, the manager follows the strategy of choosing the reliable technology regardless of whether monitoring is effective or ineffective, we will say that the manager acts *reputably* in that period.

Management compensation The firm faces an agency problem because the manager may be able to unobservably choose the unreliable technology to earn a private benefit. To mitigate the problem, the firm contracts with the manager. The blockholder chooses the contract, which specifies a non-negative payment

[8] Our results will be qualitatively unchanged if ineffective monitoring blocks opportunism with a positive probability. We can "microfound" our specification of monitoring using the conceptualization of monitoring developed in Shleifer and Wolfenzon (2002) and Johnson et al. (2000): Monitoring imposes a cost on manager opportunism. Monitoring is effective when the cost is high enough to ensure that opportunism is a dominated strategy. When the cost is too low, monitoring is ineffective. For simplicity we set the cost to zero when monitoring is ineffective. These assumptions ensure that, when monitoring is effective, the firm is committed to a strategy, just like the "tough" monopolist type in Kreps and Wilson (1982a) and "honest (H)" producer type in Maksimovic and Titman (1991).

to the manager in each period. Since quality is not verifiable or contractible, each payment can only be conditioned on the history of prices. If the firm doesn't have sufficient revenue to cover the payment in a period, shareholders cover the shortfall.

Note that the blockholder's shut-down policy decision and the manager's technology choice in period t are made after the period t good's price is set. Thus, neither decision affects the good's price in the period. Because the contracted compensation payment in period t depends only on the history of goods' prices in periods 1 through t, this implies that the actions of the firm and manager in period t do not affect the manager's contracted period t payment.

Information The blockholder's shut-down policy decisions and good prices are observed by all agents, i.e., the blockholder, the manager, and customers. All customers observe the quality of a good after a customer receives it. At date zero, informed agents observe whether monitoring is effective and uninformed agents do not. The manager and the blockholder are informed agents. Governance is opaque, so customers do not observe the manager's compensation contract. We also consider settings where the blockholder, like customers, is uninformed and governance is transparent.

Uninformed agents have a common prior distribution over the monitoring type. At the start of period 1, they believe that it is effective with probability $\theta_1 \in (0,1)$. We refer to θ_1 as the customers' initial level of trust in monitoring. We assume θ_1 is large enough to ensure that production is economically viable:

Assumption 2. $\theta_1 > e$.

Assumption 2 ensures that production is viable even in the absence of any governance actions aimed to ensure high-quality production. Absent this assumption, we would have to consider whether the firm would operate at all. This would distract from the questions we consider: When firms operate, how do their governance choices align with outsider preferences, and how do their information environments affect their ability to sustain their reputations?

Note that the firm can only produce a low quality good if the manager chooses the unreliable technology, which is only possible if monitoring is ineffective. Thus, conditioned on the production of a low quality good, the probability that monitoring is effective equals 0. If the firm has produced a low quality good in any previous period, we will say the firm is *revealed*. If the firm has not produced a low-quality good in any previous period we will say the firm is *unrevealed*.

Equilibrium The shareholders' payoff in period t is the sum of expected cash flows in period t and all subsequent periods. The manager's payoff in period t is the sum of expected cash flows and expected private benefits in period t and all subsequent periods. We refer to the shareholders' (manager's) date 0 payoff (before operation is commenced but after the compensation contract has been fixed) as the shareholder's (manager's) *ex ante payoff*. We refer to payoffs at subsequent dates as *ex post payoffs*.

An equilibrium is a date 0 compensation contract for the manager, a set of blockholder and manager strategies, prices for goods, and outsider beliefs for each period that constitute a Perfect Bayesian Nash equilibrium, i.e.,

(a) the compensation contract is incentive compatible,

(b) the blockholder's shut down/operate strategy is incentive compatible in each period,

(c) the manager's opportunism strategy is incentive compatible in each period,

(d) in each period, customers set prices equal to the goods' expected quality conditioned on blockholder and manager strategies, and

(e) in each period, belief updating by uninformed agents is consistent with Bayes' rule.

A compensation contract is called *optimal* if it is selected in some equilibrium.

3 Customer trust, reputation equilibria and optimal compensation

Before we characterize equilibria, we examine how governance policies shape manager behavior, how customers respond to the quality of goods, and the consequences of the firm being revealed. We start by establishing that the effects of revelation mirror the effects of revelation in models using the KWMR framework. Proofs appear in the appendix.

3.1 Shut-down policy after revelation and the loss of customer trust

As in any KWMR-type model, once the firm is revealed and customer trust in the firm is destroyed, customers will expect the firm to act opportunistically once it is revealed. To see this note that the period t price is set before the manager's period t technology choice. Therefore, the period t contract payment cannot influence the manager's period t action. The action can only be influenced by payments after period t. As we demonstrate in the following proposition, only if customers have at least some trust in monitoring can the manager's period t action change customers' future quality expectations, future goods' prices, and the manager's expected future payoff. Hence, governance policies are effective only if customers trust the firm's monitoring to some degree. Once the firm is revealed and customer trust in monitoring is destroyed, contracts no longer exert any incentive effects.

Lemma 1. *(i) If the firm operates in period T, the manager will act opportunistically in period T. (ii) If the firm is revealed in period T, the firm will not operate in period T. (iii) If the firm is revealed in period t, the manager will act opportunistically in period t and in all subsequent periods. (iv) If the firm is revealed in period t, the firm will shut down in period t and in all subsequent periods.*

In every KWMR-type model reputation is central because the firm will not behave reputably if it faces no adverse reputation consequence for deviating from this behavior. This is always the case in the model's final period. Claim (i) shows that this is also the case in our model.[9] Thus, like every KWMR-type model, reputable behavior is possible only until the penultimate period. However, since there is no upper bound on T, manager opportunism can be prevented for an arbitrarily long time in our model.

Claim (iii) follows from an *unraveling* argument that is frequently encountered in reputation models. The argument can be summarized as follows: The manager's period $T-1$ action only affects his period T compensation payment through the action's effect on the period T good's price. Customers know the

[9] As Milgrom and Roberts (1982) point out in Appendix A of their paper, infinite horizon reputation models support the limiting equilibrium of finite horizon models but also support many other equilibria that are intuitively unappealing.

manager will act opportunistically in period T. If the firm has been revealed in period $T-1$, they will price the period T good at δ. Since the period T good's price is fixed at δ, the manager's period T compensation will be insensitive to his period $T-1$ action and the manager will act opportunistically in $T-1$. Hence, the period $T-1$ good's price will also be fixed at δ. These arguments extend backwards to all periods following revelation.

Claims (ii) and (iv) follow directly from claim (iii). Once customers lose trust in monitoring, they will only pay δ for a good. However, because Assumption 1 requires that $e > \delta$, in this case the firm can only operate at a loss. Hence, the firm will shut down once customers lose trust in monitoring.

In KWMR-type models, reputation survives only so long as outsiders are uncertain about the firm's type. Similarly, Lemma 1 demonstrates that, to sustain the firm's reputation, the blockholder must adopt governance policies that prevent the firm from being revealed. Customer uncertainty about the firm's type, which requires a positive level of customer trust, forms the foundation of firm reputation as well as governance.

3.2 Reputation equilibria

We are concerned with the viability of equilibria with desirable welfare properties. Assumptions 1 and 2 ensure that the increase in value generated by choosing the reliable technology, $1-\delta$, exceeds the manager's private benefit loss from ensuring high-quality output, c. Thus, the reliable technology is socially efficient; the first-best solution is to use the reliable technology and always produce high-quality goods. Competition between customers ensures that the surplus generated by production is shared by shareholders and the manager, but would be entirely captured by shareholders absent the agency conflict.

Lemma 1 demonstrates that no equilibria exist in which high quality production can be assured in the final period. From a welfare perspective, the second-best outcome is the firm producing in every period and no opportunism occurring before period T. We refer to equilibria that support this second-best outcome as *reputation equilibria*. When a reputation equilibrium exists, the blockholder, acting in the interests of the shareholders, not society, chooses governance policies that ensure the second-best outcome from the perspective of social welfare.

3.3 Optimal compensation

To avoid distracting complications, we assume that managers are compensated using *simple contracts*. A simple contract commits the firm to pay the manager $b_t \geq 0$ at date t if the firm is unrevealed at date t and pay the manager 0 if the firm is revealed at date t. Thus, a simple contract is a vector $\boldsymbol{b} = (b_1, b_2, \ldots, b_T) \in \mathbb{R}^T_+$ of payments made at each date conditioned on the firm being unrevealed at that date. In Section 3.4, we show that simple contracts can be implemented by conditioning on price histories. In Section 6.2, we show that expanding the contract space cannot support equilibria producing strictly higher shareholder payoffs.

The blockholder will choose a contract that limits manager opportunism, and opportunism can occur only when monitoring is ineffective. Thus, we focus on manager behavior under ineffective monitoring. Claim (iii) in Lemma 1 shows that the firm shuts down once it is revealed, and the manager's employment is effectively terminated, so we focus on situations in which the firm is unrevealed.

Let $v_M(t)$ denote the manager's value function in period t when monitoring is ineffective and the firm is unrevealed in period t. This function captures the manager's expected compensation payments and private benefits. If the manager acts opportunistically in period t, the manager's payoff equals the bonus payment for period t (which is invariant to the manager's period t action), plus the private benefit, c, plus the manager's expected continuation value, $(1-\delta)\times 0+\delta\, v_M(t+1)$. By acting reputably the manager forgoes the private benefit but ensures that revelation will not occur, resulting in a payoff that equals the bonus payment plus continuation value $v_M(t+1)$. If the firm does not operate (i.e. the firm shuts down for period t), the manager cannot act and his payoff simply equals the bonus payment, b_t plus continuation value, $v_M(t+1)$. Hence, conditioned on the firm being unrevealed at date t, the manager's value function satisfies

$$v_M(t)=\begin{cases} b_t+\max\left[v_M(t+1),\delta\, v_M(t+1)+c\right] & \text{if the firm operates in period } t \\ b_t+v_M(t+1) & \text{if the firm shuts down in period } t \end{cases}. \tag{1}$$

Comparing the manager's two possible payoffs in case the firm operates, we see that the manager will act reputably in period t so long as

$$(1-\delta)\, v_M(t+1)\geq c. \tag{2}$$

Inequality (2) is the manager's incentive compatibility condition for reputable behavior. The term on the left captures the manager's "expected cost of opportunism," and the manager will act reputably in period t only when this cost is large. Since $b_t\geq 0$, equation (1) shows that

$$v_M(t)\geq v_M(t+1). \tag{3}$$

Thus, the manager's continuation value and expected cost of opportunism (weakly) decrease in t. Consequently, the set of periods in which the manager acts opportunistically is an order interval. Thus, either the manager will act opportunistically in every period, or there will exist τ such that the manager will not act opportunistically during or before period τ, and will act opportunistically in every period after τ.

We will refer to τ, the last period in which the manager's actions completely protect the firm's reputation, as the *assured-reputation horizon*. Lemma 1 demonstrates that opportunism is the strictly optimal strategy for the manager in period T. Hence, the longest possible assured-reputation horizon is $T-1$. In the following lemma, we formalize the pattern of managerial opportunism and the minimum compensation required to achieve an assured-reputation horizon of $T-1$, which is necessary in a reputation equilibria.

Lemma 2. *(i) Either the manager will act opportunistically in every period, or there will exist an assured-reputation horizon $\tau\in\{1,2,\dots T-1\}$, such that the manager will not act opportunistically during or before period τ, and will act opportunistically in every period after τ. (ii) The manager will act reputably until period $T-1$ so long as the firm gives him a contract that pays a minimum period T bonus of $b_T=c\delta/(1-\delta)$ so long as the firm is unrevealed until period T.*

To establish reputation equilibria we will need to establish that the blockholder will prefer the reputation horizon $\tau = T - 1$ over the other alternatives. We need to know the cost of setting a shorter reputation horizon. In the following lemma we characterize the lowest cost compensation, when the blockholder follows the shut-down policy of always operating the firm as long as it is unrevealed. Later, we will establish that, in fact, the blockholder's optimal shut-down policy is to always operate the firm so long as it is unrevealed.

Lemma 3. *If the blockholder operates the firm in every period in which it is unrevealed, a (single) payment*

$$b^*_{\tau+1} = \frac{c\,\delta^{T-\tau}}{1-\delta} \tag{4}$$

in period $\tau+1$ contingent only on the firm being unrevealed at the start of period $\tau+1$ minimizes the cost of compensation for the assured-reputation horizon $\tau \in \{1, 2, \ldots T-1\}$.

Lemma 3 shows that the blockholder can ensure the manager acts reputably until period τ with a simple contract that makes only one bonus payment to the manager. The payment is made in period $\tau+1$, immediately following the assured-reputation horizon. The right hand side of equation (4) shows that the bonus payment is proportional to the stream of future private benefits the manager expects to enjoy after period τ. Since bonus payments made before period τ will have no effect on the manager's behavior in subsequent periods, it is clear why the cost of compensating the manager is minimized by not making such payments. The following example illustrates why making bonus payments after period $\tau+1$ can increase the cost of incentivizing the manager to act reputably until period τ.

Example 1. We present two example compensation contracts, $\boldsymbol{b}$, exogenous parameters, T, c, δ, θ_1, and e, and the manager's unrevealed value function, v_M, in Table 1. In the example, the firm operates in a period if and only if it is unrevealed in that period.

t	1	2	3	4	5	6	7
	Contract #1						
$\boldsymbol{b}^1$	0	0	0	0	0.005	0	0.080
v_M	0.535	0.535	0.535	0.535	0.535	0.520	0.480
opportunism?	no	no	no	no	yes	yes	yes
	Contract #2						
$\boldsymbol{b}^2$	0	0	0	0	0.010	0	0
v_M	0.535	0.535	0.535	0.535	0.535	0.500	0.400
opportunism?	no	no	no	no	yes	yes	yes
Parameters:	$T=7$, $c=2/5$, $\delta=1/4$, $\theta_1=11/15$, and $e=2/3$						

Table 1: *Dynamics of managerial opportunism and compensation contracts.* In this example, the blockholder follows the policy of operating if and only if the firm is unrevealed.

Consider Contract 1. In period 7 (the terminal period T) there is no continuation value for the manager and acting opportunistically maximizes his payoff (as shown by Lemma 1). Thus, if the firm is unrevealed (at the start of the period), the manager's payoff in period 7 equals the bonus $b_T^1 = 0.08$ and private benefit c, so $v_M(T) = c + b_7^1 = 0.48$. When $t = T-1 = 6$, the manager's payoff from acting opportunistically equals $b_6^1 + c + \delta\, v_M(7) = 0 + 0.40 + (1/4)(0.48) = 0.52$, and his payoff from acting reputably equals $b_6^1 + v_M(7) = 0 + 0.48 = 0.48$. Hence, the manager will also act opportunistically in period 6. In period 5, $b_5^1 + c + \delta\, v_M(6) = 0.535$, and $b_5^1 + v_M(6) = 0.525$. Once again, the manager will act opportunistically, and $v_M(5) = 0.535$. In period 4, $b_4^1 + c + \delta\, v_M(5) = 0.53375$ and $b_4^1 + v_M(5) = 0.535$. Hence, the manager will act reputably in period 4. Because the manager's continuation value is at least as large in periods 1, 2, and 3, as it is in period 4, equation (2) shows he will also act reputably in periods 1, 2, and 3 as well. Thus, $\tau = 4$ is the assured reputation horizon under Contract 1.

Now consider Contract 2, which is Contract 1 without the period 7 bonus and an additional period 5 bonus payment of 0.005. Contract 1 and Contract 2 produce the same managerial continuation values, v_M, until period 4 and the same managerial behavior through period 7. Thus, the Contract 1 bonus payment in period 7, has the same effect on the manager's incentive to act opportunistically in period 4 as a payment of 0.005, sixteen-times smaller, in period 5. Moreover, Contract 2 is less costly for shareholders if they do not know the firm's type. To see this, note that the manager will act opportunistically in periods 5 and 6 if monitoring is ineffective. If so, the probability that the manager will be unrevealed in period 7 equals $\delta^2 = 1/16$. Thus, conditioned on monitoring being ineffective, the expected bonus payment is the same under Contracts 1 and 2: the payment of 0.08 in period 7 under Contract 1 is made with probability $1/16$ and the increased payment in period 4 under Contract 1, 0.005, is made with probability 1. However, if monitoring is effective, both the bonus payment in period 7 and the bonus payment in period 5 are made with probability 1. Since the prior probability that monitoring is effective, θ, equals $11/15$, expected compensation under Contract 2 is $(11/15)\,(0.08 - 0.005) = 0.03\overline{3}$ less than under Contract 1.

3.4 Good's prices

Lemma 1 demonstrates that the period t good's price, p_t, will equal δ if the firm is revealed by the period and customers know that monitoring is ineffective. Moreover, in all subsequent periods goods prices will also equal δ. We will now characterize good's prices if the firm is unrevealed in period t.

In each period, the good's price will depend on both customers' beliefs about the effectiveness of monitoring and their conjecture about the manager's action in the period. Suppose customers believe that the assured-reputation horizon is τ' and period $t-1 \le \tau'$. Then customers will expect the manager to behave reputably in period $t-1$ and they will set $p_{t-1} = 1$. If the firm operates in period $t-1$ and produces a low quality good, it will start period t revealed, so customers' belief that monitoring is ineffective and the good's price will equal δ starting with period t. If the firm shuts down in period $t-1$ or produces a high quality good, customers will not learn anything about the firm's type and the firm will enter period t unrevealed. If $t \le \tau'$ then customers will expect the manager to behave reputably and $p_t = 1$. Thus, $p_t = 1$ for all $t \le \tau'$ so long as the firm is unrevealed.

If $t > \tau'$ customers will believe that the manager will act opportunistically. If $\hat{\theta}_t > 0$ represents customers' belief that the firm is (type $\mathcal{E}$) at the start of the period t, then $p_t = m_t < 1$, where

$$m_t = \hat{\theta}_t + (1 - \hat{\theta}_t)\,\delta. \tag{5}$$

We will refer to m_t as the *monitoring price*, since it reflects a good's expected quality when managerial opportunism is constrained only by monitoring. The monitoring price, m_t, also represents uninformed agents' assessment that the firm will not be revealed by a low quality period t good.

Since the manager will act opportunistically in period $t > \tau'$, after observing a high quality period t good, if customers update their beliefs about the firm's type in accordance with Bayes rule

$$\hat{\theta}_{t+1} = \frac{\hat{\theta}_t}{\hat{\theta}_t + (1 - \hat{\theta}_t)\,\delta} = \frac{\hat{\theta}_t}{m_t} \quad \text{and} \quad 1 - \hat{\theta}_{t+1} = \frac{(1 - \hat{\theta}_t)\,\delta}{\hat{\theta}_t + (1 - \hat{\theta}_t)\,\delta} = \frac{(1 - \hat{\theta}_t)\,\delta}{m_t}. \tag{6}$$

The definition of the monitoring price, equation (5), and Bayesian updating, equation (6), imply that

$$\frac{1 - m_{t+1}}{1 - m_t} = \left(\frac{1 - \hat{\theta}_{t+1}}{1 - \hat{\theta}_t} \right) \text{and} \left(\frac{1 - \hat{\theta}_{t+1}}{1 - \hat{\theta}_t} \right) = \frac{\delta}{m_t}. \tag{7}$$

Equation (7) implies that

$$\frac{1 - m_{t+1}}{1 - m_t} = \frac{\delta}{m_t} \Longrightarrow m_{t+1} = 1 + \delta - \frac{\delta}{m_t}.$$

Thus, the period $t+1$ monitoring price will be given by the *updating function*, Γ, applied to the period t monitoring price:

$$m_{t+1} = \Gamma[m_t], \quad \text{where } \Gamma[m] = 1 + \delta - \frac{\delta}{m}, \quad m \in [\delta, 1]. \tag{8}$$

Neither customers' valuations of goods nor the probability of revelation directly depend on the probability that monitoring is effective. Instead, they depend on the probability that the good is high quality. Thus, to simplify the exposition of price dynamics we will express Bayesian updating in terms of the monitoring price, m, rather than beliefs about monitoring effectiveness.

Remark 1. Let m_1 represent the monitoring price based on the prior belief θ_1. Note that equation (5) ensures that $m_1 > \delta$, the revealed price in period t. The definition of the updating function, Γ ensures that $\Gamma[m] \geq m$, thus $m_t \geq m_1$, for all $t \in \{1, 2, \ldots T\}$. The unrevealed price, p_t, satisfies $p_t \geq m_t$. Thus, the price of the period t good is weakly greater than m_1 if and only if the firm is not revealed in period t. Hence, a simple contract that conditions the payment to the manager only on whether the firm is revealed can be implemented by a contract that depends only on the history of goods' prices as follows: Each period t, the manager receives a bonus payment b_t if the period t price of the good at least equals m_1 and a payment of 0 if the good's price is less than m_1.

4 Reputation equilibria and the managerial behavior channel

When a blockholder is informed, like the owner is in typical reputation models, its actions will reflect its private information about the firm's type. However, unlike the owner in typical reputation models, the blockholder does not directly control the firm's operating policy, i.e., production technology. Instead, the blockholder can only indirectly influence operating policy through its choice of governance policy. We now investigate the efficacy of sustaining reputation through governance policy when the policy is opaque and the inference channel shuts down.

Since customers cannot observe governance policy, they set prices based on a conjectured policy and the quality of goods they observe. In a reputation equilibrium, customers must conjecture that the firm will operate in every period and produce high-quality goods with probability 1 in every period except perhaps the last period, T. Thus, so long as the firm is unrevealed, the price of a good will equal 1 for all periods $t < T$ and equal m_1 in period T. Customers' conjectures about governance policies must be correct.

Since governance is opaque, the blockholder's only concern when setting governance policy is its effect on managerial opportunism. When monitoring is effective, opportunism is not possible so the blockholder will set compensation equal to 0. When monitoring is ineffective, compensation must satisfy condition (2) to ensure the manager behaves reputably. Verifying the existence of a reputation equilibrium requires determining conditions under which the blockholder will choose to offer reputation-assuring compensation when monitoring is ineffective.

Defection from the equilibrium will involve the blockholder unobservably setting an actual assured-reputation horizon of $\tau \in \{0, 1, \ldots, T-2\}$. To set $\tau = 0$ it is optimal to pay the manager zero compensation. Lemma 3 shows that to set $\tau \in \{1, \ldots, T-2\}$ it is optimal to pay $b^*(\tau+1) = c\delta^{T-\tau}/(1-\delta)$ in period $\tau+1$ if and only if the firm is unrevealed until then.

The blockholder will defect when defection raises firm value. Computing firm value following defection is straightforward. Whenever $t > \tau$, the manager will act opportunistically. The firm will be revealed at the start of period $t+1$ (producing a continuation value of 0) with probability $1-\delta$ and remain unrevealed with probability δ. So long as $t < T$ and the firm is unrevealed, the good's price will equal 1 and shareholders' will receive $1-e$. Let $v_S^o(t)$ represent shareholders' continuation value, excluding the cost of compensation, in periods $t \in \{\tau+1, \tau+2, \ldots T-1\}$ when monitoring is ineffective and the firm is unrevealed. Then, v_S^o will satisfy the following recursion relation:

$$
\begin{aligned}
v_S^o(t) &= (1-e) + \delta\, v_S^o(t+1) \qquad\qquad t \in \{\tau+1, \tau+2, \ldots T-1\}, \\
v_S^o(T) &= m_1 - e.
\end{aligned}
$$

Solving this relation yields

$$
v_S^o(\tau+1) = \frac{(1-e)\left(1-\delta^{T-1-\tau}\right)}{1-\delta} + \delta^{T-1-\tau}(m_1 - e).
$$

Hence, firm value from setting an actual assured-reputation horizon τ equals $v_S^o(\tau+1)$ plus operating profits up to period τ of $\tau(1-e)$, less the cost of reputation-assuring compensation, $b^*(\tau)$, if $\tau > 0$. Therefore, we can represent shareholder payoffs for each possible value of τ by the function $v_S : \{0,1,\dots T\} \to \mathbb{R}$, where

$$v_S(\tau) = \begin{cases} (1-e)\tau + v_S^o(\tau+1) - \frac{c\delta^{T-\tau}}{1-\delta} & \tau \in \{1,2,\dots T-1\} \\ v_S^o(1) & \tau = 0 \end{cases}. \tag{9}$$

A reputation equilibrium will exist if and only if

$$v_S(T-1) \geq \max\{v_S(\tau) : \tau \in \{0,1,2,\dots T-2\}\}.$$

Simple algebra yields the following proposition about the viability of reputation equilibria.

Proposition 1. *With an informed blockholder and opaque governance, reputation equilibria exist if and only if*

$$m_1 \geq e + \frac{\delta c}{1-\delta}, \text{ and} \tag{a}$$

$$T(1-e)(1-\delta) \geq (1-e)(1-\delta) + \left(1-\delta^{T-1}\right)(1-m_1+\delta(m_1-e)) + c\delta. \tag{b}$$

Inequalities (a) and (b) in Proposition 1 are necessary and sufficient conditions for the existence of reputation equilibria. They show that, holding other parameters fixed, the set of initial monitoring prices that support reputation equilibria must be empty or an interval of the form $(m_1^o, 1)$, where $m_1^o \in (e, 1)$. Thus, as is typical in the KWMR-type reputation framework, increasing θ_1 and m_1 makes it *more* likely that the reputation equilibrium conditions will be satisfied.

The conditions for reputation equilibria in Proposition 1 are intuitive. Consider condition (a). Because governance is opaque, the blockholder can unobservably deviate from reputation-assuring compensation policies. The cost of deviation is the possible loss of future operating profits due to revelation. The higher the monitoring price, the larger the loss. Thus, high customer trust in monitoring is necessary for reputation equilibria to exist.

Now consider condition (b), which captures the effect of firm longevity, T. Since governance is opaque, defection to zero-compensation policies is only detected through revelation. Increasing firm longevity makes revelation more likely if the firm defects to a zero-compensation policy. Since revelation forces the firm to shut down, defecting to zero-compensation becomes more costly relative to sticking with reputation-assuring compensation when the firm is long lived.

4.1 How does this equilibrium behavior compare with a typical reputation model?

Our characterization of reputation equilibrium conditions in Proposition 1 raises an obvious question: Are the equilibrium conditions different from those if the owner were to directly control operating policy and internalize the gain from opportunism as in a typical reputation model? To transparently answer this question we will derive conditions for reputation equilibria when there is no manager and, like an owner-manager, the blockholder picks the production technology and enjoys the private benefit from picking the inferior technology.

Note that the firm must act reputably if it is type-$\mathcal{E}$. Note also that removing the manager from the model will not change the type-$\mathcal{I}$ firm's behavior once it is revealed. Arguments virtually, identical to those we use to establish Lemma 1 establish that goods prices will equal δ once the firm is revealed and that it will shut down.

Suppose the firm is unrevealed and let the function v_O represent the shareholders' continuation value conditioned on the firm being unrevealed and type-$\mathcal{I}$. Then, in period t, the blockholder's payoff from opportunism if the firm is unrevealed equals the firm profit $1-e+c$ plus the expected continuation value, $(1-\delta)\times 0+\delta\, v_O(t+1)$. By acting reputably the blockholder receives the current period payoff of $1-e$ plus continuation value $v_O(t+1)$. If the firm does not operate, the blockholder's payoff equals 0 plus continuation value, $v_O(t+1)$. Hence,

$$v_O(t) = \begin{cases} 1-e+\max\left[v_O(t+1), \delta\, v_O(t+1)+c)\right] & \text{if the firm operates in period } t \\ 0+v_O(t+1) & \text{if the firm shuts down in period } t \end{cases}. \tag{10}$$

Comparing the payoffs from operating the firm and from shutting it down shows that the blockholder will always operate the firm so long as it is unrevealed. Comparing the possible payoffs in the case that the firm operates, we see that the blockholder will act reputably in period t so long as

$$(1-\delta)\, v_O(t+1) \geq c. \tag{11}$$

Since $\max\left[0, 1-e\right] \geq 0$, equation (10) shows that

$$v_O(t) \geq v_O(t+1). \tag{12}$$

Thus, the blockholder will act opportunistically in every period or there will exists an assured-reputation horizon $\tau \leq T-1$ such that the blockholder will act reputably for all $t \leq \tau$ and act opportunistically in all $t > \tau$; the firm will be revealed at the start of period $t+1$ with probability $1-\delta$ and remain unrevealed with probability δ.

In a reputation equilibrium $\tau = T-1$. Equation (11) shows that this will be the case so long as $(1-\delta)\, v_O(T) \geq c$, The following proposition describes this condition.

Proposition 2. *When the blockholder directly controls firm technology, reputation equilibria exist if and only if*

$$m_1 \geq e + \frac{\delta c}{1-\delta} \tag{13}$$

A comparison of Propositions 1 and 2 shows that, whether or not the blockholder directly controls the technology choice, the initial monitoring price, m_1, must satisfy a common requirement which is described in equation (13). However, reputation equilibrium conditions are more restrictive when the blockholder does not directly control the technology choice because there is also a restriction on the time horizon T. When T is sufficiently small, a reputation equilibrium can exist when the owner directly controls the technology choice but not when the the control is indirect. When T is sufficiently large so condition (b) in Proposition 1 is satisfied, a reputation equilibrium will exist when the blockholder directly controls the technology choice if and only if there is a reputation equilibrium when the choice is controlled by the manager. Thus, when the time horizon is sufficiently long and the blockholder is an insider, the principal-agent problem between the blockholder and manager has no impact on the firm's ability to sustain its reputation.

5 Governance transparency and the inference channel

By assuming that governance is opaque we have isolated and focused on the role of the managerial behavior channel. The inference channel will operate if governance is transparent: Customers will draw inferences about the quality of goods, manager behavior, and what the blockholder knows about the firm's type from the governance policy that the blockholder chooses. This raises the following question: How does the inference channel affect viability of reputation equilibria? We will demonstrate that the inference channel dramatically changes the viability of reputation equilibria and its effect depends on the blockholder's information.

5.1 The inference channel when the blockholder is informed

An informed blockholder has an incentive to choose governance policies to manipulate customers' beliefs about the firm's type. There exist Perfect Bayesian Equilibria (PBEs) that support just about any compensation policy, even reputation equilibria. To see this consider a candidate equilibrium in which the firm offers reputation-assuring compensation regardless of its type. Any other governance policy is off the equilibrium path and customer beliefs in response to deviation from the equilibrium path cannot be determined by Bayes rule. Suppose customers believe that, if the firm deviates, monitoring is ineffective with probability 1 so the firm cannot operate profitably. Because offering reputation-assuring compensation will yield positive operating profits, deviating is not a best response for the blockholder even if monitoring is effective.

The off-equilibrium beliefs that support this candidate equilibrium are odd: Customers infer from the failure to pay compensation that monitoring is ineffective. However, compensation helps deter opportunism only when monitoring is ineffective and, abstracting from its effect on customer beliefs, compensation does not benefit shareholders when monitoring is effective.

To obtain a more determinant notion of viability of reputation equilibria, we must impose restrictions on off-equilibrium beliefs (i.e., refinement criteria). The most established and accepted refinement criteria impose restrictions on off-equilibrium beliefs in static signaling games. To adopt such a refinement, we reframe our model as concatenation of an initial "signaling game" followed by "production games." The shareholders' payoff associated with each signal in the signaling game is determined by the payoff resulting from a production game following the signal. We defer a detailed description of this framework and formal analysis to the appendix and only present an intuitive discussion here.[10]

In the signalling game, the blockholder selects a "signal," i.e., a governance policy. Each production game, a subgame whose initial node is the signal chosen in the signaling game, begins with the blockholder's shut-down choice in period one. In each production game the blockholder and manager act exactly as we have described in Section 2: Each period, the blockholder chooses whether the firm operates and the manager decides whether to act opportunistically. The only difference is that, at the start of the production game, customer beliefs are given by their assessment of monitoring in the signaling game. These beliefs are subsequently updated according to Bayes rule whenever the governance policy is on the equilibrium path.

We adopt the standard D1 refinement (e.g., Cho and Kreps, 1987). We consider a signaling game equilibrium a D1 equilibrium if it is a PBE of the signaling game supported by off-equilibrium beliefs that are consistent with the D1 refinement. If the equilibrium outcomes in the production games following each signal selected with positive probability are reputation outcomes, i.e., the firm produces in all periods and produces high quality output in all periods except, perhaps, period T, then we will refer to the equilibrium as a *D1 reputation equilibrium*.

The production games are complex dynamic games of incomplete information. However, to obtain our characterization of the signaling game, we only need a very general, limited, characterization of these games. Thus, in the production games, we impose only one very standard restriction on off-equilibrium beliefs—NDOC, "never dissuaded once convinced" (page 94 Osborne and Rubinstein, 1990). NDOC stipulates that beliefs at histories off the equilibrium path satisfy the following condition: If the actions of an informed agent lead to a history at which an uninformed agent assigns a probability of 1 to the informed agent having a given type, no subsequent actions by that informed agent can change the uninformed agent's beliefs about the informed agent's type. NDOC is a very weak, and very commonly imposed, restriction on off-equilibrium beliefs in dynamic games of incomplete information (e.g., Malcomson, 2016). Bayes rule implies that NDOC is automatically satisfied for histories on the equilibrium path. Our next result, Proposition 3 provides a sufficient condition which assures that no D1 reputation equilibria exist.

Proposition 3. *If the blockholder is informed and governance is transparent, then, whenever*

$$(T-2)(1-e)+\left(m_1-e-\frac{c\delta}{1-\delta}\right)>0, \tag{14}$$

D1 reputation equilibria do not exist.

Proposition 3 shows that reputation equilibria consistent with the D1 criterion do not exist when condition (14) is satisfied. The reasoning is as follows: If monitoring is ineffective (type-$\mathfrak{I}$), the blockholder must avoid any action that reveals its information in order for the firm to operate profitably. Thus, reputation equilibria must be pooling equilibria with reputation-assuring compensation (henceforth termed "pooling equilibria"). Because reputation ensuring compensation, aside from its inferential effects, does not benefit

[10] Formally developing this framework earlier, in Section 2, would have required us to navigate unnecessary complications to establish our prior results.

type $\mathcal{E}$, if customers believe that defection from a pooling equilibrium indicates that the firm is type $\mathcal{E}$, then type $\mathcal{E}$ will defect, and thus no reputation equilibria, will exist. Condition (14) ensures that these are the only beliefs about defection consistent with the D1 refinement.

According to the D1 refinement, defections from the pooling equilibria will convince customers that the firm is type $\mathcal{E}$ if the weak defection set of type-$\mathcal{I}$ (i.e.,the set of customer responses under which defection produces a payoff at least as large as the equilibrium payoff) is a subset of the strong defection set of type-$\mathcal{E}$ (i.e., the set of customer responses under which defection produces a payoff greater than the equilibrium payoff). This condition is always satisfied if a defection triggers customer off-equilibrium beliefs that permit the firm to operate profitably for more than one period: Because operating without reputation ensuring compensation imposes the cost of revelation on type $\mathcal{I}$ but not type-$\mathcal{E}$, any defection that weakly increases type $\mathcal{I}$'s payoff strictly increases type-$\mathcal{E}$'s payoff.

However, there exist customer beliefs consistent with NDOC, the only restriction we impose on off-equilibrium beliefs, under which it is optimal for the firm to produce only in period 1. For example the customer belief that, if the firm produces in any period after period 1, it is type $\mathcal{I}$ with probability 1. We refer to such beliefs as no-future production (NFP) beliefs. Given NFP beliefs, revelation following defection has no effect on shareholder payoffs, and the strong defection set of type-$\mathcal{E}$ does not contain the weak defection set of type-$\mathcal{I}$. Thus, no D1 pooling equilibria will exist only if it is never a best response for type $\mathcal{I}$ to defect in response to customer's NFP beliefs.

This is why a long time horizon matters. Given a customer response based on NFP beliefs, type $\mathcal{I}$'s gain from defection is saved compensation payments and perhaps a higher goods price in the first period. After that, the firm shuts down. Along the equilibrium path, reputation assuring compensation is paid and the firm operates for T periods. If T is sufficiently large, operating for T periods with reputation-assuring compensation produces a higher payoff than operating only in the first period without reputation ensuring compensation even if the first-period good price is high. In this case, the D1 condition ensures that customers' beliefs cannot support pooling equilibrium and hence, reputation equilibria do not exist.

The following corollary shows that the equilibrium condition (14) is always satisfied when the firm's first-best per period operating profit, $1-e$, is sufficiently large.

Corollary 1. *If the blockholder is informed, governance is transparent, and*

$$e < \frac{T-2}{T-1},$$

the hypothesis of Proposition 3, equation (14)*, is satisfied. Consequently, no reputation equilibria satisfying the D1 refinement exist.*

Thus, when governance is transparent, a firm may not be able to sustain its reputation when its controlling blockholder knows the firm's type, as is the case with a maverick whose wealth is concentrated in the firm and is likely to be intimately familiar with the firm's operations. Longevity makes it near impossible to sustain firm reputation as does a highly profitable production technology. Previously we showed that the managerial behavior channel can enable the firm to sustain reputation. Thus, the inference channel can completely undermine the managerial behavior channel. Consequently, delegating control of operating decisions to a professional manager can completely undermine the firm's ability to sustain its reputation.

5.2 The inference channel when the blockholder is uninformed

Clearly, governance transparency undermines the firm's ability to sustain its reputation when the blockholder is informed. Is this also the case when the blockholder, like customers, is uninformed and does not know the effectiveness of monitoring? This information structure, in which the blockholder knows less about the firm than the manager, fits firms like Boeing, Broadcom and Target that are controlled by large institutional investors (e.g., BlackRock, Fidelity) with significant share blocks in many companies. We will show that when the blockholder is an uninformed outsider, governance transparency has a fundamental effect on manager and blockholder behavior that completely transforms the calculus of firm reputation and helps sustain firm reputation.

We assume that the uninformed blockholder's actions cannot change customer beliefs about monitoring. Of course, Bayes rule assures that this must always be the case along the equilibrium path. We restrict attention to equilibria in which the uninformed blockholder's actions will not affect customer beliefs off the equilibrium path as well. Customer beliefs that do not satisfy this restriction are inconsistent with the criteria for a Perfect Sequential Equilibrium (Kreps and Wilson, 1982b). Perhaps more importantly, they are obviously not very sensible.

Consider the uninformed blockholder's choice of contract for the manager when governance is transparent. Firm profitability, gross of payments to the manager, will be higher when customers expect higher quality. The blockholder could rely solely on monitoring to maintain quality. However, monitoring may be ineffective. Contracting with the manager can control opportunism and reputation risk even when monitoring is ineffective. Because of the inference channel, the blockholder knows that customers will infer the assured-reputation horizon, τ, from the compensation contract it offers the manager. In periods 1, 2, $\ldots\tau$, customers will anticipate that the manager will act reputably and set goods prices equal to 1. In periods $\tau+1$ onwards prices will equal monitoring prices so long as the firm remains unrevealed.

Given Lemma A-3, the lowest cost bonus payment securing the reputation-assured horizon τ, $b^*_{\tau+1}$, which we describe in Lemma 3, is increasing in τ. Hence, the blockholder's optimal contracting problem reduces to trading off this higher cost against the benefit of increasing the assured-reputation horizon τ. The benefit takes two forms: Postponing the risk of revelation and shutting down the firm, and raising customers' quality expectations and goods' prices until period τ.

Based on the tradeoff it faces, the blockholder may choose to not protect the firm's reputation for even one period and offer the manager no compensation. It might also choose to offer a contract that deters opportunism for only a few periods. When the condition in the following proposition is satisfied, the blockholder will choose $T-1$ as the assured-reputation horizon and a reputation equilibrium is sustainable.

Proposition 4. *If the blockholder is uninformed and governance is transparent, then, whenever*

$$m_1 < 1 - \frac{c\delta}{(1-e+\delta)(1-\delta)}, \tag{15}$$

the firm will offer the manager a payment of $(c\delta)/(1-\delta)$ *in period* T *conditional on the firm remaining unrevealed at the start of period* T. *The manager will not act opportunistically in any period before* T.

Proposition 4 demonstrates that the firm can attain a reputation equilibrium with ineffective monitoring and an uninformed controlling blockholder. Comparing this result with Propositions 1 and 3 shows that the conditions for reputation equilibria are quite different when the blockholder is uninformed and governance policy is transparent. The reason for this differences is the role of the inference channel.

First consider the role of the initial level of customer trust in monitoring. Proposition 1 shows that the initial level of trust must be high to sustain reputation equilibria when the blockholder is informed and governance is opaque. In contrast, expression (15) demonstrates that reputation equilibria exist only if m_1 is sufficiently small. The exact level of m_1 depends on firm profitability $(1-e)$ and its production technology (δ and c). Since m_1 is increasing in θ_1, reputation equilibria will exist when initial trust in monitoring is sufficiently low. This is intuitive: The shareholders' gain from assuring customers about the quality of goods, $p_t - m_1$, is largest when trust in monitoring is low.

If trust in monitoring starts sufficiently high, the blockholder optimally eschews incentive compensation. Instead, it relies only on monitoring to maintain product quality and firm reputation. Over this range, monitoring crowds out incentive compensation, and firm reputation is monotonically increasing in the level of trust in monitoring. However, increased reliance on monitoring leads to the possibility of opportunism. Therefore, firm reputation is lower when trust in monitoring is high than when trust is low. Moreover, opportunism can destroy trust only when the initial level of trust is high.

Now consider the role of the firm's time horizon. When the blockholder is informed, a long horizon facilitates reputation equilibria when governance policy is opaque and completely undermines reputation equilibria when the policy is transparent. In contrast, the reputation equilibrium condition (15) in Proposition 4 does not depend on T and firm longevity. Ensuring reputable behavior in period T automatically ensures reputable behavior in previous periods. Since the marginal gains from increasing the assured reputation horizon are decreasing, whether it is optimal to follow the reputation equilibrium strategy, only depends on whether ensuring reputation until T produces a larger payoff than ensuring reputation until $T-1$. The cost of assuring reputation is compensation, and the compensation required to ensure reputation depends on the number of periods remaining but not the number of preceding periods. Thus, whether T equals two or two hundred has no effect on the optimality of ensuring reputation until T.

Independence of firm reputation from the time horizon results from special features of the uninformed blockholder/transparent governance setting: customers can observe the manager's compensation contract, learn the assured-reputation horizon, and correctly price goods based on the firm's equilibrium commitment to ensuring reputation until period T. Off-equilibrium deviations from this commitment are also correctly priced.

6 Tying up loose ends

For analytical convenience, we have assumed that the manager is always retained, contracts are simple, an uninformed blockholder doesn't get the manager to reveal information about monitoring, and the effectiveness of monitoring is exogenously fixed. We now show that our results are robust to changing these assumptions.

6.1 Replacing the manager

We start with manager replacement. Lemma 1 shows that the manager is effectively fired when the firm is revealed. For this reason, the effect of allowing managerial replacement on our analysis depends on the effect of replacing the manager in a period in which the firm is unrevealed.

We need to consider both the ex ante (before the firm begins operating) and ex post (in and after the period the manager is replaced) effects of replacement. Because (i) managers are hired from a pool of identical agents and (ii) monitoring effectiveness is a manager-independent property of the firm, replacement has no effect on the efficiency of firm operations. As we have shown in Section 3.3, a manager's opportunism decision depends on the balance between the manager's current gain from opportunism, c, and the manager's continuation value. Holding compensation constant, anticipated replacement lowers the manager's continuation value. Thus, for a given reputation-assurance horizon, if the firm replaces the manager it must increase his compensation to ensure that the manager's incentive compatibility condition for reputable behavior (inequality (2)) remains satisfied. Hence, ex ante, replacing managers when the firm is unrevealed is inefficient.

The ex post incentive to replace managers will depend on whether replacement is verifiable. If it is not verifiable, then the replaced manager would continue to receive contracted payments based on whether the firm is revealed in periods after the manager's replacement, even though the replaced manager's actions have no effect on goods' quality. In this case, replacing the manager is clearly not optimal.

If replacement is verifiable, then contracts conditioned on replacement can be offered. For example, "golden parachutes," extremely large bonus payments contingent on the manager being replaced while the firm is unrevealed. Such contracts would ensure that, ex post, the firm will not replace the manager when the firm is unrevealed. Given that, ex post replacement along the equilibrium path reduces shareholders' ex ante payoff, adopting such golden parachute provisions would be optimal. With a golden parachute, replacement of unrevealed managers would be off the equilibrium path and would not affect shareholder equilibrium payoffs. Hence, our characterizations of the conditions for the existence of reputation equilibria would not change if we extend the model to permit managerial replacement.

6.2 Complex contracts

We have assumed that the manager receives a simple contract that can be represented by a vector $\boldsymbol{b} = (b_1, b_2, \ldots b_T)$, where b_t denotes a non-negative payment to the manager in period t conditioned on the firm being unrevealed in period t. Remark 1 in Section 3.4 showed that such contracts can be implemented by price-history dependent contracts. We now show that loosening this restriction and allowing the blockholder to use any price-history dependent "complex contract" does not affect our results.

Obviously, contracts that specify positive payouts conditioned on the firm being revealed are not optimal. First, such contracts incentivize the manager to act opportunistically. Second, the firm cannot profitably operate once revealed, thus the firm has no interest in incentivizing the manager after revelation. Hence, we can restrict attention to complex contracts that specify a non-negative payment to the manager at each date conditioned on (1) the firm being unrevealed at that date and (2) the price of the good on the unrevealed path. Let $\mathcal{C}$ represent a complex contract, then

$$\mathcal{C} = (\mathcal{C}_1, \mathcal{C}_2, \dots \mathcal{C}_T), \quad \mathcal{C}_t = \mathcal{C}_t(p_1, p_2 \dots p_t), \, t \in \{1, 2, \dots T\}.$$

In the informed blockholder/transparent governance setting, we argue that reputation equilibria generally cannot be sustained. Our argument relies on ruling out the off-equilibrium-path belief "if the firm provides reputation-assuring compensation, then the blockholder knows monitoring is effective." To rule out this belief, we use the standard D1 off-equilibrium belief refinement and the following feature of our model: if monitoring is effective, reputation-assuring compensation is redundant. Hence, our analysis of informed blockholder/transparent governance is largely independent of the simple-contract assumption. Consequently, we focus our discussion of complex contracts on the other settings we consider.

As we detail in Section B.1 of the appendix, extending the contract space to include complex contracts has no effect on the conditions for reputation equilibria provided in Propositions 1 and 4. No complex contracts exist that provide a strictly higher ex ante payoff to shareholders than every simple contract.

The underlying logic for this result is that, in any equilibrium in which the blockholder follows the policy of operating whenever the firm is unrevealed, a simple contract that fixes the bonus to the manager equal to the payment the manager receives from the complex contract given the path of unrevealed prices provides the manager exactly the same incentives as the complex contract. As we show in the appendix (Lemmas A-1 and A-3), shutting down an unrevealed firm is never a best response for the blockholder under simple contracts. Thus, both the manager's opportunism policy and the blockholder's shut-down policy are the same under this simple contract and the complex contract. Hence, the shareholders' payoff is the same as well.

When governance is opaque, customers' beliefs about the effectiveness of monitoring only adjust in response to revelation. Contracted payments are only made on the unrevealed path. Thus, shutting down when unrevealed is never a best response for the blockholder in any equilibrium. This argument establishes payoff equivalence between simple and complex contracts when governance is opaque.

When governance is transparent and the blockholder is uninformed, customers observe the compensation contract and infer from it the assured-reputation horizon, τ. Hence, in periods after τ, the operate/shut down decision affects the unrevealed price path. For this reason, complex contracts can make shutting down on the unrevealed path a best response ex post. However, such contracts are suboptimal because shutting down an unrevealed firm is not ex ante optimal for shareholders. For each such complex contract, there exists a simple contract which produces a higher equilibrium shareholder payoff. Therefore, expanding the contract space would not affect our characterizations of reputation equilibria.

6.3 Contracting and revelation

An uninformed blockholder must devise compensation policies without knowing whether monitoring is effective. Offering the manager reputation-assuring compensation is unnecessary and wasteful if monitoring is effective. Thus, if the blockholder could learn the effectiveness of the control system, ignoring inferential effects, it could design more efficient managerial compensation contracts.

As the Revelation Principle shows, without any loss of generality, revelation could be induced by offering the manager a menu of two contracts, each associated with a report of one of the two possible monitoring types, effective, $\mathcal{E}$, and ineffective, $\mathcal{I}$ (Myerson, 1989). However, the role of revelation through contracting is limited in our setting because type information is only valuable to shareholders in so far as it can be used to limit rent accruing to the manager.

Excluding effects on customer inferences, the revelation of monitoring effectiveness from separating contracts has no value to shareholders. The reason is that knowing monitoring effectiveness *after managerial compensation is fixed* will not affect the blockholder's or manager's actions in equilibrium. We discuss this in more detail in Section B.2 of the appendix. The gist of our argument is as follows: Shut-down policy decisions are the only decisions the blockholder makes after the manager's contract is fixed. In the appendix (Lemmas A-1 and A-3) we show that the blockholder's optimal shut-down policy is to shut down the firm once it is revealed and let the firm operate if it is unrevealed. This is independent of whether the blockholder knows monitoring effectiveness. Similarly, the manager's choice between reputable and opportunistic behavior depends only on the balance between compensation and private benefits, which does not vary with the blockholder's information.

With transparent governance, contracts have inferential effects that block revelation. When compensation contracts vary with the manager's private information about the effectiveness of monitoring, customers can learn whether monitoring is effective by observing the contract selected by the manager. Thus, the manager will reveal that monitoring is ineffective by picking the contract from the menu conditioned on the report that monitoring is type $\mathcal{I}$. By Lemma 1, the firm would not operate in any period and the manager would be denied the opportunity to earn private benefits. Because the manager can always enjoy private benefits from managing the firm if the firm operates for at least one period, the manager's payoff would always be greater, even in the absence of any bonus rewards, if the manager reports that monitoring is type $\mathcal{E}$ when, in fact, it is not. Hence, the manager choosing the contract conditioned on the report that monitoring is ineffective would not be incentive compatible.

6.4 Endogenous monitoring

Commitment to the reliable technology may be underpinned by a firm culture that imposes prohibitive non-pecuniary costs on the manager for adopting the unreliable technology (Kreps, 1996), the firm's ability to select managers with a strong preference for using the reliable technology (Bénabou and Tirole, 2010), or monitoring of managers' actions. Controlling blockholders can try and change firm culture, manager selection and monitoring effectiveness. This raises obvious questions: What is the blockholder's optimal culture/selection/monitoring policy in our reputation setting? Does it support or impede reputation equilibria? A complete analysis of these questions is beyond the scope of this paper but we provide a brief and intuitive discussion in the context of the following framework.

For the purposes of this discussion let us focus on monitoring policy and adopt the following framework: When the blockholder chooses the governance policy it can also *upgrade* monitoring. An upgrade does not affect monitoring if it is already effective but, it converts ineffective monitoring into effective monitoring with a positive probability. Let γ represent the intensity with which the blockholder attempts the upgrade and the probability that the upgrade succeeds. Uninformed agents believe that, without an upgrade, monitoring is effective with probability $\bar{\theta}$ that exactly satisfies Assumption 2, i.e., $\bar{\theta} = e$. After an upgrade of intensity γ, they will expect monitoring to be effective with probability $\theta_1 = \bar{\theta} + (1-\bar{\theta})\gamma$.

Consider our baseline setting with the informed blockholder and opaque governance. Suppose that monitoring policy is also opaque, so customers cannot observe monitoring upgrades but will conjecture the monitoring policy. In Proposition 1 we characterize conditions on θ_1 that support reputation equilibria. Such an equilibrium exists only when it is unprofitable for the blockholder to (unobservably) lower the assured-reputation horizon from $T-1$. Consider a defection to the assured-reputation horizon $T-2$. Defecting lowers the cost of compensation but induces a positive probability of revelation in period $T-1$. Proposition 1 establishes conditions in which the savings on compensation are inadequate to induce the defection when monitoring policy is fixed. Now the defection will be accompanied by a monitoring upgrade since the marginal benefit of monitoring rises as the assured-reputation horizon shrinks. However, so long as upgrading monitoring further is sufficiently costly, monitoring policy will not change sufficiently to make defection profitable. Thus, reputation equilibria will continue to exist with an informed blockholder and opaque governance.

What is the effect of making monitoring policy transparent? When the blockholder is informed, transparency of monitoring policy will hinder reputation equilibria. The reasoning is similar to that underlying Proposition 3: If upgrading monitoring is costly, the blockholder will not want to upgrade if monitoring is secure. Hence, an upgrade will reveal that monitoring is insecure, which will prevent reputation equilibria.

What if the blockholder is uninformed? Now an upgrade will signal commitment to restricting manager opportunism. This signal will raise customers' trust in monitoring. Consequently, after the assured-reputation horizon, goods' prices will rise and the probability of revelation will fall. As condition (15) in Proposition 4 demonstrates, the firm will attain a reputation equilibrium without a monitoring upgrade. Hence, when γ is small, commitment to monitoring via a monitoring upgrade only benefits the firm in period T. Once θ_1 is sufficiently high, the assured-reputation horizon falls below $T-1$, and the firm will reduce the expected compensation payment to the manager. Thus, in essence, the blockholder must choose whether to commit to use more effective monitoring instead of compensation to protect firm reputation. Clearly when monitoring upgrades are sufficiently costly, the blockholder will either not upgrade monitoring or make upgrades that are small enough so that condition (15) continues to be satisfied and the firm attains a reputation equilibrium. When upgrading monitoring is cheap, the blockholder will substitute monitoring for reputation-assuring compensation. The assured-reputation horizon will fall below $T-1$ unless attaining perfectly effective monitoring, i.e., setting $\theta_1 = 1$, is cheap.

7 Discussion

In this paper, we embed a principal-agent conflict within a standard incomplete information/hidden action reputation setting. The model allows us to identify and analyze two channels through which governance affects firm reputation: (1) governance directly shapes managerial behavior, creating a *managerial behavior channel* and (2) when external stakeholders observe governance policies, it creates an *inference channel*. Because of the inference channel, governance policy choices directly affect external stakeholders' perceptions of the firm and, thus, determine the firm's reputation.

Our analysis shows that maximizing firm value is often not consistent with adopting governance policies that sustain firm reputation even when firm value is derived entirely from its reputation with outside stakeholders. There do exist conditions under which a value maximizing firm will adopt governance policies that will block opportunistic managerial actions and sustain firm reputation. These conditions, and the effects of the inference channel, vary with the information environment both within and outside firms. They reflect firm profitability, monitoring effectiveness, and production technology. Firm longevity also matters.

When governance is transparent and controlling blockholders are uninformed about the effectiveness of internal monitoring, policies intended to alleviate the agency conflict signal to the outside stakeholders the firm's commitment to ensuring that they will not fall victim to the conflict. This commitment helps sustain firm reputation through the inference channel. The inference channel works quite differently when controlling blockholders are informed and monitoring is deficient: Governance policies aimed to shore up monitoring signal this deficiency to outside stakeholders. By blocking these signals, governance opacity helps sustain firms' reputations. Consequently, when controlling blockholders are informed, reputation is more likely to be sustained if the inference channel is shut down and blockholders can act confidentially.

Although governance policies help sustain firm reputation both when controlling blockholders are informed and when they are not, the adoption of policies is motivated by markedly different considerations: An informed blockholder wants to harness only the managerial behavior channel and the direct incentive effects of the policies. In contrast, an uninformed blockholder also wants to use the inference channel to signal to outside stakeholders its commitment to alleviating owner/manager agency conflict. Consequently, the economic conditions under which governance policies sustain reputations are quite different in the two information settings. When blockholders are uninformed and governance is transparent, reputations can be sustained when customers' initial trust in monitoring is low. Firm longevity doesn't matter. When blockholders are informed and governance is opaque, reputations can be sustained only when initial trust in monitoring is high. Firm longevity favors reputation sustainability.

Controlling blockholder information will tend to vary with the blockholders' identities. For example, controlling blockholders at privately or family-owned firms are likely to be intimately familiar with the firms and their day-to-day operations. This is less likely when the controlling blockholders are common or universal owners, institutional investors like BlackRock that control large blocks in many firms. Thus, our results suggest that regulations regarding disclosures will tend to have very different effects on the abilities of private/family owned firms and firms controlled by common/universal owners to sustain their reputations. Moreover, the conditions under which they can sustain reputations will also be quite different.

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Online Appendix:

Firm reputation and agency:

Information environments, corporate governance and its optics

A Proofs of results

Proof of Lemma 1. Proof of Claim (i). The period T price of the good is determined before the firm makes its operate/shut down decision and the manager makes the technology choice. Thus, since T is the final period, any compensation the manager receives at date T is independent of the manager's date T actions. Suppose the firm operates. If the manager acts opportunistically, then, when monitoring is ineffective, the manager captures the private benefit c. If the manager does not act opportunistically, the manager will not receive the private benefit when monitoring is ineffective. Therefore, the manager maximizes his payoff in period T by acting opportunistically in period T.

Proof of Claim (ii). If the firm is revealed in period T, customers know the manager will choose the unreliable technology. Thus, the price of the period T good equals δ. By Assumption 1, $\delta < e$. Thus the shareholders' period T payoff from operating equals $\delta - e < 0$. Shutting down produces an operating profit of 0. Hence shutting down is optimal.

Proof of Claim (iii). Suppose the firm operates in period $T-1$ and the firm is revealed. Customers know that the manager will act opportunistically in period T. This fixes the price of the period T good at δ. Claim (ii) shows that the firm will shut down in period T. Thus, the manager knows that he will receive no private benefits in period T. Prices up to and including period $T-1$ are fixed at the time the manager makes his technology choice in period $T-1$. The good's price in T is fixed at δ regardless of the period $T-1$ good's quality. Thus, the manager's actions in period $T-1$ will have no effect on the compensation payment the manager receives in period T. Acting opportunistically in period $T-1$ ensures that the manager will capture the private benefit c in period $T-1$ and acting reputably ensures that the manager will not capture the private benefit. Thus, if the firm is revealed in $T-1$ the manager will act opportunistically. Backward induction extends this argument back to the first period in which the firm is revealed.

Proof of Claim (iv). Claim (iii) in Lemma 1 establishes that, if the firm is revealed, the price of the period t good will equal δ. By Assumption 1, period t production is not profitable if the period t good's price is δ. Therefore, if the firm is revealed in period t, the firm will shut down in period t. If the firm is revealed in period t, it will be revealed in all subsequent periods. Thus, the firm will shut down in all subsequent periods. □

Proof of Lemma 2. Proof of Claim (i). The proof follows by noting that the manager will act reputably in period t if and only if inequality (2) is satisfied in period t. If this inequality is not satisfied for any $t \in \{1,2,\dots T\}$ then the manager will act opportunistically in every period and $\tau = 0$. Otherwise $\tau > 0$. Let t' be the last period in which inequality (2) is satisfied. Inequality (3) shows that $v_M(t) \geq v_M(t')$ for all $t \in \{1,2,\dots t'-1\}$. Hence, $\tau = t'$ since inequality (2) will also be satisfied in every period before t'.

Proof of Claim (ii). Since the manager will act opportunistically and capture the private benefit c in period T, $v_M(T) = c + b_T$. Inequality (2) indicates that the manager will act reputably in period $T-1$ if and only if $(1-\delta)(c+b_T) \geq c$. Thus, the minimum period T payment to the manager that ensures he will act reputably in period $T-1$ is given by $b_T = c\delta/(1-\delta)$. Since Claim (i) ensures he will act reputably in every preceding period, $T-1$ is the assured-reputation horizon. □

Proof of Lemma 3. Suppose that the assured reputation horizon is $1 \leq \tau < T$. Then, by the definition of the assured reputation horizon, when monitoring is ineffective, the manager will act opportunistically in all periods $\{\tau+1, \tau+2, \dots T\}$ and will act reputably in all periods $\{1, 2, \dots, \tau\}$. Because the manager will act opportunistically from $\tau+1$ onwards, the manager's value function, in period $\tau+1$, when the firm is unrevealed is given by

$$v_M(\tau+1) = \sum_{j=0}^{T-(\tau+1)} (c + b_{\tau+1+j})\,\delta^j = c\,\frac{1-\delta^{T-\tau}}{1-\delta} + \sum_{j=0}^{T-(\tau+1)} b_{\tau+1+j}\,\delta^j.$$

The incentive compatibility condition, equation (2), thus implies that

$$(1-\delta)\left(c\,\frac{1-\delta^{T-\tau}}{1-\delta} + \sum_{j=0}^{T-(\tau+1)} b_{\tau+1+j}\,\delta^j\right) \geq c$$

which is equivalent to

$$\sum_{j=0}^{T-(\tau+1)} b_{\tau+1+j}\,\delta^j \geq \frac{c\delta^{T-\tau}}{1-\delta}. \tag{A.1}$$

Next, define $\boldsymbol{\delta}_\tau$, $\mathbb{1}$, and $\mathbb{1}_\tau$ as follows:

$$\begin{aligned}
\boldsymbol{\delta}_\tau &= (\overbrace{0, 0 \dots, 0}^{\tau}, \overbrace{1, \delta, \delta^2, \dots \delta^{T-(\tau+1)}}^{T-\tau}), \\
\mathbb{1} &= (\overbrace{1, 1, \dots, 1, 1}^{T}), \\
\mathbb{1}_\tau &= (\overbrace{1, 1, \dots 1}^{\tau}, \overbrace{0, 0, \dots, 0}^{T-\tau}).
\end{aligned} \tag{A.2}$$

Ex ante, for a fixed reputation assurance horizon, the blockholder will minimize expected compensation to the manager. The expected compensation to the manager when monitoring is effective equals $\mathbb{1} \cdot \boldsymbol{b}$, where "$\cdot$" represents the inner product of the two vectors. Expected compensation payments when monitoring is ineffective and the assured-reputation horizon equals τ equals $(\mathbb{1}_\tau + \boldsymbol{\delta}_\tau) \cdot \boldsymbol{b}$. Using equation (A.1), the ex ante incentive compatibility constraint on the simple contract design, can be expressed as $\boldsymbol{\delta}_\tau \cdot \boldsymbol{b} \geq c\delta^{T-\tau}/(1-\delta)$. Because the ex ante probability that monitoring is effective equals θ_1, an optimal simple compensation contract for implementing a period τ assured-reputation horizon is a solution to the problem P_τ defined below.

$$\mathrm{P}_\tau: \quad \underset{\boldsymbol{b} \geq 0}{\mathrm{Min}} \quad \Big(\theta_1 \, \mathbb{1} + (1-\theta_1)\,(\mathbb{1}_\tau + \boldsymbol{\delta}_\tau)\Big) \cdot \boldsymbol{b} \tag{A.3}$$

$$\text{s.t.} \quad \boldsymbol{\delta}_\tau \cdot \boldsymbol{b} \geq \frac{c\delta^{T-\tau}}{1-\delta}. \tag{A.4}$$

If

$$\Big(\theta_1 \, \mathbb{1} + (1-\theta_1)\,(\mathbb{1}_\tau + \boldsymbol{\delta}_\tau)\Big) \cdot \boldsymbol{b} < \frac{c\delta^{T-\tau}}{1-\delta},$$

then, because $\boldsymbol{\delta}_\tau \leq \theta_1 \, \mathbb{1} + (1-\theta_1)\,(\mathbb{1}_\tau + \boldsymbol{\delta}_\tau)$ it must be the case that

$$\boldsymbol{\delta}_\tau \cdot \boldsymbol{b} < \frac{c\delta^{T-\tau}}{1-\delta},$$

and thus the ex ante incentive compatibility constraint, equation (A.4), is violated. Hence, the value of the objective function in any solution to P_τ must at least equal $c\delta^{T-\tau}/(1-\delta)$. Now consider the simple contract $\boldsymbol{b}^*$ defined by $b_t^* = 0$ if $t \neq \tau+1$ and $b_{\tau+1}^* = c\delta^{T-\tau}/(1-\delta)$. Using the definitions in equation (A.2), we see that

$$\Big(\theta_1 \, \mathbb{1} + (1-\theta_1)\,(\mathbb{1}_\tau + \boldsymbol{\delta}_\tau)\Big) \cdot \boldsymbol{b}^* = \frac{c\delta^{T-\tau}}{1-\delta},$$
$$\boldsymbol{\delta}_\tau \cdot \boldsymbol{b}^* = \frac{c\delta^{T-\tau}}{1-\delta}.$$

Thus, $\boldsymbol{b}^*$, the simple contract specified in Claim (3), satisfies the incentive compatibility constraint, equation A.4, and attains a lower bound of the objective function in P_τ and thus is an optimal solution to P_τ.

Remark A-1. Note that the same demonstration is valid if we replace θ_1 with 0 in problem P_τ. Thus, the characterization of optimal contracts provided by Claim (3) for an uninformed blockholder is also valid when a blockholder is informed.

□

Lemma A-1. *When the blockholder is informed and governance is opaque, if customers believe that the firm will act reputably whenever the firm is unrevealed, shutting down the firm when the firm is unrevealed is never optimal.*

Remark A-2. Note that, under a simple contract, conditioned on the firm being unrevealed in period t, the blockholder's operating decisions in periods preceding t do not affect the manager's compensation payment in period t. Operating decisions only affect the probability that the firm will remain unrevealed. When the manager would have acted opportunistically in period t, shutting down the firm in period t increases the probability that the firm will be unrevealed in period $t+1$ by preventing the manager from acting opportunistically in period t. If the manager would have acted reputably had the firm operated, then, regardless of whether the firm operates in period t, in period $t+1$ the firm will be unrevealed. Hence, the probability that the firm will be unrevealed at $t+1$ is weakly higher if the firm shuts down in period t. For this reason, future expected compensation payments to the manager will be weakly increased by shutting down the firm in period t. Moreover, the operating decision in period t has no effect on compensation paid in period t.

Proof of Lemma A-1. The shareholders' payoff when the firm is unrevealed in period t equals the gross payoff less expected compensation payments in period t and future periods. Thus, to show that shutting down the firm when it is unrevealed is not a best response for the blockholder, we need only show that shut down reduces the shareholder gross payoff, which we represent by v_S^o.

The desired result is obvious when either (a) the blockholder knows that monitoring is effective, (b) the manager will act reputably in period t, and (c) $t = T$. So, consider the case where the manager acts opportunistically in period $t < T$.

We show that operating increases the shareholders' gross payoff by a simple induction argument. First consider period $T-1$. If the firm operates in period $T-1$, the shareholder's gross payoff at $T-1$ will equal

$$(1-e)+\delta\, v_S^o(T) = (1-e)+\delta\,(m_1-e).$$

If the firm shuts down, its gross payoff will equal

$$v_S^o(T) = m_1 - e.$$

Thus the difference between the shareholder payoff from operating vs. not operating equals

$$(1-e)+\delta\ (m_1-e)-(m_1-e) = 1-m_1+\delta\ (m_1-e) > 0.$$

Now suppose that shutting down is not a best reply for the blockholder in period t_o+1, i.e. suppose that

$$(1-e)+\delta\, v_S^o(t_o+2) > v_S^o(t_o+2). \tag{A.5}$$

Equation (A.5) is equivalent to

$$(1+e)-(1-\delta)\, v_S^o(t_o+2) \geq 0. \tag{A.6}$$

Shareholders' gross payoff from operating at t_o equals $(1-e)+\delta\,(1-e+\delta v_S^o(t_o+2))$; shareholders' gross payoff from shutting down equals $1-e+\delta v_S^o(t_o+2)$. The difference between gross shareholder payoffs when the firm is operated and when it is shut down is given by

$$(1-e)+\delta\left(1-e+\delta v_S^o(t_o+2)\right)-\left(1-e+\delta v_S^o(t_o+2)\right) = \delta\left((1+e)-(1-\delta)\, v_S^o(t_o+2)\right) \geq 0. \tag{A.7}$$

Thus shutting down in period t_o is not optimal. This verifies the induction implication and completes the proof. □

Proof of Proposition 1. If, for $\tau \geq 1$, we extend the definition v_S to the interval $[1, T-1]$, we can see, by differentiation, that the resulting function is concave. Thus, a necessary and sufficient condition for $\tau = T-1$ maximizing $v_S(\tau)$ over $\tau\{1,2,\dots T-1\}$ is that $v_S(T-1) \geq v_S(T-2)$. Because the blockholder can also opt for the no compensation policy and set an assured-reputation horizon of 0, $\tau = 0$, the necessary condition for the assured-reputation horizon $\tau = T-1$ being optimal is

$$v_S(T-1) \geq \max[v_S(T-2), v_S(0)].$$

Simple algebra demonstrates that this condition is satisfied when

$$v_S(T-1) - v_S(T-2) \geq 0 \Longleftrightarrow m_1 \geq e + \frac{\delta c}{1-\delta},$$

and

$$v_S(T-1) - v_S(0) \geq 0$$
$$\Longleftrightarrow$$
$$T(1-e)(1-\delta) \geq (1-e)(1-\delta) + \left(1-\delta^{T-1}\right)(1-m_1+\delta(m_1-e)) + c\delta.$$

□

Proof of Proposition 2. To verify the existence of a reputation equilibrium we need to determine conditions under which the blockholder will choose to act reputably when monitoring is ineffective. The value function v_O will satisfy the following recursion relation:

$$\begin{aligned} v_O(t) &= (1-e+c) + \delta\, v_O(t+1) \qquad\qquad t \in \{\tau+1, \tau+2, \dots T-1\} \\ v_O(T) &= m_1 - e + c. \end{aligned}$$

Thus,
$$v_O(\tau+1) = \frac{(1-e+c)\left(1-\delta^{T-1-\tau}\right)}{(1-\delta)} + \delta^{T-1-\tau}(m_1-e+c).$$

Firm value from setting an actual assured-reputation horizon τ equals $v_O(\tau+1)$ plus operating profits up to period τ of $\tau(1-e)$. Therefore, we can represent the blockholder's payoffs for each possible value of τ by the function $v_O : \{0,1,\dots T\} \to \mathbb{R}$, where

$$v_O(\tau) = \begin{cases} (1-e)\tau + v_O(\tau+1) & \tau \in \{1,2,\dots T-1\} \\ v_O(1) & \tau = 0 \end{cases}. \tag{A.8}$$

Since the assured-reputation horizon equals $T-1$ in a reputation equilibrium, a reputation equilibrium will exist if and only if
$$v_O(T-1) \geq \max\{v_O^o(\tau) : \tau \in \{0,1,2,\dots T-2\}\}.$$

Simple algebra yields the following proposition about the viability of reputation equilibria. A necessary and sufficient condition for $\tau = T-1$ maximizing $v_O(\tau)$ over $\tau\{1,2,\ldots T-1\}$ is that $v_O(T-1) \geq v_O(T-2)$. Simple algebra demonstrates that this condition is satisfied when

$$v_O(T-1) - v_O(T-2) \geq 0 \Longleftrightarrow m_1 \geq e + \frac{\delta c}{1-\delta}$$

$\square$

Proof of Proposition 3. Viewed as an incomplete information game, there are two types of firms, j, effective firms, $j = \mathcal{E}$, with effective monitoring, and ineffective firms $j = \mathcal{I}$, with ineffective monitoring. In any reputation equilibrium, when $j = \mathcal{I}$, the blockholder must pay reputation-assuring compensation. If the blockholder chooses not to pay reputation-assuring compensation, it must be the case that $j = \mathcal{E}$.

If the blockholder does not pay reputation-assuring compensation when $j = \mathcal{E}$ and the blockholder pays reputation-assuring compensation when $j = \mathcal{I}$, the blockholder's compensation choice varies with its type. Thus, the firm's type is revealed to customers. By Bayes rule, if the blockholder pays reputation-assuring compensation customers know that $j = \mathcal{I}$. Then, by an unraveling argument virtually identical to that underlying Lemma 1, the firm will shut down, contradicting the definition of a reputation equilibrium. Thus, both types must pay reputation-assuring compensation in any reputation equilibria. Moreover, they must choose the same reputation-assuring compensation policy. Otherwise, compensation will reveal type, and the equilibrium outcome will not match that of a reputation equilibrium.

Consequently, if a D1 reputation equilibrium exists, in this equilibrium, both firm types offer the same reputation-assuring compensation contract to the manager and thus the policy of offering no compensation to the manager, the *no compensation policy*, NC, is off the equilibrium path. Thus, to show that no reputation equilibria exist, we need only show that, in any candidate equilibrium, $j = \mathcal{E}$ is strictly better off deviating from the equilibrium strategy of offering reputation-assuring compensation to the off equilibrium policy NC when customer beliefs are restricted by the D1 refinement. Because the highest possible payoff in a pooling equilibrium in which both types offer reputation-assuring compensation is obtained when the compensation policy is efficient, i.e., offers the manager the smallest payment that will ensure reputable behavior up to period $T-1$, it is sufficient to show that a pooling equilibrium in which both types offer efficient reputation-assuring compensation cannot be sustained.

We call the policy of offering efficient reputation-assuring compensation, which can be implemented by paying the manager a bonus of $b^* = c\delta/(1-\delta)$ in period T conditioned on the firm not being revealed at the start of period T, *the compensation policy*, C.

The arguments above show that (a) if we can show that C-pooling, i.e., both types pooling and choosing policy C, cannot be sustained in a D1 equilibrium which produces a reputation-assuring outcome, we will have shown that no reputation equilibria exist, and (b) showing that, in any candidate C-pooling equilibrium, it is always optimal for type $j = \mathcal{E}$ to defect to the no compensation policy, NC, will establish that no D1 reputation equilibria exist.

To show this, we will consider the following incomplete information game. It will begin with the blockholder's initial choice of compensation policy, which we will call the *signal*. As discussed above, we can restrict attention to two signals, s the $s = \text{C}$ and $s = \text{NC}$ policies, and the payoffs to the shareholders resulting from the subgames that follow the choice of signals C and NC. Thus, the game can be thought of as (1) a signaling game where the blockholder selects a signal (compensation policy), (2) customers (the responders in the signaling game) revise their beliefs about the probability that monitoring is effective based on the signal and then, (3) given the compensation policy and revised beliefs, the agents play a production game under incomplete information. In this game, the blockholder makes operating decisions as in the baseline model.

For convenience, we call the choice of the initial compensation decision, C or NC, the *signaling game*. The payoffs for this game are the result of equilibrium operating behavior. We call the operating subgames played after the initial choice of compensation policy the *production games*. We will call an equilibrium of the signaling game in which, regardless of its type, the blockholder's equilibrium operating decisions conform with the reputation outcome (operating in all periods and producing the high-quality good with probability 1 in all periods except, perhaps the last period, T, with probability 1) and equilibrium beliefs in the signaling game satisfy the D1 refinement, a *D1 reputation equilibrium*.

As discussed above, in any D1 reputation equilibrium, both types pool by sending signal $s = \text{C}$. In this case, reputation is assured up to date $T-1$ by compensation. Thus, it is easy to compute the equilibrium payoffs for the C-production game. Because the manager will act opportunistically in the final period T if and only if monitoring is ineffective, and no new information about the firm is produced along the equilibrium path, Bayes rule implies that the equilibrium price at date T in the production game, conditioned on $s = \text{C}$ will equal, $p_T^* = \theta_1 \, 1 + (1-\theta_1)\,\delta = m_1$. Thus, the equilibrium payoff to the shareholders generated by the C-production game, which we represent by V_S^*, will be given by

$$V_S^*(\mathcal{I}) = V_S^*(\mathcal{E}) = \sum_{t=1}^{T-1}(1-e) + (m_1 - e) - b^* = (T-1)(1-e) + (m_1 - e) - \frac{c\delta}{1-\delta}. \tag{A.9}$$

In the NC-production game, the "prior probability" that monitoring is effective is given by $\eta^*(\text{NC})$ the market assessment, before the first production decision, that monitoring is effective conditioned on $s = \text{NC}$. Because NC is off the equilibrium path $\eta^*(\text{NC})$ cannot be fixed by Bayes rule.

The histories of this dynamic game, in general, will include both the operate/shut down decision of the blockholder at each previous date, as well as the quality of the good produced at each previous date. However, because revelation is only possible if monitoring is ineffective, if the firm is revealed at date t, the price of the good will equal δ. Consequently, shutting down the firm in all periods $t' > t$ is a strictly dominant strategy. Thus, at histories at which the firm is revealed, we can, without loss of generality, fix the shareholders' value at 0.

It follows that we need only specify the shareholder value at unrevealed histories. At an unrevealed history, good quality was high in all previous periods. Thus, the set of unrevealed histories at a given date t,

H_t^{NC} can be represented by the blockholder's observed production decisions in previous periods: operate, $\boldsymbol{O}$, or not operate $\boldsymbol{N}$, i.e., shut down. Thus, we define the unrevealed histories in each period, H_t^{NC} as follows:

$$H_t^{\text{NC}} = \begin{cases} \{\text{NC}\} & t = 1 \\ \{\text{NC}\} \times \{\boldsymbol{O},\boldsymbol{N}\}^{t-1} & t = 2, \ldots T. \end{cases}$$

We also represent the collection of all histories with H^{NC}, i.e.,

$$H^{\text{NC}} = \bigcup_{t=1}^{T} H_t^{\text{NC}}.$$

For a given history $h_t \in H_t^{\text{NC}}$, let $h_t(i)$ represent the ith element in the history. For each $t \in \{1, 2, \ldots T-1\}$, define the function $g_t : H_t^{\text{NC}} \times \{\boldsymbol{O},\boldsymbol{N}\} \to H_{t+1}^{\text{NC}}$ by

$$g_t(h_t, y)(i) = \begin{cases} h_t(i) & i = 0, 1, \ldots t \\ y & i = t+1 \end{cases}.$$

Note that the first element of all histories is NC, and thus the ith element represents the $(i-1)$th production decision. Thus, g_t simply represents the function that appends the blockholder's operate/not operate decision in period t to the history of the game up to period t to produce the history of the game in period $t+1$.

Customers, observing a history of the firm, update their beliefs based on the history and their initial assessment, $\eta^*(\text{NC})$, the probability that the firm is effective conditioned on the firm sending signal $s =$ NC in the signaling game. As shown in the baseline model, absent compensation, the manager will act opportunistically if and only of monitoring is ineffective. Thus, the price at history h_t will equal

$$\mathbb{P}[j = \mathcal{E} | h_t] + \mathbb{P}[j = \mathcal{I} | h_t]\, \delta,$$

where $\mathbb{P}$ is the customers' probability measure over types conditioned on the observed history of the game at the time customers submit their bids for the good, h_{t-1}.

Thus, at the start of the NC-production game, the unique history in H_1^{NC}, $h_1 = \text{NC}$ customers will set the good price equal to $m_1^*(\text{NC}) = \eta^*(\text{NC}) + (1-\eta^*(\text{NC}))\,\delta$, where $\eta^*(\text{NC})$ represents the probability that the customers assign to $j = \mathcal{E}$ conditioned on compensation policy NC.

Because of the continuous 1-1 relationship between $\eta^*(\text{NC})$ and $m_1^*(\text{NC}) = \eta^*(\text{NC}) + (1-\eta^*(\text{NC}))\,\delta$, conditioning customer responses on $\eta^*(\text{NC})$ is equivalent to conditioning on $m_1^*(\text{NC})$. Thus, to reduce notation, we will represent customers' initial belief assessment with $m_1^*(\text{NC})$. Consequently, we can represent the customer's price function in the production game, $(\boldsymbol{p}) : H^{\text{NC}} \times [\delta, 1] \to [\delta, 1]$. The price, p, of the good at h_t given initial price $m_1^*(\text{NC})$ and history h_t will be given by $p = (h_t, m_1^*(\text{NC}))$.

Note, as discussed above, in any reputation equilibrium, NC is never played. Thus, Bayes rule cannot be applied because the production game is a subgame of the overall game that is off the equilibrium path.

However, the NDOC restriction on off-equilibrium beliefs does imply that, if $m_1^*(\mathrm{NC}) = 1$ (i.e., $\eta^*(\mathrm{NC}) = 1$), $\boldsymbol{p}(h, m_1^*(\mathrm{NC}) = 1)$ and, similarly, if $m_1^*(\mathrm{NC}) = \delta$ (i.e., $\eta^*(\mathrm{NC}) = 0$) then, for all $h \in H$, $\boldsymbol{p}(h, m_1^*(\mathrm{NC}) = \delta) = \delta$.

Now consider shareholder value at an unrevealed history h_t, of the production game. At this history, the blockholder decides whether to operate, $\boldsymbol{O}$, or not operate, $\boldsymbol{N}$, The period reward to shareholders from not operating is 0 and the period reward from operating is the operating profit, $p-e$, where p is the price fixed by customers for the good at the given history. Hence, period rewards are given by the function $r : \{\boldsymbol{O}, \boldsymbol{N}\} \times \mathbb{R}^+$ defined by

$$r(y,p) = \begin{cases} p-c & y = \boldsymbol{O} \\ 0 & y = \boldsymbol{N} \end{cases}.$$

Consequently, shareholder value, v^{NC}, at histories $h_t \in H_t^{\mathrm{NC}}$ for dates $t \in \{1, 2, \ldots T-1\}$, is given by

$$v_t^{\mathrm{NC}}(\mathcal{I}, h_t, m_1^*(\mathrm{NC})) = \max_{y \in \{\boldsymbol{O}, \boldsymbol{N}\}} r(y, \boldsymbol{p}(h_t, m_1^*(\mathrm{NC}))) + \delta v_{t+1}^{\mathrm{NC}}(\mathcal{I}, g_t(h_t, y), m_1^*(\mathrm{NC})) \text{ and} \tag{A.10}$$

$$v_t^{\mathrm{NC}}(\mathcal{E}, h_t, m_1^*(\mathrm{NC})) = \max_{y \in \{\boldsymbol{O}, \boldsymbol{N}\}} r(y, \boldsymbol{p}(h_t, m_1^*(\mathrm{NC}))) + v_{t+1}^{\mathrm{NC}}(\mathcal{E}, g_t(h_t, y), m_1^*(\mathrm{NC})). \tag{A.11}$$

As in the baseline model, the δ term in the firm's value function when the firm's type is $\mathcal{I}$ reflects the probability that, when compensation is not offered, the manager will act opportunistically and opportunism will result in low quality output with probability $1-\delta$, and thus cause the firm to shut down in all subsequent periods.

In the final period, $t = T$ the shareholder value at unrevealed histories, $h_T \in H_T^{\mathrm{NC}}$ is given by

$$v^{\mathrm{NC}}(\mathcal{I}, h^T, m_1^*(\mathrm{NC})) = \max_{y \in \{\boldsymbol{O}, \boldsymbol{N}\}} r(y, \boldsymbol{p}(h^T, m_1^*(\mathrm{NC}))) \text{ and} \tag{A.12}$$

$$v^{\mathrm{NC}}(\mathcal{E}, h^T, m_1^*(\mathrm{NC})) = \max_{y \in \{\boldsymbol{O}, \boldsymbol{N}\}} r(y, \boldsymbol{p}(h^T, m_1^*(\mathrm{NC}))). \tag{A.13}$$

Lemma A-2. *In any equilibrium of the production game, at the unique history at date 1, $h_1 = NC$,*

$$\textit{for all } m_1^*(NC) \in [\delta, 1], v^{NC}(\mathcal{I}, NC, m_1^*(NC)) \le v^{NC}(\mathcal{E}, NC, m_1^*(NC)), \tag{A.14}$$

and, unless $v^{NC}(\mathcal{I}, NC, m_1^*(NC)) \le \max[m_1^*(NC) - e, 0]$,

$$\textit{for all } m_1^*(NC) \in [\delta, 1], v^{NC}(\mathcal{I}, NC, m_1^*(NC)) < v^{NC}(\mathcal{E}, NC, m_1^*(NC)). \tag{A.15}$$

Proof. Equation (A.14) follows from the fact that $\delta < 1$ and an easy recursion argument. Verifying equation (A.15) is only slightly more difficult. Along the histories h_t produced by the production decisions of type $\mathcal{I}$, let t^o be the last date at which $\boldsymbol{p}(h_t, m_1^*(\mathrm{NC})) - e$ is positive, if such a period exists, and let t^o equal 0 otherwise. If $t^o = 0$, then production along $\mathcal{I}$ equilibrium path yields a period reward that is non positive in all periods, so $v^{\mathrm{NC}}(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) = 0 \leq \max[m_1^*(\mathrm{NC}) - e, 0]$. If $t^o = 1$, then production in all periods after period 1, along the equilibrium path yields a non positive payoff, so for type $\mathcal{I}$, value at the initial date will equal $\max[m_1^*(\mathrm{NC}) - e, 0]$ and thus $v^{\mathrm{NC}}(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) = m_1^*(\mathrm{NC}) - e \leq \max[m_1^*(\mathrm{NC}) - e, 0]$.

If $t^o > 1$ then, because the value for type $\mathcal{E}$ must at least equal the payoff from following the same history as followed by $\mathcal{I}$, and the fact that $\delta < 1$, imply, through an easy recursion argument, that $v_t^{\mathrm{NC}}(\mathcal{E}, h_t, m_1^*(\mathrm{NC})) > v_t^{\mathrm{NC}}(\mathcal{E}, h_t, m_1^*(\mathrm{NC}))$ for all h_t $t < t^o$ such that h_t is a predecessor of h_{t^o} and, *a fortiori*, at $h_1 = \mathrm{NC}$. □

A.1 Signaling game

Using the value function from the production game, we specify the shareholders' payoff from the blockholder selecting the off-equilibrium signal $s = \mathrm{NC}$ as follows: the shareholders' payoff in the signaling game conditioned on the blockholder defecting to NC, given the market's initial price in response to NC, $m_1^*(\mathrm{NC})$, equals shareholder value at the initial node of the production game, $h_1 = \mathrm{NC}$, conditioned on the initial price in the production game, represented by $m_1^*(\mathrm{NC})$, i.e.,

$$V_S(j, \mathrm{NC}, m_1^*(\mathrm{NC})) = v^{\mathrm{NC}}(j, \mathrm{NC}, m_1^*(\mathrm{NC})), \quad j = \mathcal{E}, \mathcal{I}. \tag{A.16}$$

The equilibrium payoffs in the signaling game for the candidate equilibrium were presented in equation (A.9). The answer to the question of whether off equilibrium beliefs exist which can support the candidate equilibrium of the signaling game and satisfy the D1 refinement rests on the relative strength of the two types, $\mathcal{E}$ and $\mathcal{I}$, incentive to defect from their equilibrium signal, $s = \mathrm{C}$ to the off equilibrium signal $s = \mathrm{NC}$. The strength of these incentives will be determined by the gain from defection, which we will compute using equations (A.9) and (A.16).

Our next observation is that $\mathcal{I}$ is unwilling do deviate from the equilibrium strategy of $s = \mathrm{C}$ when $V_S(\mathcal{I}, m_1^*(\mathrm{NC})) \leq \max[m_1^*(\mathrm{NC}) - e, 0]$, i.e.,

$$V_S(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) \leq \max[m_1^*(\mathrm{NC}) - e, 0] \Longrightarrow V_S(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) - V_S^*(\mathcal{I}) < 0. \tag{A.17}$$

To see this, note that, by equation (A.16),

$$V_S(\mathcal{E}, \mathrm{NC}, m_1^*(\mathrm{NC})) = v^{\mathrm{NC}}(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})).$$

If $v^{\mathrm{NC}}(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) \leq \max[m_1^*(\mathrm{NC}) - e, 0]$, equation (A.9) and condition (14) of the proposition, imply that $v^{\mathrm{NC}}(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) < V_S^*(\mathcal{I})$.

Next, note that equation (A.17), condition (14), and equation (A.9), imply that

$$V_S(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) - V_S^*(\mathcal{I}) \geq 0 \Longrightarrow$$
$$V_S(\mathcal{I}, \mathrm{NC}, m_1^*(\mathrm{NC})) - V_S^*(\mathcal{I}) < V_S(\mathcal{E}, \mathrm{NC}, m_1^*(\mathrm{NC})) - V_S^*(\mathcal{E}). \tag{A.18}$$

Finally, note that if $m_1^*(\mathrm{NC}) = 1$ then NDOC implies that $\boldsymbol{p} = 1$ on any unrevealed history. When $\boldsymbol{p} = 1$, the obvious optimal policy for type $\mathcal{E}$ is to produce in every period, and because type $\mathcal{E}$ never reaches an unrevealed history, the payoff to $\mathcal{E}$ in the production game, $V_S(\mathcal{E}, \mathrm{NC}, m_1^*(\mathrm{NC}) = 1) = T\,(1-e)$ which, as we see from inspecting equation (A.9), exceeds $\mathcal{E}$'s candidate equilibrium payoff, $V_S^*(\mathcal{E})$. Hence,

$$\text{there exists } m_1^*(\mathrm{NC}) \in [\delta, 1], \text{ such that } V_S(\mathcal{E}, \mathrm{NC}, m_1^*(\mathrm{NC})) > V_S^*(\mathcal{E}). \tag{A.19}$$

Equation (A.14) shows that the gain to type $\mathcal{E}$ from defecting from the equilibrium to $s = \mathrm{NC}$ in the signaling game is never less than the gain to type $\mathcal{I}$. Equation (A.18) shows that for any market response, $m_1^*(\mathrm{NC})$ to $s = \mathrm{NC}$, at which type $\mathcal{I}$ weakly gains from defection, type $\mathcal{E}$ strictly gains from defection. and type $\mathcal{E}$'s gain is larger than type $\mathcal{I}$'s gain. Equation (A.19) shows that type $\mathcal{E}$ is willing to defect from the equilibrium for some market responses to defection. Thus, the set of initial prices, $m_1^*(\mathrm{NC})$ under which type $\mathcal{I}$ weakly gains from defection is a subset of the non-empty subset of initial prices under which type $\mathcal{E}$ strictly gains from defection. Consequently, in the signaling game, under the D1 refinement, customer assessments should place all weight to the defecting type being type $\mathcal{E}$. Under this assessment, for reasons adduced above, type $\mathcal{E}$'s defection payoff exceeds type $\mathcal{S}$'s equilibrium payoff and thus the candidate signaling-game equilibrium cannot be verified. $\square$

Proof of Corollary 1. First note that Assumptions 1 and 2 imply that

$$(m_1 - e) - \frac{c\delta}{1-\delta} > -\frac{c\delta}{1-\delta}. \tag{A.20}$$

For any fixed expenditure level, e, Assumption 1, which ensures that $\delta < e - c$, and the fact that the right-hand side of equation (A.20) is increasing in δ imply that

$$\frac{c\delta}{1-\delta} \leq \frac{c\,(e-c)}{1-e+c}. \tag{A.21}$$

Viewed as a function of c, the right-hand side of equation (A.21) is concave. Maximizing this expression over c shows that the right-hand side attains its maximum over the admissible values of c, $c \in (0, e)$, at $c^* = \sqrt{1-e} - (1-e)$. Substituting this value into the right-hand side of equation (A.21) shows that

$$\frac{c\delta}{1-\delta} \leq e - 2\left(\sqrt{1-e} - (1-e)\right). \tag{A.22}$$

Equation (A.22) implies that

$$(T-2)\,(1-e) + (m_1 - e) - \frac{c\,\delta}{1-\delta} > (T-2)\,(1-e) - \left(e - 2\left(\sqrt{1-e} - (1-e)\right)\right). \tag{A.23}$$

Next note that

$$(T-2)(1-e)-\left(e-2\left(\sqrt{1-e}-(1-e)\right)\right)=(T-1)(1-e)+2\left(\sqrt{1-e}-(1-e)\right)-1. \qquad \text{(A.24)}$$

Because, $e \in (0,1)$, $\sqrt{1-e}-(1-e)>0$. Thus, equation (A.24) implies that

$$(T-1)(1-e)+2\left(\sqrt{1-e}-(1-e)\right)-1>(T-1)(1-e)-1. \qquad \text{(A.25)}$$

Thus, equations (A.23), (A.24), and (A.25), imply that

$$(T-2)(1-e)+(m_1-e)-\frac{c\,\delta}{1-\delta}>(T-1)(1-e)-1. \qquad \text{(A.26)}$$

The right-hand side of equation (A.25) is positive if and only if $e \leq (T-2)/(T-1)$. Because the left-hand side of equation (A.26) is the hypothesis of Proposition 3, $e \leq (T-2)/(T-1)$ is sufficient for the satisfaction of hypothesis of Proposition 3. □

Lemma A-3. *When the blockholder is uninformed, conditioned on any simple compensation contract, in any equilibrium, the unique best response for the blockholder in any period in which the firm is unrevealed is to let the firm operate.*

Proof of Lemma A-3. The shareholders' payoff when the firm is unrevealed in period t equals the gross payoff less expected compensation payments in period t and future periods. Remark A-2 in the proof of Lemma A-1 shows that future expected compensation payments to the manager will be weakly increased by shutting down the firm. Thus, to show that shutting down the firm when it is unrevealed is not a best response for the blockholder, we need only show that shut down reduces the shareholder gross payoff, which we represent by v_S^o. We establish this result using Lemmas A-4 and A-5 developed below. We complete the proof by establishing in Lemma A-6 that operating the firm when it is unrevealed is necessary in equilibrium.

Lemma A-4. *Let v_S^o represent the gross payoff function for the shareholders if the blockholder follows the policy of operating in period t if and only if the firm is unrevealed (i.e., the monitoring price $m \geq m_1$). In this case, for all $t \in \{1,\dots T\}$, the function $t \hookrightarrow v_S^o(m,t)$ is convex and nondecreasing in m.*

Proof of Lemma A-4. This result is established by backward induction on t. In period T, $v_S^o(m,T)=\max[m-e,0]$, and thus $v_S^o(\cdot,T)$ is evidently convex and nondecreasing in m.

Suppose that for all $t>t_o$, $v_S^o(\cdot,t)$ is convex and nondecreasing. We have two cases to consider in period t. If compensation ensures that the manager will act reputably, then the shareholders' gross payoff is given by

$$v_S^o(m,t_o)=1-e+v_S^o(m,t_o+1).$$

By the induction hypothesis, $v_S^o(\cdot,t_o+1)$ is convex and nondecreasing in m. Thus, so is $v_S^o(\cdot,t_o)$. If compensation does not assure the manager will act reputably, then

$$v_S^o(m, t_o) = m - e + m\, v_S^o(\Gamma(m), t_o + 1).$$

Since the induction hypothesis implies that $v_S^o(\cdot, t_o + 1)$ is convex and nondecreasing, to show that $v_S^o(\cdot, t_o)$ is convex and nondecreasing, we need only show that the function $m \hookrightarrow m - e + m\, v_S^o(\Gamma(m), t_o + 1)$ is convex and nondecreasing. Because $m \hookrightarrow m - e$ is convex and nondecreasing, this will be established if we can show that the function

$$m \hookrightarrow m\, v_S^o(\Gamma(m), t_o + 1), \quad m \in [\delta, 1]$$

is convex and nondecreasing.

Because Γ is increasing, and $v_S^o(\cdot, t+1)$ is nondecreasing by the induction hypothesis, it is apparent that $m \hookrightarrow m\, v_S^o(\Gamma(m), t+1)$ is nondecreasing. Now consider convexity. If the gross payoff function were twice differentiable, verification would be straightforward. However, there is no reason to suspect the gross payoff function is twice differentiable (in fact it is not twice differentiable everywhere). So, we develop the proof using a different approach.

To initiate our demonstration, for any given t_o, define

$$\eta(m) = v_S^o(1 + \delta - \delta m, t_o + 1), \quad \Lambda(m) = m\, \eta\left(\frac{1}{m}\right).$$

Note that

$$\Lambda(m) = m\, \eta(\frac{1}{m}) = m\, v_S^o\left(1 + \delta - \frac{\delta}{m}, t_o + 1\right) = m\, v_S^o(\Gamma[m], t_o + 1).$$

So establishing convexity is equivalent to showing that Λ is convex. The induction hypothesis implies that $v_S^o(\cdot, t^o + 1)$, is convex. Thus, η, the composition of $v_S^o(\cdot, t^o + 1)$, with the affine function $m \hookrightarrow 1 + \delta - \delta m$, is convex, and thus η is convex and hence continuous on the interior of its domain. This implies that Λ_o is continuous on the interior of its domain. For such a function (in fact any bounded measurable function), convexity is equivalent to mid-point convexity. Thus, to establish convexity we need to show that

$$\Lambda(\tfrac{1}{2} m' + \tfrac{1}{2} m'') \leq \tfrac{1}{2}\Lambda(m') + \tfrac{1}{2}\Lambda(m''), \quad \text{for all } m', m'' \in [\delta, 1]. \tag{A.27}$$

Equation (A.27) follows immediately from the convexity of η by the following derivation:

$$\begin{aligned}
\Lambda\left(\frac{1}{2}m' + \frac{1}{2}m''\right) &= \\
&= \frac{1}{2}\left(m'+m''\right)\eta\!\left(\frac{1}{\frac{1}{2}m' + \frac{1}{2}m''}\right) = \frac{1}{2}\left(m'+m''\right)\eta\!\left(\frac{2}{m'+m''}\right) \\
&= \frac{1}{2}\left(m'+m''\right)\eta\!\left(\left(\frac{m'}{m'+m''}\right)\frac{1}{m'} + \left(\frac{m''}{m'+m''}\right)\frac{1}{m''}\right) \\
&\le \frac{1}{2}\left(m'+m''\right)\left(\frac{m'}{m'+m''}\eta\!\left(\frac{1}{m'}\right) + \frac{m''}{m'+m''}\eta\!\left(\frac{1}{m''}\right)\right) \\
&= \frac{1}{2}m'\,\eta\!\left(\frac{1}{m'}\right) + \frac{1}{2}m''\,\eta\!\left(\frac{1}{m''}\right) = \frac{1}{2}\Lambda\left(m'\right) + \frac{1}{2}\Lambda\left(m''\right).
\end{aligned}$$

This establishes the validity of induction implication and thus completes the proof. □

Lemma A-5. *If compensation contracts are simple, in any equilibrium, the blockholder operating strategy of operating if and only if the firm is unrevealed, is a best response.*

Proof of Lemma A-5. Lemma 1 has already established that shutting down is always the blockholder's best response when the firm is revealed. Hence, we need only show that gross profit is reduced by shutting down when the firm is unrevealed.

Again, we have two cases to consider. First, suppose that, in a given period, t, the state variable, $m > m_1$, i.e. the firm is unrevealed, and compensation assures reputation. In this case, the gross payoff from operating in period t equals

$$1 - e + v_S^o(m, t+1).$$

The gross payoff from shutting down equals $v_S^o(m, t+1)$. Thus clearly, shutting down at t is not optimal.

Now, suppose that the firm is unrevealed, but compensation does not assure reputation. In this case, the gross payoff to the shareholders from operating equals

$$m - e + m\,v_S^o(\Gamma(m), t+1).$$

Next, note that

$$m = m\,\Gamma(m) + (1-m)\,\delta.$$

Thus, the convexity of $v_S^o(\cdot, t+1)$ established in Lemma A-4, and the fact that the firm shuts down when revealed, i.e., $v_S^o(\delta, t+1) = 0$, and $m > m_1 > e$ imply that

$$\begin{aligned}
m - e + m\,v_S^o(\Gamma(m), t+1) &= m - e + \Big(m\,v_S^o(\Gamma(m), t+1) + (1-m)\,v_S^o(\delta, t+1)\Big) \ge \\
& m - e + v_S^o(m\,\Gamma(m) + (1-m)\,\delta, t+1) = m - e + v_S^o(m, t+1) > v_S^o(m, t+1).
\end{aligned}$$

Because $v_S^o(m, t+1)$ represents the gross payoff from shutting down in period t, we see that the gross payoff from shutting down is always strictly less than the gross profit from operating. Thus, shutting down in period t when unrevealed is never optimal. $\square$

Lemma A-6. *If compensation contracts are simple, no equilibrium exists in which the firm shuts down when unrevealed.*

Proof of Lemma A-6. The proof is by contradiction. Suppose an equilibrium exists in which the firm shuts down when unrevealed in some period. Let t' be the last period in which the firm shuts down when unrevealed. Clearly $t' < T$. Because the firm does not shut down in any period after t', the shareholder's gross payoff function for any period $t > t'$ will be given by v_S^o, as defined in Lemma A-4. If the blockholder follows its equilibrium strategy of shutting down in period t', the shareholders' gross payoff will equal $0 + v_S^o(m, t'+1) = v_S^o(m, t'+1)$ where 0 represents the gross payoff in period t' and v_S^o represents its continuation payoff. We have two cases: if compensation assures reputation in period t, then the gross payoff from operating in period t' will equal

$$1 - e + v_S^o(m, t'+1). \tag{A.28}$$

If compensation does not assure reputation, and the firm operates, the gross payoff in period t will equal

$$m - e + m\, v_S^o(\Gamma(m), t'+1). \tag{A.29}$$

Because, $1 - e > 0$, equation (A.28), shows that the gross payoff from operating exceeds the gross payoff from shutting down when compensation assures reputation. When compensation does not assure reputation, because the firm is unrevealed, $m \geq m_1 > e$ and thus $m - e > 0$. The proof of Lemma A-5 showed that

$$m\, v_S^o(\Gamma(m), t'+1) \geq v_S^o(m, t'+1).$$

Thus, the gross payoff from shutting down, $v_S^o(m, t'+1)$, is less than the gross payoff from operating. In both cases, reputation assured and reputation not assured, the expected compensation paid to the manager in all periods $t > t'$ is weakly less if the firm operates. Thus, shutting down at t' is not a best reply, and hence the strategy involving shutting down when the firm is unrevealed is not an equilibrium strategy for the blockholder. This contradiction establishes the result. $\square$

$\square$

Proof of Proposition 4. By Lemma 2, under a policy that fully assures reputation until period τ, the manager will act opportunistically in every period starting with period $\tau + 1$. Thus, the period $\tau + 1$ good's price will equal m_1 and, so long as the firm remains unrevealed, in each subsequent period the good's price will equal the monitoring price for the period. Monitoring prices will be updated according to the updating function defined in equation (8). Thus, if the firm is unrevealed $n \geq 1$ periods after $\tau+1$, the good's price will equal

$$\Gamma^{(n)}(m_1) = \frac{(m_1-\delta)+(1-m_1)\,\delta^{n+1}}{(m_1-\delta)+(1-m_1)\,\delta^{n}}, \tag{A.30}$$

where and $\Gamma^{(n)}$ is the n-fold composition of the updating function. Since the monitoring price also captures the probability that the firm will remain unrevealed until the next period when the manager acts opportunistically, the ex ante probability that the firm will remain unrevealed at the beginning of period $\tau+2$ is $m_1 = \Gamma^{(0)}$, and the ex ante probability that the firm will remain unrevealed until the beginning of period $\tau+1+n$, where $n > 1$ equals

$$\Gamma^{(0)}(m_1) \times \ldots \times \Gamma^{(n-1)}(m_1) = \frac{(m_1-\delta)+(1-m_1)\,\delta^{n}}{1-\delta}. \tag{A.31}$$

Now consider the effect of increasing τ by one period to $\tau+1$ on the firm's expected operating profit, which is the shareholders' gain from the change. Let $\mathscr{O}_\tau$ represent the date zero expected value of the stream of operating profits under the policy that sets the assured-reputation horizon τ. Then,

$$\mathscr{O}_\tau = \overbrace{(1-e)+\ldots(1-e)}^{\tau \text{ terms}} +$$

$$\overbrace{(m_1-e)+m_1\left(\Gamma^{(1)}(m_1)-e\right)+m_1\Gamma^{(1)}(m_1)\left(\Gamma^{(2)}(m_1)-e\right)+\ldots+m_1\left(\prod_{i=1}^{T-\tau-2}\Gamma^{(i)}(m_1)\right)\left(\Gamma^{(T-(\tau+1))}(m_1)-e\right)}^{T-\tau \text{ terms}}.$$

Thus, the gain in expected operating profits from shifting the assured-reputation horizon to $\tau+1$ is

$$\begin{aligned}
\Delta\mathscr{O}_\tau \equiv \mathscr{O}_{\tau+1}-\mathscr{O}_\tau &= (1-e)-\Gamma^{(1)}(m_1)\Gamma^{(2)}(m_1)\ldots\Gamma^{(T-(\tau+2))}(m_1)\left(\Gamma^{(T-(\tau+1))}(m_1)-e\right) \\
&= (1-e)-\frac{(m_1-\delta)(1-e)-(1-m_1)(e-\delta)\delta^{T-1}}{1-\delta} \\
&= \frac{(1-m_1)(1-e)+(1-m_1)(e-\delta)\delta^{T-(\tau+1)}}{1-\delta}.
\end{aligned} \tag{A.32}$$

Consider shifting the assured-reputation horizon from $\tau = 0$ to $\tau = 1$. When $\tau = 0$ the manager is not paid. To assure the reputation in period 1, the manager will be paid $b_2^* = \frac{c\delta^{T-1}}{1-\delta}$ in period two. This is the shareholders' cost of shifting the assured-reputation horizon from $\tau = 0$ to $\tau = 1$. Hence, from definition (A.32), it follows that the shareholders' net gain from this shift equals $\Delta\mathscr{O}_0 - \frac{c\delta^{T-1}}{1-\delta}$, or equivalently

$$\frac{(1-m_1)(1-e)+((1-m_1)(e-\delta)-c)\delta^{T-1}}{1-\delta}. \tag{A.33}$$

Condition (A.33) is always positive so long as $(1-m_1)(e-\delta)-c \geq 0$. When $(1-m_1)(e-\delta)-c < 0$, condition (A.33) is positive so long as

$$\delta^{T-1} < \frac{(1-m_1)(1-e)}{-[(1-m_1)(e-\delta)-c]}.$$

Thus, the optimal assured-reputation horizon $\tau^* > 0$ so long as either $(1-m_1)(e-\delta)-c \geq 0$ or T is sufficiently large.

Now consider increasing τ by one period when $\tau > 0$. The shareholders' gain remains equal to $\Delta\mathscr{O}_\tau$. The bonus payment required to set the assured-reputation horizon to τ is

$$b^*_{\tau+1} = \frac{c\delta^{T-\tau}}{1-\delta}. \tag{A.34}$$

Thus, the increase in compensation required to assure reputation for one more period is given by $b^*_{\tau+2} - b^*_{\tau+1} = c\delta^{T-(\tau+1)}$. Let $\Delta\Pi_\tau$ represent the shareholders' net gain from assuring reputation for one more period from $\tau > 0$ to $\tau+1$, where

$$\Delta\Pi_\tau = \frac{(1-m_1)\,(1-e) + \Big((1-m_1)\,(e-\delta) - (1-\delta)c\Big)\,\delta^{T-(\tau+1)}}{1-\delta}. \tag{A.35}$$

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

$$\Delta\Pi_{\tau+1} - \Delta\Pi_\tau = \delta^{T-(\tau+2)}(1-\delta)((1-m_1)\,(e-\delta)-(1-\delta)c). \tag{A.36}$$

So long as $(1-m_1)\,(e-\delta)-(1-\delta)c > 0$, expression (A.36) is positive, implying that expression (A.35) is convex and increasing in $\tau \in \{1,\ldots,T-2\}$. Hence, when $(1-m_1)\,(e-\delta)-(1-\delta)c > 0$, the blockholder will set $\tau^* = T-1$ ensuring a reputation equilibrium. When $(1-m_1)\,(e-\delta)-(1-\delta)c < 0$, $\Delta\Pi_{\tau+1} < \Delta\Pi_\tau$, implying that the shareholders' gain from increasing τ is concave in τ. Hence, conditional on setting $\tau^* > 0$, the blockholder will set τ^* equal to the period following the largest $\tau \in \{1,\ldots,T-2\}$ that satisfies the following condition:

$$\frac{(1-m_1)\,(1-e) + \Big((1-m_1)\,(e-\delta) - (1-\delta)c\Big)\,\delta^{T-(\tau+1)}}{1-\delta} \geq 0. \tag{A.37}$$

Note that so long as

$$(1-m_1)(1-e) + [(1-m_1)(e-\delta)-c]\delta > 0, \tag{A.38}$$

expression (A.33) is positive, which ensures that $\tau^* > 0$. Moreover, expression (A.35) and thus $\Delta\Pi_\tau$ are positive for all $\tau \in \{1,\ldots,T-2\}$. Therefore, $\tau^* = T-1$. We conclude the proof by noting that expression (15) follows from solving expression (A.38) for m_1. □

B Robustness

B.1 Complex contracts

Consider the two scenarios under which we derive conditions for the existence of reputation equilibria—-uninformed blockholder/transparent governance and informed blockholder/opaque governance. Suppose there is a reputation equilibrium, $\mathrm{Eq}^{\mathcal{C}}$, when complex contracts are permitted in any one of these scenarios. Let $p_1, p_2, \ldots p_T$ represent prices on the unrevealed path in this equilibrium and let $\mathcal{C}$ be the equilibrium complex contract. Next suppose that, in this equilibrium, the firm operates when unrevealed at all dates. We claim that, given the same exogenous parameters, e, c, θ, δ, there exists a reputation equilibrium when blockholders are restricted to using simple contracts, which we term $\mathrm{Eq}^{\boldsymbol{b}}$, that produces the same payoff to shareholders.

To develop this equilibrium, define the simple contract $\boldsymbol{b}$, as follows:

$$b_t = C_t(p_1, p_2 \ldots p_T). \tag{B.1}$$

Let $\boldsymbol{b}$ be the contract used by the blockholder in the candidate equilibrium using simple contracts. Note that Lemma A-3 shows in the case of uninformed blockholders and Lemma A-1 shows in the case of informed blockholders, under any simple contract, the blockholder will follow the policy of operating whenever the firm is unrevealed. Thus, shut-down policy is the same in $\mathrm{Eq}^{\boldsymbol{b}}$ as it is in $\mathrm{Eq}^{\mathcal{C}}$. The manager's opportunism is affected by the compensation received by the manager when the firm is unrevealed. The definition of $\boldsymbol{b}$ ensures this is the same as compensation payments made at each date in $\mathrm{Eq}^{\mathcal{C}}$. Hence, expected compensation paid to the manager, managerial opportunism, and payoff to the shareholders gross of management compensation are the same in $\mathrm{Eq}^{\boldsymbol{b}}$ and $\mathrm{Eq}^{\mathcal{C}}$. Therefore, the payoff to shareholders is the same. Because $\mathrm{Eq}^{\mathcal{C}}$ maximizes shareholder payoffs over all complex contracts and simple contracts can be implemented using a subset of the set of complex contracts, no simple contract could produce a higher payoff to shareholders. These arguments establish that reputation equilibria using simple contracts can always replicate the payoff to the shareholders in reputation equilibria using complex contracts, *provided that in the complex contract equilibrium the blockholder follows the policy of operating whenever the firm is unrevealed.*

When governance is opaque, regardless of the managerial compensation contract selected, in the subgame following the selection of the contract, operating when unrevealed is always optimal even when contracts are complex. The reason is simple: In a reputation equilibrium, customers conjecture that, up to period $T-1$ the manager acts reputably. Thus at all unrevealed histories, the price of the good is 1 and independent of the blockholder's shut-down policy. If the blockholder defects from providing reputation-assuring compensation, and defection is revealed by low quality production, the firm shuts down in that period and all remaining periods and the manager receives no compensation. Thus, the blockholder's shut-down policy cannot affect the payment made to the manager on the unrevealed path. Because the period payoff from operating is always positive, shareholder payoffs gross of managerial compensation are always higher if the firm operates. Hence, operating when unrevealed is always optimal. It follows that, in the case of opaque governance, the introduction of complex contracts has no effect on our characterizations of the conditions for reputation equilibria.

The reasoning for the case of uninformed blockholders and transparent governance is a bit more delicate. When governance is transparent, customers observe both compensation and shut-down policy. Customers know the assured-reputation horizon associated with any contract selected by the blockholder. For a reputation equilibrium to exist, it must be the case that using a compensation contract that assures reputation through period $\tau = T-1$ produces a higher shareholder payoff than any contract that assures reputation only through $\tau < T-1$. Thus, to determine whether this condition is satisfied, we have to consider shareholder payoffs under contracts yielding assured-reputation horizons $\tau < T-1$. When the contracting space is expanded to include complex contracts, there exist contracts supporting assured-reputation horizon, $\tau < T-1$ with the property that, in the subgame starting with the issuance of these contracts, the firm will not always operate when unrevealed.

The logic behind shutting down on the unrevealed path when blockholders are uninformed and governance is transparent is a bit complicated. Thus, we present an example for interested readers. In essence, the reason shutting down on the unrevealed path can occur under complex, but not simple, contracts is that the payment to the manager can vary with the unrevealed price. At dates after the assured-reputation horizon, operating and shutting down produce different prices on the unrevealed path. Each period the firm operates after the assured-reputation horizon, production enables customer learning and thus not being revealed by low quality production increases the unrevealed price. Shutting down the firm can block the unrevealed price from getting large enough to trigger large compensation payments to the manager.

However, for any fixed assured-reputation horizon, a contract that induces shutting down in any period after the assured-reputation horizon, τ, is dominated, from the perspective of shareholder payoffs, by a contract that ensures an assured-reputation horizon of at least τ and that provides shareholders with a higher payoff. Thus, such contracts cannot be equilibrium contracts. Hence, as in the opaque governance cases, when shareholders are uninformed and governance is transparent our characterizations of the conditions for reputation equilibria are not affected by expanding the contract set to complex contracts.

Example B-1. In this example, we consider the uninformed blockholder/transparent governance setting and verify that in the subgame commencing with the issuance of complex compensation contract, $\mathcal{C}'$, it is not optimal for the blockholder to let the firm operate in period 2 when the firm is unrevealed.

$$\mathcal{C}'_1(p_1) = 0, \quad \mathcal{C}'_2(p_1, p_2) = 0, \quad \mathcal{C}'_3(p_1, p_2, p_3) = \begin{cases} 0 & p_3 < 0.98 \\ 0.30 & p_3 \geq 0.98. \end{cases} \tag{B.2}$$

The unrevealed price in period 3, the only period in which positive compensation is provided the manager, is insufficient for the manager to obtain a bonus payment. Thus, the manager will act opportunistically in periods 1, 2, and 3. In the final period, $T = 3$, if unrevealed, the firm's payoff from operating is positive and operating can have no effect on future payments to the manager because 3 is the final period. Hence,

	t		
	1	2	3
Mgr. value unrevealed, v_M	0.52	0.35	0.35
Blockholder operate?	yes	no	yes
Mgr. opportunism?	yes	N/A	yes
price unrevealed, p	0.938	0.968	0.968
price revealed, δ	0.486	0.486	0.486

Parameters: $T = 3$, $c = 0.35$, $\delta = 17/35 \approx 0.486$, $\theta_1 = 0.88$, and $e = 0.875$

Table B.1: *Complex compensation contracts and blockholder shut-down policy.* In this example, the blockholder follows the policy of operating when unrevealed except in period 2.

the firm will operate in period 3.

We want to verify that shut down is a best response in period 2 when the firm is unrevealed. Hence we compare payoffs if the firm operates with the payoff from shutdown.

If the blockholder shuts down the firm at $t = 2$ when unrevealed: The firm's period 2 payoff will equal 0. With probability 1, the firm will not be revealed in period 2. Because the manager acts opportunistically in period 3, the unrevealed price of the good in period 3 will equal the monitoring price in period 3. Since the firm doesn't operate in period 2, the monitoring price in period 3 will equal the monitoring price in period 2. Because $p_3 = p_2 < 0.98$, the manager will not receive a bonus payment in period 2 even if the firm is unrevealed in period 2. Therefore, the period 2 unrevealed shareholder value from shutting down the firm in period 2 equals

$$0 + (p_3 - e) = 0.968 - 0.875 = 0.093.$$

Suppose the blockholder operates the firm in period 2. Even if the period 3 unrevealed price is sufficient to capture the bonus payment of 0.30, because $0.30 < c\delta/(1-\delta)$, customers rationally anticipate that the manager will act opportunistically in period 2. Thus, if the good produced in period 2 is high quality and the firm remains unrevealed in period 2, customers will update the monitoring price, which because the manager acts opportunistically in period 3, equals the period 3 good's price. Hence, the monitoring and good's price in period 3, which we denote by m'_3 and p'_3 respectively, will equal

$$m'_3 = p'_3 = 1 + \delta + \frac{\delta}{m_2} = 1 + \delta + \frac{\delta}{p_2} = 0.984.$$

Because $p'_3 > 0.98$, the manager will capture a bonus payment of 0.30. Therefore, the payoff to shareholders if the blockholder defects to operating in period 2, will equal period 2 profits, $p_2 - e$, plus the expected period 3 profit if the firm remains unrevealed less the period 3 cost of management compensation. The probability that the firm will remain unrevealed until period 3 despite operating in period 2 is $m_2 = p_2$. The period 3 cost of management compensation is 0.30. If the firm is revealed, the firm shuts down, the manager receives no compensation, and the period 3 payoff equals 0. Hence, the payoff from defecting to operating the firm equals

$$(p_2 - e) + p_2(p_3' - e - 0.30) = -0.092.$$

Consequently defection to operating is not a best response for the blockholder.

Contract $\mathcal{C}'$ is clearly not an optimal contract. It commits the firm to make a substantial payment to the manager, 0.30, if the firm operates twice before period T and the firm is not revealed. Although the payment is substantial enough to impose a significant cost on shareholders, it is not substantial enough to stop the manager from acting opportunistically. The blockholder can only avoid this payment to the manager by shutting down the firm, either in period 1 or period 2, even if the firm is unrevealed. In essence, the blockholder has designed a managerial compensation contract that induces the blockholder to ex post undertake an action, shutting down, that is opposed to the shareholder's ex ante interests.

In this example, using the simple contract corresponding to the complex contract $\mathcal{C}'$ greatly increases ex ante shareholder payoff in the resulting equilibrium. In example B-1, the corresponding simple contract to contract $\mathcal{C}'$, $\boldsymbol{b}'$, defined by equation (B.1) is given by

$$b_1' = \mathcal{C}_1'(p_1) = 0, \quad b_2' = \mathcal{C}_2'(p_1, p_2) = 0, \quad b_3' = \mathcal{C}_3'(p_1, p_2, p_3) = 0,$$

where the vector of unrevealed prices, p_1, p_2, p_3, is provided by Table B.1 and the definition of the complex contract $\mathcal{C}'$ by equation (B.2). As Lemma A-3 shows under the simple contract, $\boldsymbol{b}'$, the blockholder will always let the firm operate. A simple calculation shows that the shareholders gross payoff, which equals the shareholders payoff because $\boldsymbol{b}' = 0$, equals 0.256, which exceeds the shareholders' ex ante payoff under $\mathcal{C}'$, which, by another simple calculation, can be shown to equal 0.153.

The insights from Example B-1 generalize. Consider any complex contract, $\mathcal{C}$, under which the firm shuts down when unrevealed in some period. Let $\tau^{\mathcal{C}}$ be the assured-reputation horizon produced by $\mathcal{C}$. Using equation (B.1), define the corresponding simple contract, $\boldsymbol{b}$. As shown by Lemma A-3, the blockholder will operate when unrevealed under the simple contract $\boldsymbol{b}$. The compensation received by the manager if the firm is revealed equals 0 under both contracts. The period t payment to the manager conditioned on the firm being unrevealed is, in all periods, the same under both $\mathcal{C}$ and $\boldsymbol{b}$. As shown in Remark A-2, expected compensation payments are no greater under $\boldsymbol{b}$ than under $\mathcal{C}$. Because the option to act opportunistically created by operating the firm cannot lower the manager's payoff, in every period t, the manager's payoff is weakly greater under $\boldsymbol{b}$ than it is under $\mathcal{C}$. Thus, the assured-reputation horizon under $\boldsymbol{b}$, $\tau^{\boldsymbol{b}}$ is weakly greater than $\tau^{\mathcal{C}}$. Holding the effects of shut-down policy on managerial opportunism fixed, because the unrevealed price exceeds e, operating in all periods produces a higher ex ante gross shareholder payoff than shutting down in any period. Increasing the assured-reputation horizon also increases shareholder gross payoffs. From these observations, we conclude that $\boldsymbol{b}$ produces a higher ex ante shareholder payoff than $\mathcal{C}$.

Thus, although some complex contracts, if they were offered in equilibrium, would produce different blockholder operating behavior than simple contracts, such contracts are never optimal contracts. Hence, expanding the set of contracts to include complex contracts, would not alter any of our results.

B.2 Contracts and information revelation

First consider the case where governance is transparent. Suppose the manager is given contract $C^{\mathcal{I}}$ ($C^{\mathcal{E}}$) if he reports monitoring is ineffective (effective). If the manager picks $C^{\mathcal{I}}$ customers will believe that the firm is ineffective. Then, by Lemma 1, the good's price will equal δ in each period the firm operates, and by Lemma 1, the firm will shut down at $t = 0$ and not operate in any period. Thus, any payment under $C^{\mathcal{I}}$ is effectively a severance payment, which we can represent by $B \geq 0$. Regardless of the firm's type, the manager can select $C^{\mathcal{I}}$ and guarantee himself the severance payment, B. If the manager picks $C^{\mathcal{E}}$, customers will believe that monitoring is effective. They will set a price of 1 for each period's good so long as the firm is unrevealed and the blockholder will let the firm operate in every period in which it is unrevealed. Let the manager's expected payoff from picking the effective contract be represented by $M^{\mathcal{E}}$, when monitoring is effective and $M^{\mathcal{I}}$, when it is ineffective.

In order for picking $C^{\mathcal{E}}$ to be incentive compatible when monitoring is effective, it must be the case that $B \leq M^{\mathcal{E}}$. Similarly, picking $C^{\mathcal{I}}$ is incentive compatible only if $B \geq M^{\mathcal{I}}$. Thus incentive compatibility requires that $M^{\mathcal{I}} \leq M^{\mathcal{E}}$. However, this condition can never be satisfied. From the perspective of the manager, the only difference between the firm being effective or ineffective is that when the firm is ineffective, the manager has the option to act opportunistically. This option cannot make the manager worse off. Moreover, if the firm operates in period T, the manager always strictly gains from opportunism, which is only possible if the firm is ineffective. The probability of the firm operating in period T is positive. Thus, $M^{\mathcal{I}} > M^{\mathcal{E}}$.

Next consider the case where governance is opaque. In this case, the compensation contract is not observed by the customer. Thus, the choice of compensation contract will not affect customer beliefs. As shown in Section 3.3 under any compensation contract, when monitoring is ineffective, the manager will either never act reputably or act reputably up to some assured-reputation horizon, τ.

Suppose the blockholder offered two distinct contracts to the manager conditioned on the manager's reports concerning the effectiveness of monitoring. The manager would under any such contracts, always act reputably when monitoring is effective, and, as shown in Section 3.3, when monitoring is ineffective, act reputably up to period τ. All contracts that implement an assured-reputation horizon of τ produce the same shareholder payoff gross of compensation. Hence, for these distinct alternative contracts to increase shareholder welfare it would have to be the case that for some τ, perhaps $\tau = 0$, the expected payments contracted to the manager would be smaller than the expected contracted payments specified in Lemma 3 for assured-reputation horizon τ. However, as shown in the proof of Lemma 3, the contracts specified in that Lemma minimize the sum of contracted payments to the manager when monitoring is effective subject to the constraint that the assured-reputation horizon τ is incentive compatible when monitoring is ineffective. When monitoring is effective, the payoff to the manager equals the sum of contracted payments. Thus, in order for the manager to report that monitoring is effective when the system is effective, the alternative contracts would have to offer weakly larger expected payments to the manager than the contract specified in Lemma 3. Moreover, in order for the manager to act reputably over the assured-reputation horizon τ, the contract associated with reporting the control system is ineffective would have to provide the manager with weakly larger compensation than the contracts specified in Lemma 3.

Thus, for any fixed assured-reputation horizon, the alternative distinct contracts, one associated with the report that monitoring is effective and one associated with the report that monitoring is ineffective, cannot increase shareholder payoffs. Verifying the existence of a reputation equilibrium involved verifying that defections are not optimal when compensation is provided by the contracts specified in Lemma 3. Thus, the shareholder's payoff from defections under the alternative distinct contracts is no larger than the defection payoffs used to verify the existence of a reputation equilibrium. The conditions provided in that proposition ensure that, under the contracts specified in Lemma 3, non-defection is a best reply for shareholders. Thus, non-defection will be a best reply even if the contracting space is increased to include offering distinct contracts that depend on the reported effectiveness of monitoring.