

Governance, Reputation, Crises and Recovery: Theory and Experiment

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Abstract

We examine the interaction of firm governance with reputation, when reputation damage can be repaired through organizational reform. In a rational-choice framework our model explains how the option to mitigate reputation crises through reform affects firm reputation. The model produces two key conclusions: (a) Although, ex post, reputation repair through reform can increase firm value, ex ante, the option to repair reputation dilutes the incentive to maintain reputation. (b) Separating ownership and control by delegating management to professionals can ameliorate this dilution. An experimental implementation of the model supports these conclusions and shows they are robust to behavioral deviations from rational-choice behavior.

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1 Introduction

Kobe Steel, without input from regulators or other outside parties, concluded that the company had erred by elevating the pursuit of short-term profit over the maintenance of scrupulous quality standards. That failing, it said, was exacerbated by lax oversight by senior executives and an “insular” corporate culture that discouraged employees from questioning improper but long-established practices . . . The report published on Friday outlined several changes the company plans to make to prevent cheating, including automating record keeping for product tests and requiring multiple employees to verify that test results are accurate.

–New York Times (Nov. 10, 2017)

Reputation can account for up to 60% of firm value (Gaines-Ross, 2008a,b; Cole, 2012). Like Kobe Steel, many firms face costly reputation crises precipitated by managers’ actions. The firms typically respond by undertaking “corporate reform.” That is, they reform internal control systems for manager monitoring and oversight (Gaines-Ross, 2008a; Economist, 2018). Adopting corporate reform often enables firms to overcome reputation crises (Farber, 2005; Chakravarthy et al., 2014).¹

Clearly, after reputation crises, reform can benefit firms by rehabilitating their reputations. However, the ex ante effects of the option to respond to reputation crises with corporate reform are unclear: lowering the ex post costs of reputation crises can weaken the ex ante incentive to avoid them. The relevant costs are those borne by agents whose decisions affect the likelihood of reputation crises. Because governance determines how decision-rights as well as the ex post costs of reputation crises are allocated, governance will have a profound effect on ex ante incentives to protect firm reputations. In this paper, we investigate two questions: How does the possibility of successful corporate reform ex post affect ex ante incentives to maintain firm reputations? How are the ex ante effects of reform tied to firm governance?

We advance two hypotheses: (a) the corporate reform option makes it more difficult to sustain reputable behavior ex ante; (b) incentive conflicts between professional managers and dispersed shareholders can facilitate commitment to reputable behavior ex ante. We verify these hypotheses in a rational-choice model and test them in a laboratory experiment. Both our model and evidence indicate that, when corporate reform is a viable option, separating ownership and management can lead to superior reputation maintenance, higher product value, and greater social welfare.

To model firm reputation, we adopt the finite-horizon, incomplete information framework developed by Kreps and Wilson (1982) and Milgrom and Roberts (1982) (KWMR) and regularly employed in financial economics (John and Nachman, 1985; Diamond, 1989; Maksimovic and Titman, 1991). In our model, a firm’s reputation determines outsider’s assessments of the expected quality of its goods.² Insiders (managers or shareholders depending on the governance structure) have private information about the effectiveness of a

¹In Table B.1 in Appendix B we describe reforms undertaken by a small sample of firms that recently faced reputation crises.

²“Quality” represents any aspect of the goods that consumers value, including intrinsic qualities (e.g., durability) and extrinsic qualities (e.g., produced using environmentally sound production processes).

control system for monitoring and oversight to prevent opportunistic actions.³ When the monitoring system is ineffective, insiders can act opportunistically. Because insider opportunism lowers the expected quality of goods, firm reputation is influenced by outsiders' assessment of the monitoring system's effectiveness. Insider opportunism can damage firm reputation and trigger a reputation crisis since reduced good quality reveals (to outsiders) that the monitoring system is ineffective. The firm can attempt to repair reputation damage by reforming the monitoring system. Attempting reform is costly but, when reform succeeds, it resets outsider beliefs about monitoring and good quality.

To assess the ex ante effects of reform, we examine firm behavior and product quality in the presence and absence of the option to reform. To examine how governance structure interacts with reform, we compare two governance structures that have been the focus of governance research: professional-management and owner-management. Under owner management product quality is directly controlled by owners. Under professional management, because of ownership diffusion, owners are informational outsiders. Product quality is controlled by a non-owner manager.

In our model, as in other reputation models, firm reputation is fragile because firm insiders are tempted to opportunistically exploit firm outsiders.⁴ The extent to which reputations are fragile varies with governance structure. When the firm is owner managed, the manager has "skin in the game" and internalizes the entire cost of reputation crises through their effects on the value of her ownership stake. Thus, the owner manager would like to commit to reputable behavior. However, the rewards from unobservably defecting to opportunistic production strategies can motivate owner behavior that risks the firm's reputation.

Because professional managers are not endowed with ownership claims on firm cash flows, they are not inherently motivated to protect firm reputation. Owners can commit to compensation and retention policies that make reputable managerial decisions incentive compatible. However, these policies impose costs that owners might not be willing to bear. Thus, the firm also faces the risk of reputation crises under professional management. However, the conditions that foster crises are markedly different than under owner management.

Under both owner and professional management, after a reputation crisis, corporate reform increases firm value and is essential for overcoming the crisis. Moreover, under both governance structures, by lowering the anticipated cost of a crisis, reform weakens the ex ante incentive to ensure that ex post opportunism does not occur. However, like conditions that foster reputation crises, the adverse ex-ante incentive effects of reform vary with ownership structure. Under owner management, the owner-manager internalizes both the cost of reputation crises and the benefits of corporate reform. Under professional management, optimal owner policies tie managerial compensation and retention to reputation maintenance. Hence, although the professional manager internalizes the cost of a crisis, employment termination in the wake of a crisis ensures that the manager does not internalize the gains from reform. Consequently, separating ownership

³Fama and Jensen (1983) and Bushman and Smith (2001) discuss in detail such systems to monitor managerial behavior (e.g., cost accounting, and information and risk-management systems). They authors argue that boards are generally incapable of personally monitoring the behavior of managers and instead rely on systems, termed information systems by Fama and Jensen and accounting systems by Bushman and Smith. Because of our emphasis on the monitoring role of boards, we call these systems *monitoring systems*.

⁴See Bar-Isaac and Tadelis (2008) for an extensive survey of reputation models.

and management separates agents whose actions affect reputation (management) from the benefits of corporate reform. Since these benefits reduce the cost of opportunism, separating ownership from management mitigates the pernicious ex ante effects of corporate reform.

Testing the predictions of our model on field data is a daunting task because of endogeneity. Governance structures vary across firms, industries, and countries and are not randomly assigned. The structures may be chosen for their reputational effects, but myriad other factors also matter. While some of these factors, like legal protections for shareholders (La Porta et al., 1999), may be observable, others, such as the managerial human capital of owners, may not. Hence, standard econometric fixes for the endogeneity of governance structure are problematic (Coles et al., 2012).

Lacking a natural experiment to test our predictions, we perform a laboratory experiment. This too is a challenging setting for examining our model's predictions because, in laboratory reputation experiments, uninformed agents typically form backward-looking adaptive expectations rather than forward-looking rational expectations (e.g., Brandts and Figueras, 2003; Noe et al., 2012). Relative to the rational expectations setting of our model, adaptive expectations lower the gains from reputation and thus the incentive to adopt policies that protect reputation.

In our experiment too uninformed agents form backward-looking adaptive expectations, and experience weighted attraction models similar to Erev and Roth (1998) and Camerer et al. (2002) nicely explain their behavior.⁵ Nevertheless, our experimental results show that the logic behind our model's predictions is robust to deviations from the rational choice setting in which they were developed. In the experiment, introducing the reform option increases opportunism. There is a significant reduction in the steady-state rate of reputable behavior under owner management but not under professional management. When the theoretical analysis predicts that, under owner management, the incentives produced by the reform option make reputation-assuring policies unsustainable, owner management results in significantly more opportunism than professional management in our experiment. Similarly, when the theoretical analysis predicts that the gains from reform are insufficient to vitiate reputation-formation incentives, the difference in the incidence of opportunism under owner and professional management is insignificant in the experiment.

These results have the following implications:

- a. Reform has a dark side. It encourages ex post opportunism. Thus, as the technology of corporate reform improves, corporate reputations may become more unstable.
- b. In the shadow of reform, separating ownership and management can provide a competitive advantage in reputation maintenance. Thus, the reform option should increase the degree of association between firm reputation and professionalized management.
- c. Because product market pricing deviates from rational expectations, in practice, efficient reputation management is likely to involve considerable investment in coordinating consumer expectations, e.g., public relations and advertising. Such investments are complements, not substitutes, for effective oversight and managerial incentive programs.

⁵Such adaptive learning is commonly observed in experimental settings (Part 4.3 Plott, 1982).

Related literature

Our paper is part of a very broad stream of research, perhaps initiated by Jensen and Meckling (1976), devoted to analyzing the effect of governance on firm value. We focus on the effect governance exerts through the reputation channel. We develop our model of the reputation channel using the basic framework of Kreps and Wilson (1982) and Milgrom and Roberts (1982) (KWMR) but modify this framework to accommodate first-order features of reputation formation and repair in a corporate context: (a) the decisions that affect reputation are frequently made by non-owner agents incentivized by owners or their agents, corporate boards, and (b) reputation adheres to the corporation as a whole. In contrast, most reputation models focus almost exclusively on the owner-manager structure (e.g., Maksimovic and Titman, 1991; Mailath and Samuelson, 2001; Cripps et al., 2004; Liu, 2011). While some reputation research does recognize agency conflicts inside firms, this research models firm reputation founded on manager's personal reputations (Holmström and Costa, 1986; Stein, 1989; Gibbons and Murphy, 1992; Holmström, 1999), or on models partnerships where the team of owner-managers can claim all the firm's reputation rents (e.g., Cremer, 1986; Tirole, 1996; Morrison and Wilhelm, 2004; Levin and Tadelis, 2005).

In a somewhat different context, Hirshleifer (1993) and Hirshleifer et al. (2001) study owner/manager conflicts when managers are concerned with their own personal reputations. They also find managers act more or less in the long run interests of the firm. However, in their model alignment between firm and managerial incentives is produced by career concerns. In our model, career concerns are absent and ownership structure, managerial contracts, and reform possibilities drive managerial behavior.

We focus on organizational reputations as opposed to the reputation of firm insiders. Hence, consistent with empirical evidence (Farber, 2005; Chakravarthy et al., 2014) and the examples in Table B.1, in our model reputation crises must be overcome by organizational reform of corporate monitoring systems. Replacing management is neither necessary nor sufficient to overcome a reputation crisis. In contrast, much of the existing analysis of organizational reputation is based on the idea that a firm is a "name" whose value is initially based on the characteristics of its founding owner manager. Customers believe that a "good" name will produce quality output but their assessment can be changed by the actions of the name's current owner. Owners can separate themselves from their names by selling the names (Tadelis, 1999; Kreps, 1996; Mailath and Samuelson, 2001) or by separating partners from the name (e.g., Cremer, 1986; Tirole, 1996).

Our experimental analysis draws on previous experimental research on reputation. Our significant departure from this literature is the introduction of the reform option. Despite this departure, our experiments verify the same deviations from equilibrium behavior observed in other experiments on reputation and learning (Camerer and Weigelt, 1988; Brandts and Figueras, 2003; Noe et al., 2012): Managers behave less reputably than predicted on average and prices suggest consumers expect even less reputable behavior. Subjects approach the rational-expectations equilibrium over repeated plays of the game but their behavior does not immediately converge to the predicted equilibrium.

2 Model

Consider an economy that operates for two periods. We refer to the beginning of period 1 as date 0. The risk free rate is zero. The economy has one firm. If the firm operates in period $t \in \{1, 2\}$, 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 during the period.

Agents All agents in the economy are risk-neutral. They consist of firm owners, a continuum of identical manager candidates and a continuum of identical consumers. The firm is operated by an “operator.” As discussed below, the ownership structure will determine whether the operator is the owner or a manager. The utility or payoff for each agent is given by her expected future cash flows plus the expected value of the goods she purchases. Owners have a sufficient endowment of cash in each period to fund all firm activities.

Products Each good the firm produces may be either high, h , or low, l , quality. Our definition of quality includes aspects of the good the consumer values including whether it is produced in a socially responsible manner. All agents observe a good’s quality after it has been consumed. Hence, the period t good’s quality is common knowledge at the end of period t . A good’s quality is neither verifiable nor contractible.

Product price formation Consumers compete in Bertrand fashion by bidding for each good. The price they set for the period t good, p_t , represents a bid that will be filled if the good is produced.⁶ Prices are verifiable and contractible. Consumers have identical preferences, which are common knowledge: they assign a value of one to a high-quality good and a value of zero to a low-quality good. Consistent with Bertrand competition, we assume that the consumers’ bid price equals their expected valuation of the good. This assumption rules out a “trivial equilibrium” in which consumers believe goods are worthless and bid zero, goods are not produced and, because consumer bids are never filled, Bayes rule cannot be applied to consumer beliefs.

Production decisions In each period, after observing the price set by consumers, owners choose whether or not the firm will “operate,” i.e., produce a good. To ensure that the firm operates, owners must supply it with capital equal to e . Otherwise, the owners “shut down” production for the period, i.e., the owners supply no capital and the firm does not produce a good in the period. The operator invests the supplied capital in the firm’s operations. If the operator invests the entire capital, e , the firm employs the “reliable technology.” This technology produces a high quality good with probability one. The operator also has access to a “vulnerable technology.” This technology requires a capital investment of $I = e - c < e$, but only produces a high quality good with probability $\delta \in (0, 1)$, and a low quality good otherwise.

⁶This timing for consumer bids ensures that in each period there is a price for the good on which contracts can be written. If prices are set after production, in any period in which the firm does not produce, the good would not have a price and a contract based on the period’s price would be ill defined. We would obtain the same results by assuming price setting after production, extending the definition of “price” to include the “null price”, and specifying contracts over this extended set. However, this modification of the model would add complexity without producing insight. See Allen and Gale (1988) for a similar assumption.

Monitoring system and diversion The firm has a monitoring system. The system can be either “secure” or “insecure.” If it is secure, the operator can only invest in the reliable technology. If it is insecure, the operator can unobservably choose between the reliable and vulnerable technologies.⁷ If the operator chooses the vulnerable technology, the cost savings, $c > 0$, is diverted unobservably from the firm’s account and is consumed by the operator.⁸ We call the operator’s choice of the vulnerable technology “diversion.” If, in a given period, the operator follows the strategy of diverting whenever diversion is possible, i.e., choosing the reliable technology if and only if the monitoring system is secure, we will say that the operator “acts opportunistically” during the period. If no period qualification is given, acting opportunistically should be interpreted as acting opportunistically in both periods. In contrast, if, in a given period, the operator follows the strategy of choosing the reliable technology regardless of whether the monitoring system is secure or insecure, we will say that the operator acts “reputably” in that period.

Information At date zero, the operator, and only the operator, observes whether the monitoring system is secure. The remaining agents (including owners if the firm is not owner operated), whom we collectively refer to as “outsiders,” do not know whether the monitoring system is secure.⁹ Instead, outsiders have a common prior distribution over the security of the monitoring system. At the start of period 1, they believe that the monitoring system is secure with probability ρ_1 . Thus, ρ_1 measures outsiders’ initial assessment of the monitoring system’s effectiveness.

Revelation A good’s quality can reveal the monitoring system’s type to outsiders: A low quality good can only be produced if the operator chooses the vulnerable technology, which is only possible if the monitoring system is insecure. Since nothing happens after period 2, this revelation is only meaningful in period 1. We refer to the firm and its monitoring system as “revealed” once the period 1 good’s quality reveals that the monitoring system is insecure.

Prices and belief updating If outsiders’ conjecture the operator will act reputably in period t , the period t good’s price, $p_t = 1$. When $p_1 = 1$, outsiders will expect the firm will be unrevealed after period 1. If outsiders conjecture the operator will act opportunistically in period 1, the period 1 good’s price will equal its “floor price,” F_1 , where

$$F_1 = \rho_1 + (1 - \rho_1) \delta. \quad (1)$$

F_1 also represents outsiders’ assessment that the firm will remain unrevealed after period 1.

In period 2, if outsiders conjecture that the operator will act opportunistically, the period 2 good’s price will vary in accordance with Bayes rule based on what outsiders expected and observed in period 1 as

⁷Imperfect monitoring is implicit in models of managerial moral hazard (Jensen and Meckling, 1976). Dye (1988) and Verrecchia (1986) demonstrate why firms may optimally choose imperfect monitoring systems.

⁸Our analysis and results would be virtually unchanged if implementing the vulnerable technology yields no cost savings but instead yields a private benefit of c for the operator.

⁹At Volkswagen and Boeing insiders exploited flawed monitoring systems for a considerable period before the firms’ owners and boards learned that monitoring systems had failed. This pattern is typical for reputation crises we summarize in Table B.1 in Appendix B. Kothari et al. (2009) and Karpoff and Lou (2010) provide evidence supporting the existence of owner-manager information gaps like these. Owner-manager and board-manager information gaps are the central feature in many models of agency conflict (Adams et al., 2010).

follows: First, if outsiders conjectured that the operator would act reputably in period 1 and the period 1 good was high quality, or if the firm did not operate in period 1, outsiders' initial assessment of the monitoring system's effectiveness will not change and the period 2 good's price will equal F_1 . Second, if outsiders conjectured that the operator would act opportunistically in period 1 and, nevertheless, the firm produced a high quality good, outsiders will update their assessment of the monitoring system's effectiveness and the period 2 good's price will equal F_2 , where

$$F_2 = \frac{\rho_1}{F_1} + \left(1 - \frac{\rho_1}{F_1}\right) \delta = 1 + \delta - \frac{\delta}{F_1}. \quad (2)$$

Note $F_2 > F_1$. Third, if outsiders observe a low quality good in period 1 and hence the firm is revealed, the period 2 good's price will equal δ . Because goods' prices and the probability of revelation do not directly depend on the probability that the monitoring system is secure, but rather on the probability that the good is high quality, we use the good-quality assessments we have just described to capture Bayesian updating.

Reform If the reform option is available and the firm's monitoring system is revealed to be insecure in period 1, owners can "reform" the monitoring system at the start of period 2 by paying a price for reform, R . Reform is publicly observable. It succeeds and transforms the monitoring system to a secure system with probability $r \in (0, 1)$. Reform fails and the monitoring system remains insecure with probability $1 - r$. To reform the monitoring system and ensure that the firm operates in period 2, owners must pay R in period 2 (in addition to the period-two operating cost of e). Only the operator observes whether reform succeeds. Following reform, if outsiders conjecture that the operator will act opportunistically, the price of the good will equal $F_r = r + (1 - r) \delta$, which we refer to as the "reform floor price."

2.1 Ownership structures

We examine outcomes under two ownership structures: "owner management" and "professional management." Under owner management, the firm has a single owner who also operates the firm and thus fully internalizes all the consequences of diversion. The owner management structure is similar to sole proprietorships. Under this structure our model is close to the classic models of reputation (e.g., Kreps and Wilson, 1982; Milgrom and Roberts, 1982), and the source of reputation crises is the conflict between the owner's ex post and ex ante incentives to adopt the reliable technology.¹⁰

2.1.1 Professional management

The professional management structure is modeled on the governance of modern corporations: A set of diffuse shareholders collectively owns the firm. The shareholders are represented by a "benevolent" board that acts in their interest to maximize expected firm value.¹¹ To start period 1 the board hires a professional

¹⁰Like most of the reputation literature, we abstract from non-pecuniary motivations for maintaining product quality, such as the desire of family owners and managers to "protect the family name." Sraer and Thesmar (2007) argue that such non-pecuniary motivations are an important facet of reputation in family firms.

¹¹Under professional management, shareholders neither extract private benefits nor exert personal effort on monitoring, so assuming their collective interest is represented by a board simply makes the analysis more compact.

manager as the operator. The board can change the manager at the start of period 2. The market for managers is competitive with a continuum of identical candidates whose abilities and preferences are common knowledge. Managers have a per-period reservation wage of zero, which lowers the minimum level of managerial compensation and thus increases the likelihood of managerial opportunism.

In contrast to standard reputation models, an owner-manager agency conflict arises from the professional manager's ability to unobservably divert funds intended to ensure quality, lowering goods' expected quality and price. This conflict within the firm arises because decisions affecting the firm's reputation are made by an agent who has no ownership rights over the rents from reputation but who does capture gains from opportunistic diversion.

To mitigate this agency conflict, the board can contract with a manager when he is hired. We assume that outsiders, even consumers, observe the contract's terms and account for them when choosing strategies. This is likely to be the case, for instance, if the consumers are firms and the goods are essential inputs into their production processes. For example, when buying aircraft airlines likely account for the incentives of managers at Boeing or Airbus to produce aircraft that are safe to operate.

Since the period t good's price is set before production and technology decisions are made, a payment based on the period t good's price will be insensitive to the manager's technology choice in period t . Thus, a period t incentive payment cannot motivate the manager's period t technology choice but may affect the manager's $t - 1$ choice. Consequently, an incentive payment in period 1 is wasteful. Thus, without any loss of generality, we only consider contracts with the manager hired in period 1, and contracts that make a payment to him only in period 2. The payment depends solely on the only contractible variables: goods' prices in periods one and two. We assume that the payment is non-negative.

2.2 Parametric assumptions

In order to focus on the subset of the parameter space that yields interesting and insightful results, we impose the following restrictions:

Assumption 1. $I > \delta > 0$.

Assumption 2. $F_1 - e \geq 0$.

Assumption 3. $F_r - e - R > 0$.

Assumption 4. $r \leq \rho_1$.

Assumption 1 ensures that the vulnerable technology produces high-quality goods with positive probability, but that this probability is too low to make known use of the vulnerable technology profitable. Assumption 2 ensures that, even under the most pessimistic consumer conjecture about good quality in period 1, production will be profitable in period 1. Assumption 3 ensures that reform is profitable in expectation. Assumption 4 simply ensures that reform following revelation (i.e. reputation damage) caused by insider opportunism cannot increase consumer assessments of the security of the firm's monitoring system above its pre-revelation level.¹²

¹²While the reformed monitoring system is less likely to be effective than the original system in expectation, reform

2.3 Equilibrium

A Sub-Game Perfect Bayesian Nash equilibrium is a set of owner/board and manager actions, prices for goods, and beliefs in each period such that:

- i. Under professional management the board's managerial hiring and replacement decisions are incentive compatible.
- ii. The owner's/board's reform and shut down/operate decisions are incentive compatible.
- iii. The operator's divert/not divert decisions are incentive compatible.
- iv. Consumers set prices equal to the goods' expected quality conditioned on the owner's and operator's strategies.
- v. Belief updating is consistent with Bayes' rule.

Under owner management, an equilibrium is a Sub-Game Perfect Bayesian Nash equilibrium. Under professional management, an equilibrium is a compensation contract and an associated Sub-Game Perfect Bayesian Nash equilibrium such that there exists no other contract with an associated Sub-Game Perfect Bayesian Nash equilibrium that produces a higher ex ante expected value for the firm. We will refer to an equilibrium in which the operator acts reputably in period 1 as a "reputation equilibrium."

3 Equilibrium outcomes

We focus on deriving conditions for reputation equilibria with and without the option to reform. We derive equilibrium conditions separately under owner management and professional management. We first characterize common features of equilibria under these two ownership structures. Formal proofs appear in Appendix A.

3.1 Common characteristics of equilibrium outcomes

Although the model features many actions, the equilibrium actions in many cases are determined simply by the fact that our model, like classic reputation models, is a finite-period incomplete information game. Because period 2 is the last period in the model and good quality is not observed until the good is consumed, opportunism in period 2 imposes no costs on the operator but allows him to benefit from the cost reduction, c , from adopting the inferior vulnerable technology. Thus, the operator will always act opportunistically in period 2. If the firm is revealed (in period 1), consumers will price the period 2 good's price $p_2 = \delta$. Consequently, by Assumption 1 period 2 production will not be profitable absent reform. At the same time, Assumption 3 ensures that period 2 production will be profitable if the monitoring system is reformed. If the firm is unrevealed, Assumption 2 along with $F_2 > F_1$ ensures that operating the firm is profitable even when consumers conjecture the operator will act opportunistically. The consequences of these observations are summarized in the following lemma.

Lemma 1. *Regardless of the firm's ownership structure,*

can yield a more effective monitoring system. In a model in which the firm could operate for multiple periods after reform, after the firm produced high quality goods for several periods outsiders' assessment of the monitoring system's effectiveness would exceed their pre-revelation assessment.

- a. In period 2, if the firm produces, the operator will act opportunistically.
- b. If the firm is revealed, absent reform, the consumer's period 2 bid price for the good will equal δ and the firm will not produce in period 2.
- c. If the firm is revealed and the reform option is available, the owner/board will choose reform and the firm will operate in period 2.
- d. The firm will operate in period 1 and, if it is not revealed, it will operate in period 2.

3.2 Professional management

We identify the optimal replacement policy for managers and characterize their optimal compensation. These results help us derive conditions for reputation equilibria.

3.2.1 Manager replacement policy

Lemma 1.d shows that the firm will operate in period 1 and will operate in period 2 if it is not revealed. Diversion when the monitoring system is insecure is the only action that a professional manager can undertake which reduces firm value. As Lemma 1.a shows, the board cannot curb the manager's opportunism in period 2. Thus, for any given expected expenditure on managerial compensation, firm value is maximized by selecting compensation contracts and managerial replacement policies that minimize the manager's gain from opportunistic actions relative to reputable actions in period 1. The replacement policy that maximizes firm value is the policy of terminating the manager at the start of period 2 if and only if the firm is revealed. Retaining the manager permits the manager to capture diversion gains in period 2. Terminating the manager if the firm is revealed deprives him of period 2 diversion gains, and thus imposes an opportunity cost on period 1 diversion. This replacement policy is incentive compatible in period 2 since the replacement manager is equally likely to divert in period 2. This observation is summarized by the next Lemma.

Lemma 2. *The incumbent manager will be retained in period 2 if and only if the firm is unrevealed.*

Lemma 2 demonstrates that, once a firm's reputation is damaged, it is optimal to replace its manager. The factors driving this result differ dramatically from Tirole (1996), who also considers how a firm can overcome reputation damage. In Tirole (1996), the firm is a group of agents who share a reputation and it is optimal to terminate agents whose actions damage the group's reputation. Termination allows the group to repair its reputation by bringing more reputable agents into the group. In our model, the incumbent and replacement managers are identical in characteristics and incentives. Replacement acts only as a penalty for deviant behavior, which maximizes the manager's ex ante incentives to act reputably. This logic resembles the incentive effect of termination in Cremer (1986) who, like Tirole (1996), models the firm as a team of agents. Unlike Tirole (1996) and Cremer (1986), in our setting, the firm fails after revelation because consumers learn about the character of the monitoring system. Thus, consistent with the arguments developed in the management literature and the corporate actions documented in Table B.1 in Appendix B, personnel policies, in and of themselves, cannot restore corporate reputations. Only reforming monitoring systems can. Replacing management is merely coincident with reputation repair, not the means of repair.

3.2.2 Optimal compensation

Determining the optimal incentive contract for the manager is relatively simple. Optimal contracts, for a fixed level of expected compensation payments, minimize the gains from opportunism in period 1. Consequently, an optimal contract always takes the following form: The contract makes no payment to the manager in period 1. In period 2, the contract specifies a payment of b , where $b \geq 0$ if $p_2 \geq F_1$ and a payment of 0 if $p_2 < F_1$. Verifying the optimality of this contract form is straightforward. The period 2 price is greater than or equal to F_1 if and only if the firm is not revealed. To see this, note that Lemma 1.a implies that the manager will act opportunistically in period 2. Thus, if the firm is revealed and the board reforms, the period 2 good's price will equal F_r . By Assumption 4, $F_r = r + \delta(1 - r) < \rho_1 + \delta(1 - \rho_1) = F_1$. If the board does not reform, the good price will equal $\delta < F_1$. If the firm is unrevealed, regardless of the consumer's conjecture about managerial behavior the price of the good will at least equal F_1 . Thus, this form of contract in effect specifies (a) a payment in period 2 of $b \geq 0$ if the firm is unrevealed, (b) a payment in period 2 of 0 if the firm is revealed, (c) and a payment in period 1 of 0. Because period 1 payments have no incentive effects for reasons discussed in Section 2.1.1, and because, for any fixed $b \geq 0$, a payment of 0 when the firm is revealed maximizes the difference between the manager's payoff from acting reputably and payoff from acting opportunistically, this contract form is optimal.

Next consider the problem of setting the specific contracted payment, b . Compensation only affects managerial behavior when the monitoring system is insecure. So consider the problem of a manager who knows the monitoring system is insecure. If the firm is unrevealed, the manager will be retained (Lemma 2) and can divert in period 2. In addition, he will receive the contracted bonus b . Thus, his payoff in period 2 will equal $b + c$. If the firm is revealed, the manager will be terminated, thus cannot divert in period 2, and will not receive the contracted payment b . Therefore, the manager's period 2 payoff will equal 0. If the manager diverts in period 1, the probability that the firm will be unrevealed at the start of period 2 equals δ . Hence, not diverting will be a best response for the manager in period 1 if and only if

$$\overbrace{c + \delta(b + c)}^{\text{payoff: divert}} \leq \overbrace{b + c}^{\text{payoff: not divert}}. \quad (3)$$

Solving for the minimum b that satisfies this inequality yields

$$b^* = \frac{c\delta}{1 - \delta}. \quad (4)$$

Thus, b^* is the minimum incentive payment that will induce the manager to act reputably in period 1. If the board offers any positive compensation payment, i.e., chooses to set $b > 0$, the owner will set $b = b^*$. We call such a compensation scheme "reputation-assuring compensation." If the board does not offer reputation-assuring compensation, then it will not offer any compensation to the manager, i.e., the board will offer the contract that sets $b = 0$. Reputation-assuring compensation increases the manager's utility above his reservation level and the prospect of losing these rents deters opportunism. Hence, in our analysis, reputation-assuring compensation functions similarly to efficiency wages in Klein and Leffler (1981). In

contrast to Klein and Leffler's setting, in our setting, opportunism is not directly observable and can only be estimated via a noisy signal, the good's price. Hence, our implementation is somewhat different.

3.2.3 Conditions for reputation equilibria

As the earlier analysis demonstrated, reputation equilibria can only be supported if the board offers reputation-assuring compensation. If the board offers such compensation, the manager will act reputably in period 1 and the period 1 good's price, p_1 , will equal one. In period 2 the manager will act opportunistically as shown by Lemma 1.a. Therefore, the period 2 good's price will equal F_1 . Thus, under reputation-assuring compensation, the firm's expected value is:

$$\underbrace{1 - e}_{\text{period 1}} + \underbrace{F_1 - e - b^*}_{\text{period 2}}. \quad (5)$$

If instead, the board does not offer reputation-assuring compensation, outsiders will expect the manager to act opportunistically in period 1 and set a period 1 good's price of F_1 . With probability, $1 - F_1$ the firm will be revealed at the start of period 2. In this case, Lemma 1.c shows the board will opt for reform, if this option is available. With probability F_1 the firm will remain unrevealed through period 1, and the price of the good in period 2 will be given by $F_2 > F_1$, where F_2 is defined by Equation (2). Lemma 1.d ensures that the firm will operate in period 2. Thus, if the option to reform is available, the firm's expected value contingent on not offering reputation-assuring compensation is given by

$$\underbrace{F_1 - e}_{\text{period 1}} + \underbrace{(1 - F_1)(F_r - R - e) + F_1(F_2 - e)}_{\text{period 2}}. \quad (6)$$

When the reform option is not available, by Lemma 1.b, the firm will shut down in period 2 if and only if the firm is revealed. Consequently, the firm's expected value contingent on not offering reputation-assuring compensation is given by

$$\underbrace{F_1 - e}_{\text{period 1}} + \underbrace{F_1(F_2 - e)}_{\text{period 2}}. \quad (7)$$

A reputation equilibrium will exist whenever firm value from offering reputation-assuring compensation at least equals its value from not offering reputation-assuring compensation. These observations, and a bit of algebraic manipulation, yield the following conditions for reputation equilibria under professional management:

Proposition 1. *Under professional management, if the option to reform is available, then a reputation equilibrium exists if and only if*

$$\rho_1 \leq 1 - \frac{b^*}{\delta + \pi_1 - \pi_r} \times \frac{1}{1 - \delta}, \quad (8)$$

where b^* is defined in equation (4), $\pi_1 = 1 - e$, is the period 1 profit if the good's price is 1, and $\pi_r = F_r - e - R$ equals the period 2 profit if the firm is reformed. If the option to reform is not available, then a

reputation equilibrium exists if and only if

$$\rho_1 \leq 1 - \frac{b^*}{\delta + \pi_1} \times \frac{1}{1 - \delta}. \quad (9)$$

This characterization is intuitive. Reputation-assuring compensation yields two benefits. First, it eliminates the possibility of revelation. The board's assessment of this probability absent reputation-assuring compensation is $1 - F_1$. Thus, the direct gain from reputation-assuring compensation is inversely related to the floor price. This benefit is reflected in the proposition by the range of outsiders' initial assessments of the monitoring system's effectiveness that support reputation equilibria being a lower interval. Second, reputation-assuring compensation has an informational effect. When consumers observe such compensation it leads them to set a price of 1 for the period 1 good, and thus permits the firm to capture a profit of π_1 in period 1. This effect is reflected through the positive relation between π_1 and the length of the interval of initial outsider assessments which support reputation equilibria. The cost of offering reputation-assuring compensation is captured by the required payment to the manager, b^* . This cost is reflected in the proposition by the negative relation between b^* and the length of the interval supporting reputation equilibria.

Since $\pi_r > 0$ by Assumption 3, the following corollary is immediate.

Corollary. *Under professional management, the set of parameter values for the model that support reputation equilibria when the option to reform is available is a proper subset of the set of parameter values that support reputation equilibria when the option to reform is absent.*

The corollary shows that the option to reform, by generating profit π_r after revelation, lowers the firm's loss from revelation and thus weakens the board's incentive to adopt reputation-assuring compensation. Hence, the option to reform shrinks the interval over which reputation equilibria are sustainable, as does higher profitability of reform.

When the equilibrium conditions of Proposition 1 are not satisfied, the board does not pay reputation-assuring compensation, it operates the firm in both periods if it is unrevealed, and the equilibrium price in period t equals F_t when the firm is unrevealed. If the firm is revealed, when the option to reform is available, the firm operates and the period 2 equilibrium price equals F_r . If the option to reform is not available, the revealed firm shuts down in period 2.

3.3 Owner management

There are three essential differences between the incentives generated under owner management and professional management. First, the owner-manager, being the operator, is an informational insider who knows whether the monitoring system is secure. Thus, the conditions for a reputation equilibrium depend only on the owner-manager's payoffs when the monitoring system is insecure. Second, when the monitoring system is insecure, the owner-manager captures the rents generated by outsider's mistaken confidence in the security of the monitoring system. Third, the owner-manager also captures the rents from diversion after failed reform. To capture the third difference, let $g = (1 - r)c$, where g represents expected post-reform gains from diversion. To see this, note that, in period 2, by Lemma 1.a, the owner-manager will always

divert when the monitoring system is insecure. After reform the probability that the monitoring system is insecure equals $1 - r$ and the reward for diversion is c .

Now consider the viability of reputation equilibria under owner management. Consider the owner's diversion decision when the monitoring system is insecure. Lemma 1.d shows it is optimal for the owner to operate the firm in period 1. Regardless of whether the option to reform is available, if the owner-manager chooses the reliable technology in period 1, the period 1 good's rational expectations equilibrium price is 1. In period 2, by Lemma 1.a, the owner-manager diverts and produces using the vulnerable technology, making a net investment of I . The rational expectations price for the period 2 good is, thus, F_1 . Hence the owner-manager's payoff in an equilibrium in which the owner-manager does not divert equals

$$\overbrace{1 - e}^{\text{period 1}} + \overbrace{F_1 - I}^{\text{period 2}}. \quad (10)$$

If the owner-manager defects from the equilibrium and diverts in period 1, the firm enters period 2 unrevealed with probability δ . With probability $1 - \delta$ the firm is revealed. If the firm is revealed and the reform option is available, by Lemma 1.c, the owner-manager will reform and the firm will operate in period 2; otherwise, by Lemma 1.b, the firm will shut down. By Lemma 1.a, the owner-manager will divert in period 2 if the firm operates. Thus, the owner-manager's payoff if she defects from the equilibrium and if the reform option is available equals

$$\overbrace{1 - I}^{\text{period 1}} + \overbrace{\delta (F_1 - I) + (1 - \delta) (r(F_r - e) + (1 - r)(F_r - I) - R)}^{\text{period 2}}, \quad (11)$$

and, if the option to reform is not available, equals

$$\overbrace{1 - I}^{\text{period 1}} + \overbrace{\delta (F_1 - I)}^{\text{period 2}}. \quad (12)$$

A reputation equilibrium will exist if and only if not diverting in period 1 when the firm is insecure produces at least as great a payoff for the owner-manager as deviating to diversion. These conditions, and a bit of algebraic manipulation, yield the following characterization of reputation equilibria under owner management:

Proposition 2. *Under owner management, if the option to reform is available, reputation equilibria exist if and only if*

$$\rho_1 \geq 1 - \frac{\pi_1 - b^* - (\pi_r + g)}{1 - \delta}, \quad (13)$$

where b^* is defined by equation (4) and π_1 and π_r are defined in Proposition 1. When the option to reform is not available, reputation equilibria exist if and only if

$$\rho_1 > 1 - \frac{\pi_1 - b^*}{1 - \delta}. \quad (14)$$

Some aspects of the conditions for reputation equilibria for owner management are quite similar to those for professional management. For example, under both owner and professional management, increasing the profits from reputable behavior, π_1 , increases the length of the interval of initial outsider beliefs about the monitoring system's effectiveness over which reputation equilibria can be supported. Moreover, under both ownership structures, increasing the gains from opportunism, which are proportional to b^* , reduces the length of this interval.

However, there are also two significant differences between the conditions for reputation equilibria under owner as opposed to professional management. First, although the gains from opportunism make sustaining reputation more difficult under both ownership structures, they do so for very different reasons. With professional management, increasing the gains from opportunism increases the reputation-assuring compensation required to induce the manager to forgo opportunism. This cost is traded off against another expected cost: the cost to the uninformed owners of revelation. With owner management, the owner-manager is informed about the monitoring system. Because diversion is only possible when the monitoring system is insecure, the incentives of the owner when the monitoring system is insecure determine the viability of reputation equilibria. When the monitoring system is insecure, the owner can gain from diversion. Thus, the gain from opportunism represents a temptation not a cost under owner management.

The primary difference between the reputation conditions for owner and professional management is the role of outsiders' prior beliefs about the effectiveness of the monitoring system. The owner-manager's incentive to eschew diversion in period 1 arises because diversion risks revelation and losing profits in period 2. Period 2 profits depend on the price of the good in period 2, which by Lemma 1.a depends on ρ_1 . Thus, a higher prior belief expands the region of the parameter space over which reputation equilibria can be sustained. The effect of a higher prior belief changes under professional management. If ρ_1 is higher, failing to provide reputation-assuring compensation is less likely to reveal the firm as insecure. Thus, owners obtain less value in paying compensation, making it less likely the board will pay to sustain a reputation. Hence, under owner management, the interval of prior beliefs that sustain reputation equilibria is an upper interval and under professional management the interval is a lower interval.

Because $\pi_r + g > 0$, Proposition 2 leads immediately to the following corollary:

Corollary. *Under owner management, the set of parameter values for the model that support reputation equilibria when the option to reform is available is a proper subset of the set of parameter values that support reputation equilibria when the option to reform is not available.*

The effect of reform on the viability of reputation equilibria, like the case of professional management, includes π_r , the expected firm profit after reform. As in the case of professional management an increase in π_r reduces the interval of outsider prior beliefs about the monitoring system's effectiveness over which reputation equilibria are sustainable. However, there is an additional impediment to sustaining reputation equilibria under owner management—the gain from diversion post reform, g . Under professional management this gain is not captured by the owners, but rather by a (replacement) manager and thus does not enter into the board's decisions. Under owner management this gain is captured by the owner when the monitoring system is insecure and increases the owner-manager's temptation to divert.

When the reputation equilibrium conditions of Proposition 2 are not satisfied, depending on the parameter values, the equilibrium is either a mixed strategy equilibrium in which the owner-manager randomizes between reputable and opportunistic behavior in period 1 or the owner manager always acts opportunistically in period 1. The expressions defining the operating strategies are somewhat complex and not directly relevant to the focus of our analysis. However, they are required for predicting the outcomes of the experiment. Thus, we develop these equilibria in Lemma A-1 in Appendix A.

3.4 Reform and reputation

As Propositions 1 and 2 indicate, the conditions for reputation equilibria under professional and owner management vary considerably, particularly when the option to reform is available. Under both ownership structures, the option to reform makes sustaining reputation equilibria more difficult. However, the effect of reform on owner payoffs is fundamentally different under the two ownership structures. The cost of failed reform is lower for owner-managers. To see this note that under both ownership structures increasing the effectiveness of reform, by increasing r , benefits owners as it increases F_r , implying a higher price for the period 2 good. However, increasing r imposes a cost on the owner manager when the monitoring system is insecure, albeit a cost smaller than the benefit: increasing r reduces their expected diversion gains. Thus, the value of reform to the owner-manager is less sensitive to the effectiveness of reform than is the value of reform to owners when the firm is professionally managed. At the same time, because the owner-manager always has some probability of capturing diversion gains, her expected gain from the reformed firm's operation, is higher.

Thus, the owner manager finds relatively ineffective (low r) reform more attractive than non-owner managers. Because reform is never so effective that it completely restores the reputation of the firm's monitoring system to its pre-revelation level (Assumption 4), reform will not be extremely effective unless the consumers initial assessment of the monitoring systems effectiveness, and thus F_1 , is very high. These results imply that, as long as the outsiders' prior belief about the monitoring system's effectiveness is not too high and reform is fairly effective, an owner-managed firm is more likely than a professionally managed firm to eschew reputable behavior in period 1 in favor of opportunism in period 1 and risk having to reform in period 2.

Proposition 3. *When the option to reform is available and*

$$\rho_1 < 1 - \frac{\pi_1 - (\pi_r + g)}{(1 - \delta)(1 + \delta + \pi_1 - \pi_r)}, \quad (15)$$

then, if a reputation equilibrium exists under owner management, a reputation equilibrium exists under professional management.

Proposition 3 implies that professional management is more likely to support reputation equilibria when the prior probability that the monitoring system is secure, ρ_1 , is low. Because the right-hand side expression in condition (15) is increasing in the gain from diversion post reform, g , the larger the expected scope for

opportunism by owner-managers, the larger the set of prior probabilities over which professional management can better support reputation equilibria. Similarly, the right-hand side of condition (15) is decreasing in, $\pi_1 - \pi_r$. This expression represents the loss in profit produced by a loss of reputation when the option to reform is available. Thus, when reform is fairly cheap and effective, the set of prior probabilities over which professional management can better support reputation equilibria will be larger.

We provide further insight into Proposition 3 and the effects of reform across the two ownership structures in Figure 1. We graph, for a specific choice of the other parameter values, combinations of prior probabilities that the monitoring system is secure, ρ_1 , and probabilities that the monitoring system is secure conditioned on reform, r , that support reputation equilibria. Panel A depicts the case where the reform option is absent. Panel B presents the case where the reform option is available. The gray shaded region depicts the region excluded by Assumption 4, which requires that the expected quality of the post reform monitoring system is no higher than the prior quality of the pre-reform monitoring system.

Consistent with the corollaries to Propositions 1 and 2, for both owner and professional management the regions that support reputation equilibria when the reform option is available are subsets of the regions that support reputation equilibria when the reform option is absent. In Panel B, the combinations of ρ_1 and r that satisfy the condition of Proposition 3 are enclosed in the dashed red lines. Consistent with the proposition, within the enclosed region, it is never the case that a reputation equilibrium is supported by owner management and not supported by professional management. Consistent with the earlier discussion, the conditions of Proposition 3 are satisfied when the prior probability that the monitoring system is secure is not extremely high and reform is fairly effective, i.e., r is not much smaller than ρ_1 .

4 Experiment

Our experiment tests the prediction that introducing the option to reform is more likely to lead to opportunistic behavior when firms are owner-managed (Proposition 3). The experiment employs the two parameterizations of our model presented in Table 1. The only difference is that Parameter Set II features a higher value of ρ_1 , the outsiders' initial effectiveness rating of the monitoring system. To ensure "salience," i.e., that subjects' payoffs vary meaningfully with their choices (e.g., Plott, 1982), both parameterizations involve a slight departure from the model's assumptions: We scale up all cash flows by a factor of 1,000. For example, we set the value of a high quality good at 1,000 instead of 1.

Under Parameter Set II, the model predicts a reputation equilibrium under both owner and professional management, regardless of whether the option to reform is available. Similarly, under Parameter Set I, the model predicts a reputation equilibrium under professional management both with and without the reform option. However, under owner management, it predicts a reputation equilibrium when the option to reform is not available, and a mixed strategy equilibrium in which the owner manager sometimes chooses the vulnerable technology in period 1 when reform is available. Table 2 presents the operator's predicted period 1 equilibrium behavior as well as period 1 and 2 goods' prices.

The key effects of the parameter changes and the option to reform are on the operator's period 1 technology choice and the pricing of the period 1 good. Our experiment focuses on these period 1 operating policies

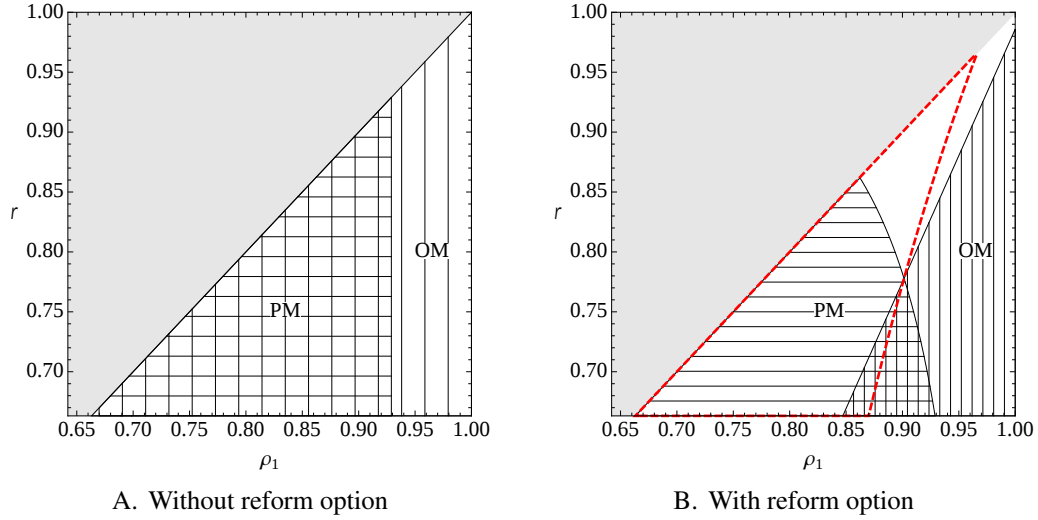


Figure 1: *Reputation equilibria under owner and professional management.* In the figures, the horizontal axis represents the date 1 probability that the firm's monitoring system is secure, ρ_1 ; the vertical axis represents the probability that the firm's monitoring system is secure conditioned on reform, r . The vertically (horizontally) hatched region represents the (ρ_1, r) pairs that support reputation equilibria under owner (professional) management. The common parameters in the two panels are $c = 0.5, \delta = 0.05, R = 0.02, e = 0.6\bar{6}$. In Panel B, the region enclosed in the dashed red boundary represents (ρ_1, r) pairs that satisfy the condition (15) in Proposition 3.

Table 1: *Parameters used in the experiment.*

Parameter	ρ_1	I	c	δ	R	r	Value l	Value h
Parameter Set I	0.125	51	60	0.05	10	0.1	0	1000
Parameter Set II	0.250	51	60	0.05	10	0.1	0	1000

Table 2: *Equilibrium predictions.*

	Parameter Set I			Parameter Set II	
	w/o Reform	w/ Reform		w/o Reform	w/ Reform
Operator	Owner or Prof.	Prof.	Owner	Owner or Prof.	Owner or Prof.
Reputation equilibrium	Yes	Yes	No	Yes	Yes
Probability of reputable behavior	1.000	1.000	0.802	1.000	1.000
Period 1 Price	1,000	1,000	835.3	1,000	1,000
Period 2 Price Unrevealed	168.75	168.75	192.2	287.5	287.5
Period 2 Price Revealed	50	145	145	50	145

and prices, and we attempt to answer the following question at the core of our model: How do ownership structure and corporate reform affect the propensity of firms to form reputations through operating policy? Specifically, we test the following prediction:

Hypothesis 1. *Under Parameter Set II, the operator’s probability of selecting the vulnerable technology in period 1 is invariant to ownership structure and the option to reform. Under Parameter Set I, if the firm is owner managed, introducing the option to reform will increase the likelihood that the operator will choose the vulnerable technology. If the firm is professionally managed, the introduction of the option to reform will have no effect on the operator’s technology choice.*

4.1 Experimental design

Our theoretical analysis is not particularly complex relative to recent models of reputation. However, implementing it in an experimental setting, especially the professional management structure, is quite complex relative to the typical game implemented in laboratory settings. Complexity increases subject decision costs and, thus, subject errors (Smith and Walker, 1993). Hence, implementing the complete theoretical model would make it difficult to diagnose differences between model predictions and experimental behavior (Davis and Holt, 1993). Implementing the complete model would also involve providing a great deal of contextual information which might increase subjects’ likelihood of making decisions based on the contextual information rather than the monetary payoffs from the experiment (Zizzo, 2010). Therefore, we design our experiment to lower its complexity as well as the decision costs faced by subjects. Our design has the added benefit of allowing us to closely match the professional management and the owner management treatments.

In the predicted equilibria, operate/shut down decisions do not vary across the two parameterizations: In period 1, the firm is always capitalized. In period 2, the firm is capitalized if it is unrevealed, effectively shut down if it is revealed and the reform option is unavailable, and reformed and capitalized if the reform option is available. In the experiment, we restrict operate/shut down decisions to conform with this predicted behavior. Hence, the owner manager under owner management, like the manager under professional management, focuses only on making technology choices. For a professional manager both compensation and employment policies do not vary across predicted equilibria under the two parameterizations. In the experiment, we fix the manager’s compensation, b , equal to 30. This is perceptibly larger than the minimum reputation-assuring compensation of 3.16 (under both parameterizations) characterized by equation (4). The larger bonus does not alter the predicted equilibrium operating policies or prices. It does, however, lower subject decision costs and ensure salience (Plott (1982)) by ensuring a meaningful incentive across strategies instead of indifference.¹³ We also set employment policy to conform with the predicted equilibrium by retaining a professional manager in period 2 if the firm is unrevealed and effectively terminating the manager if it is revealed. Thus, under both owner and professional management, subjects only play the role of consumers and operators, which greatly reduces the complexity of the experiment.

¹³Moreover, setting the bonus to 30 roughly equalizes the expected cost of managerial defection from the reputation equilibrium across treatments. The bonus of 30 leads to a net expected cost of 25.50 when a professional manager defects from the reputation equilibrium. This is comparable to the 22.24 incentive that an owner manager has to maintain a reputation equilibrium under Parameter Set I.

In period 2, the opportunistic policy of choosing the vulnerable technology is strictly dominant. Hence, in order to increase the number of rounds implementable in each experimental session and reduce strategic uncertainty arising from noise created by subject conjectures about the rationality of other subjects' period 2 choices, we restrict subjects' period 2 actions to conform with our model's predictions.¹⁴ Specifically, in accordance with Lemma 1.a, each operator is restricted to using the vulnerable (reliable) technology in period 2 if the monitoring system is insecure (secure). Period 2 operator payoffs are based on the owner's optimal operate/shut down decision and the period 2 good's equilibrium price conditional on the publicly available information about the firm's type. These payoffs are detailed in Table C.2 in Appendix C.

Thus, in the experiment, the operator effectively acts only in period 1: When the monitoring system is insecure, the operator chooses either the reliable or vulnerable technology. When the monitoring system is secure, the operator is constrained to choosing the reliable technology. Given equilibrium owner actions, both the reform and no-reform scenarios produce the same payoffs to the operator when the firm is professionally managed. In both scenarios, the operator is employed in period 1, and the operator remains employed in period 2 (and receives the same bonus compensation) if and only if the firm is unrevealed. Consequently, the professional management/reform treatment is equivalent to a professional management/no reform treatment. Therefore, for each parameter set in Table 1, we run the following three treatments, each consisting of two sessions: (1) owner management without the opportunity to reform, (2) owner management with the opportunity to reform and (3) professional management with the opportunity to reform. Because of the equivalence between a professional management/reform treatment and a professional management/no reform treatment, our design effectively becomes a 2 (parameter set) $\times$ 2 (ownership structure) $\times$ 2 (reform opportunity) design relative to operator choices and first-period prices. Table 3 summarizes our design. We will use the labels in the table to identify the experiments, dropping the parameter set suffix when the discussion applies to both parameter sets.

Table 3: *Experimental design.*

Ownership Structure	Parameter Set			
	I	II		
	Label	Obs.	Label	Obs.
Owner Management	OM-I	264	OM-II	264
Owner Management w/ Reform	OMR-I	264	OMR-II	264
Professional Management (w/ or w/o Reform)	PM-I	228	PM-II	264

¹⁴Lucas (1986) argues that players follow adaptive strategies and higher levels of strategic uncertainty slow convergence. Van Huyck et al. (1990) show how strategic uncertainty affects convergence to equilibria in repeated games, leading to coordination failures, for example. Because our focus is on operator choices, we eliminate strategic uncertainty as much as possible along other dimensions.

4.1.1 Subjects, instructions, and payments

Subjects were drawn from a volunteer pool of undergraduate business and MBA students at the University of Iowa. Sessions lasted for at most two hours and subjects were paid a \$5 show-up fee. The experimental currency was “francs,” which were converted to dollars at known exchange rates (depending on the treatment and subject’s role). Subject payments (including the \$5 show-up fee) ranged between \$10.31 and \$32.00. They averaged \$21.45 with a standard deviation of \$4.37. Expected profits across roles were equalized by allowing consumers to keep some of an endowment they received each period and setting different exchange rates for operators across the treatments.

Upon arrival, subjects sat at separate computer terminals and received a set of instructions (provided in Appendix E), forms to record profits by period, and receipts to be filled in during the session. They were randomly assigned to roles (“Green” player (consumer) or “Blue” player (operator)) and remained in their roles throughout the session.¹⁵ The instructions were read aloud and all questions were answered in public before each session. The experiments were programmed in Z-Tree (Fischbacher, 2007).

Each session consisted of a number of “rounds.” Each round implemented one two-period play of the experimental game. To start a round, subjects were randomly assigned to groups consisting of one consumer and one operator. Each operator was assigned available production technologies or “methods.” All operators could produce using a reliable technology (called “Method 1: Sure” in the experiment) that always produced a high quality good (a “round item” in the experiment) worth 1,000 francs to the consumer. A fraction of operators ($7/8$ or $3/4$ depending on the parameter set) could alternatively produce with the vulnerable technology (called “Method 2: Mixed” in the experiment) that cost 60 francs less but produced a high quality good only 5% of the time and a low quality good (a “square” item worth 0 francs to the consumer) 95% of the time. Effectively, the monitoring system was insecure (secure) if the operator could (not) use the vulnerable technology. All players knew the production technology assignment rules and fractions of each firm type.¹⁶

In the first period of each round, the operator chose a production technology and consumers set a price. In the second period, as discussed earlier, operator production choices and consumer prices were fixed based on predicted equilibrium actions and the prices presented in Table C.2 in Appendix C. Because operators effectively only made technology choices in the first period, we will refer to operator technology choices in the first period simply as technology choices.

¹⁵While we will refer to the players as consumers and operators, following the standard in the literature (see e.g., Plott, 1982), these terms were not used during the experiment to avoid value-laden connotations. The neutral language allows us to test our hypothesis without bringing in external preconceptions and framing effects that can make preferences deviate from those induced by the payoffs and contracts in the game. For example, if we refer to low-quality good production a “reputation failure,” subject behavior may be influenced by their experiences with reputation failures in other contexts in unpredictable ways, which can complicate strategic decision making by other subjects.

¹⁶Throughout each session, the technology determination methods were displayed on computer screens at the front and sides of the room. The displays showed (1) the probability the Blue players (operators) had only reliable or both reliable and vulnerable technologies, (2) the probability that each technology produces each item type and (3) the period 2 technology imposed by the experimenter based on period 1 quality and available technologies.

4.1.2 Price setting

We used a modified Becker et al. (1964) procedure (hereafter “BDM procedure”) to set prices. This procedure is designed to elicit the highest price the consumer is willing to pay for the good.¹⁷ First, the consumer specifies the most she is willing to pay. Once this “limit price” is set, the experimenter randomly draws a “discounted price” between 0–1,000 francs from a uniform distribution. The experimenter then buys the good from the firm at the limit price. The experimenter resells the good to the consumer at the discounted price only if the limit price exceeds the discounted price. Otherwise, the experimenter keeps the good. When a consumer purchases the item, she receives a payoff equal to her endowment plus the value of the item minus the discounted price. When the experimenter keeps the good, the consumer receives only her endowment. In either case, she receives an ex post report showing the quality of the item and the discounted price. In the following analysis we report consumer limit prices.

5 Evidence on reform and reputation equilibria

Figure 2 graphs the percentage of times operators of insecure firms use the reliable technology under each treatment. Consistent with prior evidence (e.g., Brandts and Figueras, 2003; Noe et al., 2012), there is a systematic deficiency in reputable behavior across all treatments. When our model predicts mixed equilibria (treatment OMR-I) in which a firm should use the reliable technology about 80% of the time, in our experiment firms use the reliable technology only about 50% of the time. Similarly, while our model predicts a 100% use of the reliable technology in the remaining treatments, we observe it only a maximum of 73% of the time, which occurs in treatment OM-I.

Nevertheless, the relative rates of the reliable technology’s use conform with our model’s predictions. Introducing reform lowers the reliable technology’s usage significantly by owner managed firms under Parameter Set I from 73% to 50%. Under Parameter Set II, the corresponding drop is from 68% to 57%, which is both smaller and statistically insignificant.

To minimize the confounding effects of subject learning, we test for differences in subject behavior in the second half of each session.¹⁸ Table 4 presents the frequency with which insecure firms use the reliable technology during the second half of the experiment. Consistent with Figure 2, there is a systematic deficiency in reputable behavior across all our treatments. However, the variation in reputable behavior across treatments is consistent with model predictions. Under Parameter Set I, in treatment OMR-I, in which the owner can reform after the firm is revealed, we expect the firm to adopt the reliable technology less frequently than in treatments OM-I and PM-I (Hypothesis 1). Consistent, with this prediction, in treatment

¹⁷See the instructions in Appendix E for details. Research shows that, on average, the BDM procedure elicits risk neutral valuations (Berg et al., 2005) which, here, correspond to competitive prices. Through this procedure, we elicited a competitive price from a single subject. Further, it was fast to implement, it avoided complications from auction procedures (e.g., overbidding, as in Kagel and Levin, 1993), and did not require pre-specifying a limited set of allowable prices (e.g., Forsythe et al., 1999).

¹⁸Using the entire data set leaves the results essentially unchanged, but there is some adjustment as subjects learn about the game. As a result, we are more comfortable using statistical tests based on the later periods in the experiment. Later we will provide insights into subject learning.

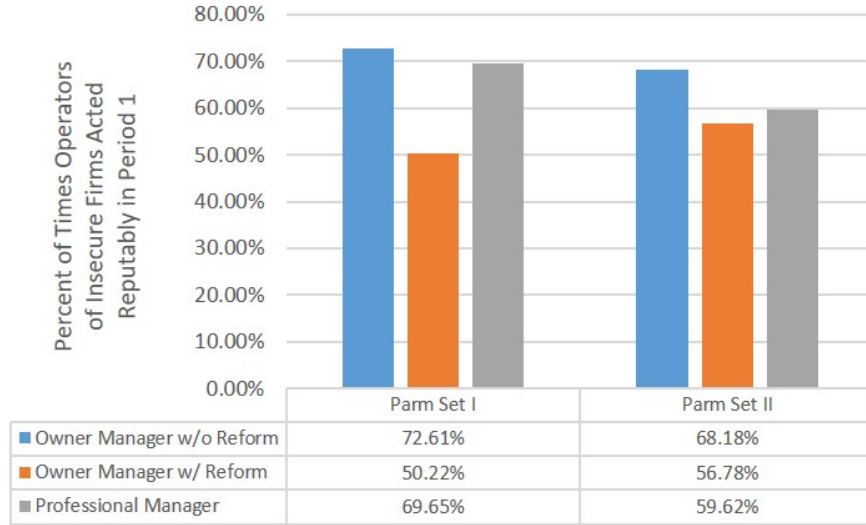


Figure 2: *Frequency of reputable behavior.* This figure presents the frequency with which operators of insecure firms choose the reliable production technology.

OMR-I, the firms used the reliable technology only 48.7% of the time. This usage is statistically significantly lower than the usage of the reliable technology in treatment OM-I ($t=4.35$, $p\text{-value}=0.00$). Under Parameter Set II, we expect the firm to act reputably regardless of its ownership structure and the availability of the option to reform (Hypothesis 1). The treatment OMR-II rate of reputable behavior (58.4%) was not statistically significantly different than the rate in treatments OM-II (68.4%) or PM-II (66.0%). Consistent with our model's predictions, we find no significant difference between the incidence of reputable behavior between Parameter sets I and II for treatments OM and PM. While, consistent with our expectations, we find more reputable behavior in treatment OMR-II than in OMR-I, the difference is not statistically significant.

Table 4: *Incidence of reputable behavior.* In this table we present the frequency with which insecure firms use the reliable production technology during the second half of each session.

Ownership Structure		Parameter Set		Parameter Set I vs II	
		Parm. I	Parm. II	Difference	t-Stat. p-Value
OM		75.42%	68.37%	-7.06%	-1.15 0.25
OMR		48.67%	58.43%	9.75%	1.38 0.17
PM		71.43%	66.04%	-5.39%	-0.83 0.41
OM	Difference	-26.75%***	-9.94%		
vs	t-Stat.	-4.35	-1.41		
OMR	p-Value	0.00	0.16		
OM	Difference	-4.00%	-2.33%		
vs	t-Stat.	-0.66	-0.35		
PM	p-Value	0.51	0.73		
OMR	Difference	22.76%***	7.61%		
vs	t-Stat.	3.43	1.09		
PM	p-Value	0.00	0.28		

5.1 Explaining subject strategies

Like earlier research on reputation in laboratory settings, we find less reputable behavior than in the rational choice equilibrium benchmark. Prior research also documents that, as subjects gain experience, their strategies better approximate equilibrium predictions (e.g., Brandts and Figueras, 2003; Noe et al., 2012). For this reason, we now examine the evolution of subject behavior in our experiment.

5.1.1 Evolution of operator strategies

We initiate our study of strategy evolution by modeling operator choices as a Markov process (cf. Axelrod, 1987; Erev and Roth, 1998). The states for the Markov model are determined as follows: the firm's monitoring system can be in one of two possible conditions—secure or insecure. When the firm is secure the operator has one feasible choice, the reliable technology, and, when the firm is insecure, the operator has two feasible choices: the reliable and vulnerable technology. Thus, there are three possible choice–condition pairs: (reliable, secure), (reliable, insecure), (vulnerable, insecure). These three pairs are the states of the Markov model. We term the first pair the “secure” state. The second the “reputation” state, and the third, the “opportunistic” state.¹⁹

We estimate the transition matrix using the method of moments, and use the estimated transition matrix to compute steady-state probabilities (Norris, 1998). The estimates are presented in Panel A of Table 5. Except perhaps for treatment OMR-I, the estimates suggest an increase in reputable behavior over time. Initial frequencies of adopting the reliable technology, are measurably lower than overall frequencies, which, in turn, are measurably lower than the estimated steady-state probabilities.

Panel B of Table 5 provides suggestive evidence for the drivers of reputation formation. Except for the OMR treatments, operators of insecure firms, whose firms were secure in the previous round, were more likely to select the reliable technology in the current round. Operators of insecure firms who, in the previous round, operated insecure firms and chose the reliable technology, were also more likely to choose the reliable technology in the current round. However, consistent with our earlier observations, the dominance of reliable technology is weaker for the OMR treatments. Except for treatment OMR-I, operators of insecure firms who, in the previous round, operated insecure firms, chose the vulnerable technology and produced a low quality good, were also more likely to choose the reliable technology in the current round. The only case where the vulnerable technology dominated the reliable technology was when the operator, in the previous round, operated an insecure firm, chose the vulnerable technology and produced a high quality good. However, the probability of a high quality good being produced by the vulnerable technology is low in our experiment, so the effect of this case on the overall evolution of subject actions is small. In general, Table 5 documents a tendency for reputation formation to increase with operator experience.

¹⁹Of course, the operator has no control over transitions to the secure strategy. These transitions are controlled entirely by the parameter set and random draws. However, the transitions will figure into the overall stable probabilities and, therefore, must be considered.

Table 5: Evolution of reputation formation. Panel A presents the initial frequency, overall frequency, and estimated steady state probability of the reputation state, the state where the firm is insecure yet the reliable technology is adopted by the operator. Panel B presents the frequency of adoption of the reliable technology by operators whose firms are insecure conditioned on the outcome in the previous round. The last column of Panel B shows the χ^2 statistic for independence between the prior strategies and reputable behavior in the next period.

Panel A: Frequencies and steady state (SS) probabilities of reputation building						
Treatment	Parameter Set I			Parameter Set II		
	Round 1	Overall	SS	Round 1	Overall	SS
OM	61.9%	72.6%	74.0%	61.1%	68.2%	68.7%
OMR	50.0%	50.2%	50.2%	50.0%	56.8%	57.2%
PM	46.7%	69.7%	72.8%	47.1%	59.6%	61.3%

Panel B: Frequency of reputation building conditioned on previous round's outcome						
State: Good's Quality:	Outcome in previous round					χ^2 (p-value)
	Treatment	Secure High	Reputation High	Opportunistic Low	Opportunistic High	
Parameter Set I	OM	80.0%	78.5%	61.1%	0.0%	12.10 (0.007)
	OMR	30.8%	61.5%	46.4%	0.0%	13.12 (0.004)
	PM	59.1%	83.9%	51.0%	33.3%	22.38 (0.000)
Parameter Set II	OM	58.7%	75.3%	66.7%	0.0%	4.70 (0.195)
	OMR	48.7%	62.2%	58.6%	0.0%	6.36 (0.095)
	PM	52.3%	85.2%	31.5%	20.0%	46.31 (0.000)

5.1.2 Reasons why operators' strategies evolve

To examine the forces underlying the evolution of operators' choices, we estimate logit models of the operators' choice of the reliable technology. We model their choice as a function of the treatment, subject demographics, and experience. We use dummy variables to represent treatments and parameter set/treatment interactions and gender (which is the only demographic variable that appears significantly correlated with behavior). We account for subject experience using experience weighted attraction (EWA) models along the lines of Erev and Roth (1998) and Camerer et al. (2002), that account for the profitability of past choices. We formally define the experience weighted attraction variables in Appendix D, but, to summarize, each model assumes that the propensity to make a choice (i.e., the choice's "attraction") depends on the weighted average of the prior profitabilities of playing each choice relative to the prior profitabilities of playing other choices. We calculate two sets of attraction measures: In one set, the propensities depend only on the profitabilities of prior choices, referred to as "Gross Profit EWA." In the second set, the propensities are computed by comparing the outcome of each choice relative to the most profitable feasible alternative choice, defined as "Net Profit EWA."²⁰ Our estimates employ robust standard errors clustered by subject to control for repeated observations. Further details about our implementation of EWA model are provided in Appendix D.²¹ We present the estimates in Table 6.

The first two columns in Table 6 show estimates of a baseline model under each parameter set. The positive and highly significant intercept indicates significant reputation building behavior in the OM treatments. Consistent with our model's prediction, adding reform significantly reduces reputable behavior under Parameter Set I, as indicated by significant negative coefficients on the dummy variable capturing owner-manager with reform treatments. Surprisingly, the introduction of reform also reduces reputable behavior in Parameter Set II, though the effect is only marginally significant. Also, consistent with our model's predictions, there is no significant difference between the OM and PM treatments in fostering reputation. Men are somewhat more likely to form reputations under Parameter Set I.²²

The estimates using EWA models clearly show that operators are more likely to choose the reliable technology when this choice has led to higher payoffs in previous rounds. The Gross Profit EWA models and the Net Profit EWA models yield qualitatively similar results: Men are more likely to form reputations under Parameter Set I (and overall in unreported aggregate regressions). Under Parameter Set II (and overall), operators are less likely to form reputations in treatment PM-II than in treatment OM-II. However, the dominant factors influencing reputable behavior are payoffs from prior choices. Higher rewards for the reputable choice (the reliable technology) increase the probability of doing so in the future. Under both parameter sets, professional managers are more responsive to past profitability than owner-managers.

²⁰We note that, because propensities are probabilities, alternative specifications of these models would be to use the log-odds ratio of the reliable technology choice propensity as the independent variable. While the results mirror those displayed in Table 6, we lose 28% of the observations because the propensities are either 0 or 1.

²¹Fixed effects models cannot be used because each subject participates in only one treatment.

²²In unreported regressions aggregating across treatments, men remain somewhat more likely to form reputation than women. Men (women) account for 50.36% (49.64%) of operator decisions for insecure firms. Interactions of gender, treatment and parameter set show no significant coefficients.

Table 6: *Logit regression analysis of reputable behavior by operators of insecure firms.* The dependent variable equals 1 if an operator chooses the reliable technology. Gender is a dummy variable equal to 1 if the subject is male. Owner-Mgr., Owner-Mgr. w/ Reform and Professional Mgr. are dummy variables for the ownership structure treatments. Experience weighted attraction (EWA) regressions include separate propensities to play the reputation strategy in each treatment as defined in equations (D.13) and (D.14) with $\delta = 0$ or $\delta = 1$. Robust standard errors clustered by subject appear in parentheses below each estimate.

	Gross Profit EWA				Net Profit EWA	
	Parameter Set		Parameter Set		Parameter Set	
	I	II	I	II	I	II
Constant	0.66*** (0.24)	0.69*** (0.25)	-0.57 (0.41)	-0.03 (0.37)	-0.39 (0.39)	-0.06 (0.45)
Gender (1=Male)	0.53* (0.28)	0.17 (0.28)	0.45** (0.20)	0.08 (0.20)	0.56** (0.24)	-0.02 (0.23)
Owner-Mgr. w/ Reform	-0.84*** (0.30)	-0.48* (0.29)	-0.24 (0.46)	-0.47 (0.41)	-0.30 (0.46)	-0.30 (0.50)
Professional Mgr.	-0.15 (0.40)	-0.40 (0.36)	-0.77 (0.70)	-1.21*** (0.47)	-1.39 (0.91)	-1.61*** (0.55)
Exp. Wtd. Propensity x Owner-Mgr.			2.09*** (0.66)	1.39*** (0.54)	1.26*** (0.47)	1.21** (0.53)
Exp. Wtd. Propensity x Owner-Mgr. w/ Reform			1.52*** (0.51)	1.76*** (0.54)	1.11* (0.63)	1.17** (0.54)
Exp. Wtd. Propensity x Professional Mgr.			2.94*** (0.76)	3.09*** (0.54)	3.06*** (0.92)	3.74*** (0.60)
Obs.	667	605	667	605	667	605
Pseudo R2	4.43%	0.87%	11.84%	9.45%	8.50%	9.98%

***, ** and * denote significance at the 99%, 95% and 90% levels of confidence, respectively.

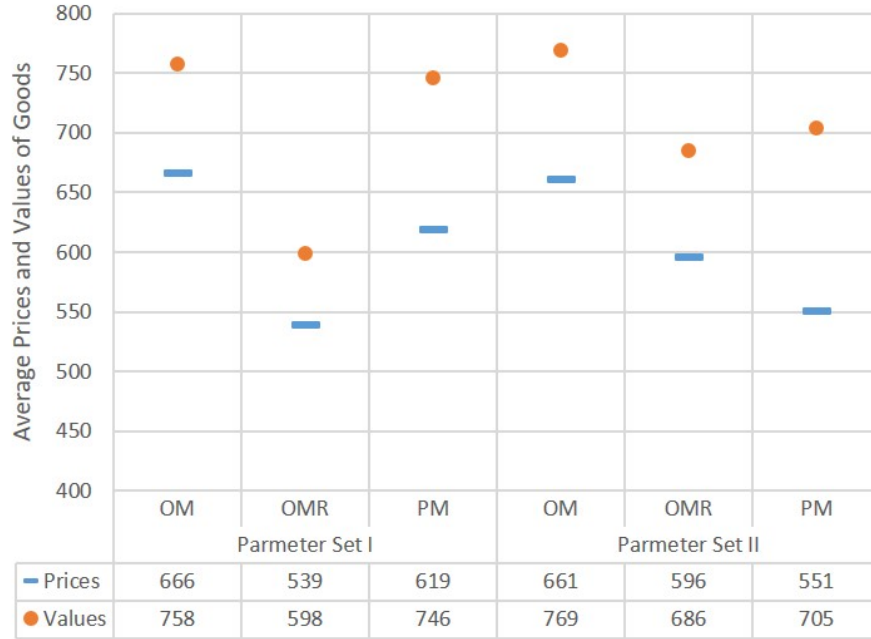


Figure 3: *Period 1 values and limit prices established by consumers.*

5.2 Consumer perceptions of firm reputation

The estimates in Table 6 indicate that operator behavior evolves based on past profitabilities of choices, which depend on goods' prices. These prices reflect consumers' choices and capture firms' reputations with consumers. To provide deeper insights into our experimental outcomes, we examine goods' prices and consumer choices.

Figure 3 shows both average limit prices set by consumers (bars) under each treatment, and the average actual values of the goods (circles) offered to consumers. Consumers generally under-price goods.²³ First, compare prices in the experiments to equilibrium prices predicted by our model. In a reputation equilibrium, the period 1 good's price should equal 1,000 francs. The experimental prices are well below this prediction. The OM treatments produce the highest average prices: 666 francs in OM-I and 661 francs in OM-II. In the mixed equilibrium supported by treatment OMR-I, the period 1 good's equilibrium price is 835.3 francs. Once again, prices in the experiment are much lower, averaging only 539 francs. The prices consumers offer for goods are even markedly lower than the actual values of the goods on offer. The undervaluation of the good ranges from 154 francs in treatment PM-II to 59 in treatment OMR-I. The effect of this undervaluation of goods on lowering operators' profits from using the reputation strategy can help explain the systematic deficiency in reputable behavior.

To examine the effect of the firm's ownership structure and the option to reform on prices, we compare goods' prices across treatments in Table 7. To limit confounding effects arising from subject learning which we will examine later, we focus on prices in the second half of the experiments.²⁴ As in Figure 3, prices are

²³This accords with prior research in Noe et al. (2012).

²⁴As with our operator analysis, using the entire data set leaves the results essentially unchanged.

systematically lower than their equilibrium values across all our treatments. For example, under Parameter Set I, the average price is only 716.7 francs in treatment OM and 666.4 francs in treatment PM compared with our model's prediction of 1000 francs. Under Parameter Set II, contrary to our model's predictions, the prices are even lower in the OM and PM treatments, though the drop is statistically significant only in the case of the PM treatment. The prices in treatments OMR-I and OMR-II are not statistically different.

Table 7: *Consumer assessments of firm reputation.* In this table we present prices for goods in the second half of the experiment.

Treatment		Parameter Set		Parameter Set I vs II		
		Parm. I	Parm. II	Difference	t-Stat.	p-Value
OM		716.73	668.27	-48.46	-1.24	0.22
OMR		554.75	601.66	46.91	1.07	0.29
PM		666.39	590.47	-75.92*	-1.77	0.08
OM vs OMR	Difference	-161.98***	-66.61			
	t-Stat.	-3.87	-1.61			
	p-Value	0.00	0.11			
OM vs PM	Difference	-50.35	-77.80**			
	t-Stat.	-1.17	-1.99			
	p-Value	0.24	0.05			
OMR vs PM	Difference	111.64***	-11.19			
	t-Stat.	2.62	-0.25			
	p-Value	0.01	0.80			

The effect of introducing the option to reform on goods' prices is consistent with our model's predictions. Under Parameter Set I, in treatment OMR-I, in which the owner can reform, we expect prices to be lower than in treatments OM-I and PM-I. Consistent with this prediction, the average price in OMR-I is 554.8 francs, which is statistically significantly lower than the average price of 716.7 francs in OM-I ($t=3.87$, $p\text{-value}=0.00$) as well as the average price of 666.4 francs in PM-I ($t=2.62$, $p\text{-value}=0.01$). Under Parameter Set II, we expect the good's price to be the same regardless of the firm's ownership structure and the availability of the option to reform. Consistent with this prediction, we find that goods' prices in treatment OMR-II (601.7 francs) are not significantly different from prices in OM-II (668.3 francs) or PM-II (590.5 francs). Thus, it appears that consumers recognize the effect of firms' ownership structures and the availability of the option to reform on the incentives for reputable behavior.

5.2.1 Evolution of Prices

A comparison of goods' prices in Figure 3 and Table 7 indicates that average prices during the second half of sessions were higher than in the overall experiment. This difference is less marked in the treatments with the option to reform. The increase in prices is consistent with consumers increasingly recognizing the value of firm reputation.

Table 8 presents estimates of the effect of treatments, parameter sets and experience on prices. Once again, we account for experience using experience weighted attraction (EWA) models. We modify the

experience models to account for the fact that the consumers' strategy space is continuous. We define two measures of attraction: (1) average net profits, value less the purchase price paid ("Average Prior Net Profit Attraction"), and (2) the average of good values observed in prior rounds ("Average Prior Value Attraction"). The detailed definitions of these variables are provided by Appendix D.²⁵

Table 8: *Censored normal regressions explaining prices.* Gender is a dummy variable equal to 1 if the subject is male. Round number is the number of rounds at that point in the experimental session. Owner-Mgr., Owner-Mgr. w/ Reform and Professional Mgr. are dummy variables for the ownership structure treatments. Attraction regressions include average values and average prior net profits in previous rounds. Robust standard errors clustered by subject appear in parentheses below each estimate.

	Average Prior Net Profit Attraction				Average Prior Value Attraction	
	Parameter Set		Parameter Set		Parameter Set	
	I	II	I	II	I	II
Constant	704.15*** (112.30)	759.76*** (100.35)	540.03*** (93.44)	704.04*** (132.96)	119.00 (164.59)	416.77** (163.00)
Gender (1=Male)	-48.07 (83.45)	-135.84 (83.84)	-74.04 (72.09)	-129.39 (90.13)	-56.42 (73.37)	-82.46 (76.20)
Round Number	8.02** (3.42)	4.94* (2.87)	7.41** (3.78)	4.34 (2.91)	8.96** (3.59)	2.98 (3.07)
Owner-Mgr. w/ Reform	-215.63** (105.40)	-98.53 (111.94)	-115.73 (106.33)	-148.14 (166.53)	54.08 (188.91)	-335.57 (262.44)
Professional Mgr.	-104.89 (112.12)	-143.75 (97.45)	-28.87 (127.02)	-134.22 (132.67)	168.22 (201.16)	-188.76 (199.58)
Attraction x Owner-Mgr.			1.07*** (0.36)	0.18 (0.23)	0.80*** (0.21)	0.42** (0.18)
Attraction x Owner- Mgr. w/ Reform			0.44*** (0.14)	0.64* (0.37)	0.48*** (0.16)	0.88*** (0.30)
Attraction x Professional Mgr.			0.41* (0.21)	0.49 (0.33)	0.41*** (0.16)	0.58*** (0.21)
Obs.	756	792	693	726	693	726
Left Censored	76	96	71	88	71	88
Right Censored	191	196	174	178	174	178
Psuedo R2	0.41%	0.29%	1.46%	0.70%	1.35%	1.40%

***, ** and * denote significance at the 99%, 95% and 90% levels of confidence, respectively.

In the baseline models, presented in the first two columns, we do not control for experience-based attraction. The statistically significant coefficients on the experience variable "Round Number" in these estimates indicate that prices increase between 5 francs to 8 francs with each round. These increases bring prices closer to their equilibrium values. Adding reform to the owner-manager treatment reduces prices under Parameter Set I by an economically meaningful and statistically significant 215.6 francs. Under

²⁵Because, in theory, prices directly convey probabilities of high quality items, we could construct a logistic version of this regression using OLS on the implied logistic variable defined as $\ln\left(\frac{P/1000}{1-P/1000}\right)$. However, if we do this, we lose 36% of the observations because subjects either set prices at 0 or 1000.

Parameter Set II, the introduction of reform lowers prices by 98.5 francs but the effect is not statistically significant. Under both sets of parameters, the difference in prices between treatments OM and PM are not statistically significant. These effects of reform and ownership structure are consistent with our model's predictions.

The estimates incorporating EWA models uniformly indicate that experience matters. For treatments using Parameter Set I, experience alone significantly raises prices, as shown by the significant positive coefficients on the variable "Round Number." However, these changes are dwarfed by the effect of past profits. Average Prior Net Profit has a uniformly large and positive effect on prices in all treatments under Parameter Set I. The effect remains positive but is only weakly significant (at best) in Parameter Set II. In contrast, Average Prior Values always has a large and statistically significant positive effect on prices in both parameter sets. The estimates range from 0.41 francs to 0.80 francs for a one franc increase in the goods' average prior value under Parameter Set I and from 0.42 francs to 0.88 francs under Parameter Set II. Thus, in general, consumers markedly raised (lowered) their bid prices for goods after observing higher (lower) valued goods in the past.²⁶ Our earlier evidence indicates that operators' strategies evolve toward adoption of the reputation strategy, especially after experiencing higher profits. This tendency, when combined with the evolution of consumer strategies toward setting higher good prices suggests that the feedback between consumer and operators' strategies tends to reduce both the systematic deficiency in reputable behavior as well as the substantial undervaluation of goods observed in the experiment.

6 Discussion

We extend a seminal modeling framework of organizational reputation to incorporate two features. The first is a "monitoring" system to prevent managerial opportunism. The monitoring system allows the firm to form an organizational reputation based on evidence about the system's effectiveness. This reputation is distinct from those of individuals who own or operate the firm. The second feature is the option to reform the monitoring system and, potentially, replace it with a more effective system. This allows firms to repair damaged reputations and continue operating after reputation loss. In this context, we study two standard ownership structures: (1) owner operated firms and (2) firms that separate ownership and control. The latter structure is typical of a modern corporation with outside owners and professional management, creating well known agency problems. Our concept of corporate reputation is based on the perceived quality of its products, in which "quality" means the attributes of the product consumers value, including reliability, responsible governance, sustainability and/or socially responsible production processes.

We find that ownership structure and the opportunity for monitoring system reform interact in important ways. The ownership structure affects both (1) the relative sizes and (2) the costs and benefits of reputations. Owner-management eliminates the agency conflict between owners and professional managers while allowing the owner to internalize all reputation costs and benefits. While professional management introduces an owner-manager agency conflict, the owner can incentivize the manager to form and maintain a reputation.

²⁶Differences across treatments are generally not significant. Thus, we find no evidence that consumer responses to operator actions differ significantly across ownership structures and parameter sets.

This enables firms with professional management to maintain reputations even when owner management cannot.

Under either ownership structure, the opportunity to restore reputation through reform dilutes incentives to form and maintain reputations. However, the extent of the dilution varies with ownership structure. When a firm reforms, owners always benefit because the firm can continue operating after its reputation is damaged. Unlike owner-managers, professional managers do not benefit from reform because they are fired from firms following reputation damage. Thus, professional managers are less inclined to risk a reputation for short run gains than owner-managers. This makes it even more likely that professionally managed firms with outside owners will focus on creating and maintaining reputations.

We design and run an experiment to test these ideas. Similar to prior experiments on reputation, subjects under-invest in reputations. However, the data clearly show incentive effects of ownership structure and reform on outcomes. We vary both the ownership structure and reform option with the initial effectiveness of the monitoring system. Changing each dimension generally moves the data in the directions predicted by our theory. In one critical treatment we both predict and observe significantly reduced reputation formation, product quality and prices when the option to reform is available.

Because the experimental outcomes do not immediately and exactly conform to theory, they provide insight into the evolution of reputations when owner, manager and consumer behaviors differ from theory. We find that all parties learn from past outcomes. This process results in differences in data across treatments that converge toward differences predicted by theory. Thus, we conclude that the effects we predict are likely to be present in real-world data.

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Appendix

Ownership Structure, Reputation Crises and Recovery: Theory and Experiment

A Proofs of results

Proof of Lemma 1. Claim a. We first establish the claim when a professional manager is the operator and then when the owner is the operator. Note that the operator can only choose the production technology when the oversight system is insecure and makes the choice after the period 2 price, p_t , is set by consumers.

Suppose the oversight system is insecure and the professional manager is contracted to receive a payment of $b \geq 0$ in period 2 contingent on the observed period 1 and period 2 prices p_1 and p_2 . Both prices are insensitive to the manager's period 2 technology choice. Hence, if the manager acts opportunistically, her period 2 payoff is $b + c$. If the manager acts reputably, her period 2 payoff is b . Thus, acting opportunistically in period 2 is always optimal for the manager.

Now consider the owner manager's period 2 technology choice when the oversight system is insecure. If the owner manager acts opportunistically, her payoff is $p_2 - e + c = p_2 - I$. If she acts reputably, her payoff is $p_2 - e$. Thus, period 2 diversion is always optimal for the owner manager.

Claim b. Given Claim a, once the firm is revealed, consumers will correctly anticipate that the operator will act opportunistically in period 2 and thus the period 2 good will be high quality with only probability δ . Rationally, consumers will set $p_2 = \delta$, and by Assumption 1, $\delta < I$. Hence, the owner's period 2 payoff will be negative if the revealed firm operates, and shutting down the revealed firm is optimal for the owner.

Claim c. Claim b demonstrates that the owner will shut down the revealed firm if the oversight system is not reformed, earning a payoff of zero. Suppose that consumers anticipate that the revealed firm will reform its oversight system. Then, by Assumption 3, reform always yields a positive operating profit of $F_r - R - e$, and an owner manager will always choose to reform and operate the firm if it is revealed. If the firm is professionally

managed, after consumers set the period 2 price, F_r , the owner has to pay the manager the contracted compensation based on the price F_r whether or not the oversight system is reformed. Since reform provides a higher payoff than shutting down, the owner will reform.

Claim c. Suppose the firm is unrevealed in period 2. Given Claim a, the period 2 good's price will equal F_1 if consumers believe that the operator acted reputably in period 1 or will equal F_2 if they believe the operator chose diversion in period 1. From Equation 2 it follows that $F_2 > F_1$. Hence, by Assumption 2 it follows that the owner manager will earn a positive payoff by operating the unrevealed firm in period 2 compared with a payoff of zero from shutting it down. If the firm is professionally managed, since the manager's compensation is tied to the period 1 and 2 goods' prices, and these prices are set before the owner's period 2 investment decision, the owner must pay the contracted compensation whether or not the firm operates. Hence, the owner's payoff is higher if the unrevealed firm operates in period 2.

Now consider the owner's investment decision in period 1. If the firm shuts down for period 1, by Claim a, the period 2 good's price will equal F_1 . Thus, if the firm shuts down for period 1, since it is optimal for the firm to operate in period 2 if it is unrevealed, an owner manager's expected payoff will equal $F_1 - e$ if the oversight system is secure and $F_1 - I$ if it is insecure. If the firm operates in period 1, the owner manager can ensure a period 1 payoff of at least $F_1 - e$ if the oversight system is secure and $F_1 - I$ if it is insecure. Moreover, the owner also receives a positive payoff in period 2 if the firm is unrevealed and if it is revealed and the owner has the option to reform. Thus, the owner manager will always operate the firm in period 1.

If the firm is professionally managed and it doesn't operate in period 1, given Claim a, the owner will not pay the manager incentive compensation in period 2. Therefore, the owner's expected payoff will equal $F_1 - e$. The owner can choose not to offer the manager compensation and operate the firm in period 1. Suppose that with no compensation the manager will always act opportunistically. Hence, the owner's expected period 1 payoff from operating the firm in period 1 equals $F_1 - e$. If the firm remains unrevealed, which occurs with probability F_1 , the owner will also earn a period 2 payoff of $F_2 - e$. This is the lower bound on the owner's payoff from operating the firm in period 1 since the owner can choose to offer the manager incentive compensation if it generates a higher expected payoff. Consequently, the owner will always operate a professionally managed firm in period 1. $\square$

Proof of Lemma 2. By Lemma 1.a, a professional manager will always act opportunistically in period 2. Moreover, since all manager's are identical, the owner's period 2 payoff will not change if the incumbent manager is replaced.

Suppose the manager is contracted to receive an incentive payment of $b(p_1, p_2)$ in period 2. If the manager acts reputably in period 1 and is retained in period 2, his expected payoff will equal $b(p_1, p_2) + c$. If the manager acts reputably and is replaced in period 2, because he earns his reservation wage of zero in the managerial labor market, his expected payoff will equal $b(p_1, p_2)$. Thus, retaining the manager raises the manager's payoff from acting reputably.

Now consider the manager's payoff from acting opportunistically in period 1. By Lemma 1.c, the owner will always reform after the firm is revealed if the option to reform is available. If the owner replaces the manager after reform, by acting opportunistically in period 1, the manager can expect a payoff of $c + \delta(b(p_1, p_2) + c)$. In contrast, if the owner retains the manager after reform, the manager's expected payoff from acting opportunistically is $c + \delta(b(p_1, p_2) + c) + (1 - \delta)(b(p_1, F_r) + (1 - r)c)$. Hence, replacing the manager after reform lowers the manager's expected payoff from acting opportunistically in period 1. Since Lemma 1.b demonstrates that the firm will shut down in period 2 if it is revealed, it is never optimal for the owner to retain the manager after it is revealed and the owner does not have the option to reform.

The proof is completed by noting that the above arguments demonstrate that retaining the manager when the firm is unrevealed and replacing him when the firm is revealed, maximizes the manager's incentive to act reputably in period 1. Moreover, retaining the manager if the firm is unrevealed is incentive compatible for the owner as is replacing the manager once the firm is revealed. $\square$

Proof of Proposition 1. First consider the case where the owner has the option to reform. Offering reputation-assuring compensation is optimal if and only if

$$\begin{aligned}
1 - e + F_1 - e - b^* &\geq F_1 - e + (1 - F_1)(F_r - R - e) + F_1(F_2 - e) \\
\iff \pi_1 - b^* &\geq (1 - F_1)\pi_r + F_1 \left(1 + \delta - \frac{\delta}{F_1} - e \right) \\
\iff \pi_1 - b^* &\geq (1 - F_1)(\pi_r - \delta) + F_1\pi_1 \\
\iff b_1^* &\leq (1 - F_1)(\pi_1 - \pi_r + \delta). \tag{A.1}
\end{aligned}$$

Condition 8 follows directly.

Now consider the case where the owner does not have the option to reform. Offering reputation-assuring compensation is optimal if and only if

$$\begin{aligned}
1 - e + F_1 - e - b^* &\geq F_1 - e + F_1(F_2 - e) \\
\iff \pi_1 - b^* &\geq F_1 \left(1 + \delta - \frac{\delta}{F_1} - e \right) \\
\iff b_1^* &\leq (1 - F_1)(\pi_1 + \delta). \tag{A.2}
\end{aligned}$$

Condition 9 follows directly. $\square$

Proof of Proposition 2. First consider the case where the owner has the option to reform. When the oversight system is insecure, defecting to act opportunistically is suboptimal if and only if

$$\begin{aligned}
1 - e + F_1 - I &\geq 1 - I + \delta(F_1 - I) + (1 - \delta)(r(F_r - e) + (1 - r)(F_r - I) - R) \\
&\iff F_1 - e \geq \delta(F_1 - e) + \delta c + (1 - \delta)(\pi_r + g) \\
&\iff (1 - \delta)(F_1 - e) \geq \delta c + (1 - \delta)(\pi_r + g) \\
&\iff F_1 \geq 1 - \pi_1 + b^* + \pi_r + g. \tag{A.3}
\end{aligned}$$

Now consider the case where the owner does not have the option to reform. When the oversight system is insecure, defecting to act opportunistically is suboptimal if and only if

$$\begin{aligned}
1 - e + F_1 - I &\geq 1 - I + \delta(F_1 - I) \\
&\iff F_1 - e \geq \delta(F_1 - e) + \delta c \\
&\iff (1 - \delta)(F_1 - e) \geq \delta c \\
&\iff F_1 \geq 1 - \pi_1 + b^*. \tag{A.4}
\end{aligned}$$

$\square$

Lemma A-1. When the firm is controlled by an owner-manager who has the option to reform the oversight system, in a mixed equilibrium

1. $p_1^* = \frac{F_1 - \delta}{p_2^* - \delta}$.
2. If the firm remains unrevealed, $p_2^* = 1 - \pi_1 + b^* + \pi_r + g$.
3. If the oversight system is insecure, the manager diverts with probability $\eta = \frac{1 - p_1^*}{(1 - \rho_1)(1 - \delta)}$.

Proof of Lemma A-1. To be willing to randomize, the owner must be indifferent between diverting and not diverting. Her expected payoff from not diverting equals:

$$p_1^* - e + p_2^* - I, \tag{A.5}$$

Her expected payoff from diverting equals:

$$p_1^* - I + \delta(p_2^* - I) + (1 - \delta)(r(F_r - e) + (1 - r)(F_r - I) - R). \tag{A.6}$$

The price in each period equals the total probability of a high quality good. Since beliefs and, thus, prices conform to Bayes' rule. The period 2 posterior probability of the firm

being the secure type conditioned on remaining unrevealed $\frac{\rho_1}{F_1^*}$. Thus, the period 2 price conditioned on the firm remaining unrevealed in period 1 equals:

$$\begin{aligned} p_2^* &= \frac{\rho_1}{p_1^*} + \left(1 - \frac{\rho_1}{p_1^*}\right) \delta = \delta + \frac{\rho_1(1 - \delta)}{p_1^*} = \delta + \frac{F_1 - \delta}{p_1^*} \\ &\iff p_1^* = \frac{F_1 - \delta}{p_2^* - \delta}. \end{aligned} \quad (\text{A.7})$$

Equating the two expected payoffs, (A.5) and (A.6), we obtain

$$\begin{aligned} p_1^* - e + p_2^* - I &= p_1^* - I + \delta(p_2^* - I) + (1 - \delta)(r(F_r - e) + (1 - r)(F_r - I) - R) \\ &\iff p_2^* - e = \delta(p_2^* - I) + (1 - \delta)(\pi_r + g) \\ &\iff (1 - \delta)(p_2^* - e) = \delta c + (1 - \delta)(\pi_r + g) \\ &\iff p_2^* = 1 - \pi_1 + b^* + \pi_r + g. \end{aligned} \quad (\text{A.8})$$

□

Proof of Proposition 3. We prove the contrapositive of the proposition, i.e., that if a reputation equilibrium exists under owner management but not under professional management, then the hypothesis of Proposition 3, equation (15) is false.

To see this note that, if the conditions for a reputation equilibrium are satisfied under owner-management but not delegated management, then Propositions 1 and 2 imply that

$$\begin{aligned} F_1 &> 1 - \frac{b^*}{\delta + (\pi_1 - \pi_r)}, \\ F_1 &\geq 1 + b^* - (\pi_1 - \pi_r) + g. \end{aligned} \quad (\text{A.9})$$

Expression (A.9) implies that

$$F_1 \geq \max \left[1 - \frac{b^*}{\delta + (\pi_1 - \pi_r)}, 1 + b^* - (\pi_1 - \pi_r) + g \right]. \quad (\text{A.10})$$

Clearly,

$$\begin{aligned} \max \left[1 - \frac{b^*}{\delta + (\pi_1 - \pi_r)}, 1 + b^* - (\pi_1 - \pi_r) + g \right] &\geq \\ \inf_{b \geq 0} \max \left[1 - \frac{b}{\delta + (\pi_1 - \pi_r)}, 1 + b - (\pi_1 - \pi_r) + g \right]. \end{aligned} \quad (\text{A.11})$$

Let

$$b^o = \frac{\delta + (\pi_1 - \pi_r)}{1 + \delta + (\pi_1 - \pi_r)} ((\pi_1 - \pi_r) - g).$$

Algebra shows that

$$1 - \frac{b^o}{\delta + (\pi_1 - \pi_r)} = 1 + b^o - (\pi_1 - \pi_r) + g.$$

Again, simple algebra shows that $(\pi_1 - \pi_r) - g > 0$ and thus $b^o \geq 0$. Because,

$$\begin{aligned} 1 - \frac{b}{\delta + (\pi_1 - \pi_r)} & \text{ is strictly decreasing in } b, \\ 1 + b - (\pi_1 - \pi_r) + g & \text{ is strictly increasing in } b, \end{aligned}$$

$$1 - \frac{b}{\delta + (\pi_1 - \pi_r)} > (<) 1 + b - (\pi_1 - \pi_r) + g \iff b < (>) b^o.$$

Thus,

$$\begin{aligned} \inf_{b \geq 0} \max \left[1 - \frac{b}{\delta + (\pi_1 - \pi_r)}, 1 + b - (\pi_1 - \pi_r) + g \right] \\ = \max \left[1 - \frac{b^o}{\delta + (\pi_1 - \pi_r)}, 1 + b^o - (\pi_1 - \pi_r) + g \right] = \frac{1 + \delta + g}{1 + \delta + (\pi_1 - \pi_r)}. \end{aligned} \quad (\text{A.12})$$

Expressions (A.10), (A.11), and (A.12) imply that

$$F_1 \geq \max \left[1 - \frac{b^*}{\delta + (\pi_1 - \pi_r)}, 1 + b^* - (\pi_1 - \pi_r) + g \right] \geq \frac{1 + \delta + g}{1 + \delta + (\pi_1 - \pi_r)}.$$

Which implies that the hypothesis of the proposition, inequality (15), is false. $\square$

B Examples of organizational reputation crises in firms

Table B.1: Examples of organizational reputation crises and recovery attempts.

Year	Company	Event		Response
2015-2018	Theranos	Falsified medical testing ability.		Theranos denied allegations. Partners stopped using Theranos. SEC charged Thernos with Fraud, removed CEO control, and barred her from serving as an officer or director of public companies. Thernos closed 9/5/2018.
2017	Kobe Steel	Falsified quality data.		Changed quality control processes and reporting procedures. Established an Independent Investigation Committee, a Quality Governance Restructuring Deliberation Committee and a Quality Management Department.
2016	Wells Fargo	Fake accounts.		Fined by regulators. Terminated employees, ended sales goals, restructured sales practices, replaced CEO and other management. New CEO resigned in April 2019.
2015	Volkswagen	Faked emission test results.		Replaced CEO. Suspended some employees. Recalled cars. Refocused on electric and hybrid vehicles. Compensated owners. Regulators signed off on software updates.
2013	Lululemon	“Too sheer” yoga pants.		Created new factory oversight system and new organizational structure. Replaced CEO.
2012	Barclays	Manipulated rates.	LIBOR	Created new “Brand and Reputation Committee.” Replaced CEO. Adopted “zero tolerance” policy.
2012	JP Morgan	“London Whale”		Overhauled risk metrics. Replaced personnel. Dismantled trading arm that caused the problem.
2009-2016	Takata Air Bags	Manipulated test data on air-bag inflators.		NHTSA ordered revision of production and quality control procedures. NHTSA fined Takata for inadequate response. Takata filed for bankruptcy on 6/26/17.
2009-2010	Toyota	Acceleration problems.		Recalled and redesigned systems. Developed the “Toyota Way.” Restructured oversight under “Customer First Committee.”
2007	Mattel	Lead paint on toys.		Recalled toys. Created new testing procedures. Changed suppliers. Put Mattel personnel in supplier’s factories.
2007	RC2	Lead paint on toys.		Recalled toys (initially at owners’ shipping expense). Takara Tomy purchased RC2 in April, 2011.
2006-2008	Siemens	Corruption		Set up anticorruption task force. Created rules and compliance processes, training programs, disciplinary actions, terminated employees.

C Second period payoffs in the experimental game.

Table C.2: Operator payoffs in the second period.

Firm Type	Period 1	Reform	Period 2	Parameter Set	
	Good Quality	Outcome	Technology	I	II
Panel A: OM Treatments					
Secure	High	N.A.	Reliable	169 - 111 = 58	288 - 111 = 177
Insecure	High	N.A.	Vulnerable	169 - 51 = 118	288 - 51 = 237
Insecure	Low	N.A.	Vulnerable	0	0
Panel B: OMR Treatments					
Secure	High	N.A.	Reliable	192 - 111 = 81	288 - 111 = 177
Insecure	High	N.A.	Vulnerable	192 - 51 = 141	288 - 51 = 237
Insecure	Low	Success	Reliable	145 - 111 - 10 = 24	145 - 111 - 10 = 24
Insecure	Low	Failure	Vulnerable	145 - 51 - 10 = 84	145 - 51 - 10 = 84
Panel C: PM Treatments					
Secure	High	N.A.	Reliable	30	30
Insecure	High	N.A.	Vulnerable	30 + 60 = 90	30 + 60 = 90
Insecure	Low	Success	Reliable	0	0
Insecure	Low	Failure	Vulnerable	0	0

D Experience Weighted Attraction Models

Along the lines of Erev and Roth (1998) and Camerer et al. (2002), we define the attraction to the reputation, opportunism and secure strategies for an operator as follows:

$$\begin{aligned}
A_{s,t}^{Reputation} &= A_{s,t-1}^{Reputation} + \Phi_{s,t-1}^{Reputation} \left[\pi_{s,t-1}^{Reputation} - \delta E(\pi_{s,t-1}^{Defection}) - \min(\pi_{s,t-1}^i - \delta E(\pi_{s,t-1}^j)) \right], \\
A_{s,t}^{Opportunism} &= A_{s,t-1}^{Defection} + \Phi_{s,t-1}^{Defection} \left[\pi_{s,t-1}^{Defection} - \delta E(\pi_{s,t-1}^{Reputation}) - \min(\pi_{s,t-1}^i - \delta E(\pi_{s,t-1}^j)) \right], \text{ and} \\
A_{s,t}^{Secure} &= A_{s,t-1}^{Secure} + \Phi_{s,t-1}^{Secure} \left[\pi_{s,t-1}^{Secure} - \delta E(\pi_{s,t-1}^{Secure}) - \min(\pi_{s,t-1}^i - \delta E(\pi_{s,t-1}^j)) \right], \tag{D.13}
\end{aligned}$$

where t indexes rounds (each consisting of two periods), $A_{s,t}^i$ is the attraction that strategy i holds for subject s in round t (with $A_{s,1}^i = 0$); $\Phi_{s,t-1}^i$ is an indicator function equal to 1 if subject s plays strategy i in round $t-1$; $\pi_{s,t-1}^i$ is the (two-period overall) profit received by subject s who played strategy i in round $t-1$; $E(\pi_{s,t-1}^i)$ is the profit subject s would have expected to receive by playing the best alternative strategy to i in period $t-1$; and δ is a weighting function for the strategies not played. Subtracting the minimum possible profit difference both normalizes the attractions and insures that attractions are never negative. If $\delta = 0$, the subject weights only payoffs actually received in updating attractions. If $\delta = 1$, the subject weights strategies played equally with the forgone earnings of unplayed

strategies.

To see the intuition behind these attraction measures, consider a simple example. Suppose an owner manager of an insecure firm plays the reputation strategy in treatment OM-I. The payoff to the strategy is: $p_0 - 111 + 118$. The expected payoff from the opportunism strategy is: $p_0 - 60 + 0.05 \times 118$. In this case, the lowest possible payoff to any strategy is -53 . So, if $\delta = 0$, the increment to attraction is: $p_0 - 111 + 118 + 53 = p_0 + 60$. If $\delta = 1$, the subject considers the expected payoff to the defection strategy and the lowest difference in expected payoffs between strategies is -58 . So, the increment to attraction becomes $p_0 - 111 + 118 - (p_0 - 51 + 0.05 \times 118) + 58 = 110.1$.

Given the attractions at the beginning of a round, the propensity to play a strategy is given by:

$$q_{s,t}^i = \frac{A_{s,t}^i}{\sum_j A_{s,t}^j}. \quad (\text{D.14})$$

Note that, as defined, higher (lower) payoffs from playing the reputation strategy in the past add to (subtract from) the propensity to play it again. Similarly, lower (higher) payoffs to playing the opportunism strategy in the past adds to (subtract from) the propensity to play the reputation strategy currently. Thus, a greater reputation building propensity is driven by either high past payoffs to the reputation strategy or low past payoffs to opportunism.

For consumers, we change the attraction measures slightly because of the continuous strategy space. We measure attraction as either (1) average period 1 net profits received by consumers in prior interactions as a result of buying goods or (2) average prior period 1 values observed by consumers in prior rounds. Specifically, we define the “attraction” of a good as either:

$$A_{s,t}^{good} = \sum_{n=1}^{t-1} \frac{\Phi_{s,n}^i (V_{s,n}^{good} - DP_{s,n}^{good})}{t-1} \quad (\text{D.15})$$

or

$$A_{s,t}^{good} = \sum_{n=1}^{t-1} \frac{V_{s,n}^{good}}{t-1} \quad (\text{D.16})$$

where $A_{s,t}^{good}$ is subject s ’s attraction to the good in round t , $V_{s,n}^{good}$ equals the good’s value in round n , $\Phi_{s,n}^i$ is an indicator function equal to 1 if subject s purchased the good in round n , and $DP_{s,n}^{good}$ is the good’s discounted price for subject s in round n . We refer to the first measure as “Average Prior Net Profit Attraction.” It averages prior net profits, weighting un-purchased goods by 0 and purchased goods by their value relative to their purchase prices (analogous to $\delta = 0$ in equation D.14). Thus, it considers not just the

value of goods purchased, but also the cost of purchasing them. This measure does not capture the effect of goods not purchased. The second, “Average Prior Value Attraction,” is the prior average good value. It is the analog of equation (D.13) with $\delta = 1$ because goods not purchased have the same weight as purchased goods.¹

E Subject instructions

This appendix contains instructions for all three treatments under Parameter Set I. Differences are set off by “((” followed by OM: for Owner Management, OMR: for Owner Management with Reform or DMR: for Professional management; and closed by “)).” Parameter Set II instructions differ in describing the fraction of managers who have Method 2 (the vulnerable production technology) available and changes manager payoffs in accordance with the parameter set.

INSTRUCTIONS

General

You are about to participate in an experiment on decision making. If you follow these instructions carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment.

At the beginning of the experiment, all players are assigned a type: Blue or Green. You will remain Blue or Green throughout the experiment. Next, one Blue and one Green Player are randomly assigned to a 2-player group. These players will interact with each other for two periods. Then, players are randomly re-assigned to new groups for two more periods. This process repeats until the end of the experiment.

The currency used in these games is francs. Each period, you receive franc payoffs that are yours to keep. At the end of the experiment, you will exchange francs for dollars. Your individual exchange rate will be displayed on your computer terminal after the experiment starts. Do not reveal this number to anyone. At the end of the experiment, your francs will be converted to dollars at this rate, and you will be paid in dollars. Note that the more francs you earn, the more dollars you earn regardless of the exchange rate.

Stages of the Game

Each period is divided into two stages.

Briefly, in Stage I, the Blue Player makes decisions about producing an item and sells it to the experimenter. In Stage II, the Green Player will have an opportunity to buy the

¹We note that this also happens to be the method of moments estimator for a Beta-Binomial Distribution for the probability of a high quality good based on prior observations.

item from the experimenter. There are two types of items: Round, worth 1,000 francs to the Green Player and Square, worth 0 francs to the Green Player.

Because it will make it easier to understand, we describe the Stages in reverse order.

Stage II Instructions

Green Player Decision

In Stage II, the Green Player sets a “Limit Price” for an item and may buy the item. If he or she does buy the item, it will be at a “Discounted Price” that is less than or equal to the Limit Price.

If the Green Player buys the item, he or she will receive a “Redemption Value” of 1,000 francs for a Round item and 0 francs for a Square item.

The item type is determined in Stage I but the type will not be known by the Green Player until after he or she establishes the Limit Price in Stage II.

Procedures

The Limit Price and the Discounted Price for the item will be determined as follows.

1. Limit Price: The Green Player will be asked to indicate the highest price he or she is willing to pay for the item. This determines the Limit Price. The Limit Price must be between 0 and 1,000 (inclusive). The Green Player is asked to enter the price and press “OK” to continue.
2. Discounted Price: The computer program will determine a Discounted Price by drawing a random number between 0 and 1,000 (inclusive) to be the Discounted Price.

If the random draw is less than or equal to the Limit Price, the Green Player will buy the item at the Discounted Price from the experimenter and receive the Redemption Value.

If the random draw is greater than the Limit Price indicated by the Green Player, then the Green Player will not buy the item.

Thus, the Limit Price defines the highest price that the Green Player will pay for the item. If he or she buys the item it will be at a Discounted Price less than or equal to the Limit Price.

Payoff Determination

The Green Player starts each period with working capital of 1,000 francs. This allows the Green Player to pay up to 1,000 francs for an Item. Three quarters (75%) of the working capital will be deducted at the end of the period. The Green Player's payoffs are determined as follows:

If the Discounted Price is greater than the Limit Price:

$$\text{Period Payoff} = 1,000 - 750 = 250.$$

If the Discounted Price is less than the Limit Price:

$$\text{Period Payoff} = 1,000 + \text{Redemption Value} - \text{Discounted Price} - 750.$$

Notice that buying the item increases your payoff whenever the Redemption Value is higher than the Discounted Price AND you buy the item (that is, the Limit Price is higher than the Discounted Price).

Notes on this Procedure

If you are a Green Player, it is in your best interest to be accurate; that is, the best thing you can do is state truthfully the highest price you would be willing to pay for the item as the Limit Price. If the price stated is too high or too low, then you pass up opportunities that you would prefer.

Suppose you are a Green Player and you are certain that the Item will be Round. Then, you should set a Limit Price of 1,000. If you set it less, say 800, then whenever the random draw is between 800 and 1,000, you will not purchase the item even though the item is worth more to you than the discounted price. For example, if the Discounted Price is 900, you are better off buying the item ($\text{Payoff} = 1000 + 1000 - 900 - 750 = 350$) than not buying the item ($\text{Payoff} = 1000 - 750 = 250$). The only way to insure that you will always buy the item when the Discounted Price is less than the value is to set the Limit Price at 1,000.

Similarly, if you are certain that the Item will be Square, then you should set a Limit Price of 0. If you set it more, say 200, then whenever the random draw is between 0 and 200, you end up buying the item even though it is worthless to you. For example, if the Discounted Price is 100, you are worse off buying the item ($\text{Payoff} = 1000 + 0 - 100 - 750 = 150$) than not buying the item ($\text{Payoff} = 1000 - 750 = 250$). The only way to insure that you will never buy the item when the Discounted Price is more than the value is to set the Limit Price at 0.

Similar arguments imply that, if, on average, you expect the item value to be X francs (e.g., 500), then you should set a Limit Price equal to X (e.g., 500). If so, you always buy

the item when the Discounted Price is less than what you think it is worth on average and never buy it if the Discounted Price is more than what you think it is worth.

We will discuss Stage I next. Before doing that, are there any questions about the Green Player's actions in Stage II and the Green Player's payoffs?

Stage I Instructions

In Stage I, the Blue Player selects a "production method." Methods available and the earnings received by the Blue Player vary as described below.

Determining Available Production Methods

In the first period of a group interaction, the computer randomly determines the production methods available to the Blue Player.

In the first period, $1/8$ (12.5%) of the Blue Players MUST produce according to the following method in BOTH periods:

- Method 1: Sure, which always produces a Round Item

In the first period, the other $7/8$ (87.5%) of the Blue Players can CHOOSE between producing according to:

- Method 1: Sure, which always produces a Round Item.
- Method 2: Mixed, which produces a Round Item $1/20$ (5%) of the time and a Square Item $19/20$ (95%) of the time.

In the second period, these Blue Players will be restricted to a single production method as follows:

- ((OM: They MUST produce according to Method 2 Mixed in the second period of the group interaction.))
- ((OMR & DMR: If these Blue Players produce a Round Item in the first period of a group interaction, they MUST produce according to Method 2 Mixed in the second period of the group interaction.))
- ((OMR & DMR: If these Blue Players produce a Square Item in the first period of a group interaction, the computer will randomly re-draw production methods for the second period of the group interaction. In this case, $1/10$ (10%) of the Blue Players MUST produce according to Method 1: Sure and $9/10$ (90%) MUST produce according to Method 2: Mixed in the second period of the group interaction.))

Payoff Determination

The Blue Player's payoffs are determined by a "Sale Price" set by the experimenter and a method payment in each period.

In the first period of a group interaction, the Sale Price equals ((OM & OMR: the Limit Price set by the Green Player)) ((DMR: 111)). Thus, the payoff is ((OM & OMR: the Limit Price)) ((DMR: 111)) minus a method payment that depends on the method chosen. Specifically:

Period 1 Payoff		
Method:	Method 1: Sure	Method 2: Mixed
Availability:	Always	7/8 (87.5%) of the time
+ Sale Price	((OM & OMR: Limit Price)) ((DMR: 111))	((OM & OMR: Limit Price)) ((DMR: 111))
- Method Payment	-111	-51
Total Payoff	((OM & OMR: Limit Price - 111)) ((DMR: 0))	((OM & OMR: Limit Price - 51)) ((DMR: 60))

For example, suppose the Limit Price was 500 in Period 1. Your payoff would be:

- ((OM & OMR: 500-111=389)) ((DM: 111-111=0)) if Method 1: Sure was available and chosen.
- ((OM & OMR: 500-51=449)) ((DM: 111-51=60)) if Method 2: Mixed was available and chosen.

In the second period of the group interaction, the Blue Player is always restricted to one production method. The Sale Price is set by the experimenter depending on the Item Type produced in Period 1((OMR & DMR: and the redraw outcome. In addition, if the Period 1 Item was Square, the experimenter will charge a cost to redraw production methods)).

The Blue Player's payoffs are summarized in the following table:

((OM:

Period 2 Payoff			
Period 1 Item:	Round		Square
Method:	Method 1: Sure	Method 2: Mixed	Method 2: Mixed
Availability:	If only Method 1 was available in Period 1	If both Methods were available in Period 1	Always
+ Sale Price	169	169	51
- Method Payment	-111	-51	-51
Total Payoff	58	118	0

))

((OMR:

Period 2 Payoff				
Period 1 Item:	Round (No Redraw)		Square (Redraw)	
Method:	Method 1: Sure	Method 2: Mixed	Method 1: Sure	Method 2: Mixed
Availability:	If only Method 1 was available in Period 1	If both Methods were available in Period 1	1/10 (10%) of the time	9/10 (90%) of the time
+ Sale Price	192	192	145	145
- Method Payment	-111	-51	-111	-51
- Redraw Cost	0	0	-10	10
Total Payoff	81	141	24	84

))

((DMR:

Period 2 Payoff				
Period 1 Item:	Round (No Redraw)		Square (Redraw)	
Method:	Method 1: Sure	Method 2: Mixed	Method 1: Sure	Method 2: Mixed
Availability:	If only Method 1 was available in Period 1	If both Methods were available in Period 1	1/10 (10%) of the time	9/10 (90%) of the time
+ Sale Price	141	141	121	121
- Method Payment	-111	-51	-111	-51
- Redraw Cost	0	0	-10	70
Total Payoff	30	90	0	0

))

In Period 2 after a Round Item in Period 1, your payoff would be:

- ((OM: 58)) ((OMR: 81)) ((DMR: 30)) if Method 1: Sure becomes the only available method in Period 2 because it was the only available method in Period 1.
- ((OM: 118)) ((OMR: 141)) ((DMR: 90)) if Method 2: Mixed becomes the only available method in Period 2 because both methods were available in Period 1 and a Round item was produced.

In Period 2 after a Square Item in Period 1 ((OMR & BMR: and a redraw in Period 2)), your payoff would be:

- ((OM: 0 with Method 2: Mixed becoming the only available method.))
- ((OMR: 24 if Method 1: Sure becomes the only available method as a result of the redraw.))
- ((DMR: 0 if Method 1: Sure becomes the only available method as a result of the redraw.))
- ((OMR: 84 if Method 2: Mixed becomes the only available method as a result of the redraw.))
- ((DMR: 0 if Method 2: Mixed becomes the only available method as a result of the redraw.))

We will discuss how player types and groups are determined next. Before doing that, are there any questions about the Blue Player's actions in Stage I and the Blue Player's payoffs?

Group, Player Type and Technology Determination

At the beginning of the experiment, you are assigned a player type: "Blue" or "Green." You remain this type of player for the entire experiment. Every 2 periods, one Blue and one Green Player are matched randomly to play the game for two periods. Everyone is re-assigned to new groups every 2 periods. Thus, in periods 1 and 2, you will be with one group. In period 3, you will be randomly re-assigned to new groups for periods 3 and 4, etc.

The computer draws new Production Methods at the beginning of each group interaction (that is, every 2 periods) as follows:

1. $1/8$ (12.5%) of the Blue Players will ONLY be able to produce using "Method 1: Sure."
2. $7/8$ (87.5%) of the Blue Players on average will be able to produce using EITHER "Method 1: Sure" OR "Method 2: Mixed."

((OM: In)) ((OMR & DMR: If no redraw occurs in)) Period 2 of a group interaction, "Method 1: Sure" remains the only available production method if it was the only available method in Period 1. "Method 2: Mixed" becomes the only available production method if both methods were available in Period 1.

((OMR & DMR: If a redraw occurs in Period 2 of a group interaction because a Square item was produced in Period 1, “Method 1: Sure” becomes the only available production method 1/10 (10%) of the time and “Method 2: Mixed” becomes the only available production method 9/10 (90%) of the time.))

Neither the Methods available nor the Method actually chosen are revealed to the Green Player. The Item type is revealed after Period 1 ((OMR & DMR: and whether methods were redrawn is revealed between periods)). So, in Period 2, there are the following possibilities:

1. The Blue Player produced a Round Item in Period 1. Thus, the Green Player does not know whether “Method 1: Sure” or “Method 2: Mixed” was used in Period 1 nor which is the only available method in Period 2. (Recall, Method 1: Sure is always available and, sometimes, Method 2: Mixed produces a Round Item in Period 1.)
2. ((OM: The Blue Player produced a Square Item in Period 1. Thus, the Green Player knows that “Method 2: Mixed” was available and used in Period 1 AND Method 2: Mixed will be the only method available in Period 2.)))
3. ((OMR & DMR: The Blue Player produced a Square Item in Period 1 and a redraw occurred. Thus, the Green Player knows that “Method 2: Mixed” was available and used in Period 1, but does not know the method available in Period 2. (Recall that, after a redraw, 1 in 10 times, only Method 1: Sure is available and 9 in 10 times only Method 2: Mixed is available.)))

End of Period Results

The computer program reports results to you at the end of each period. Beginning in the next period a history of results appears in two windows. The left window shows the publicly available information given to all players in your group. Note that this will NOT give the Methods available to or used by the Blue Player. The right window gives your private information and shows your payoff. You can scroll through these windows and record results as you wish. In particular, you may want to fill in your earnings on your receipt each period.

End of Experiment Rules

The computer will total your earnings in francs at the end of the experiment. It multiplies this amount by the exchange rate to determine the amount of dollars you

receive. Fill this number in on your receipt. You will be paid this amount of dollars in cash.

Are there any questions?

Summary Sheet

Methods are drawn randomly each time groups are reassigned as follows:

1. Initially, $1/8$ of the Blue Players will have ONLY “Method 1: Sure” available.
2. The other $7/8$ of the Blue Players will have both “Method 1: Sure” and “Method 2: Mixed” available.

Within a group:

1. If the Period 1 item is Round and “Method 1: Sure” was the only method available, it remains the only available method in Period 2.
2. If the Period 1 item was Round and both methods were available, “Method 2: Mixed” becomes the only available method in Period 2.
3. ((OM: If the item produced in Period 1 was Square then, “Method 2: Mixed” becomes the only available method in Period 2.))
4. ((OMR & DMR: If the item produced in Period 1 was Square then, methods are redrawn in Period 2.
 - 4.1. “Method 1: Sure” will be the only method $1/10$ times.
 - 4.2. “Method 2 Mixed” will be the only method the other $9/10$ times.))

Neither the methods available nor the method actually used in any given period will be revealed to the Green Player. Only the Item type will be revealed.

The game proceeds as follows:

1. Players are randomly assigned to groups every two periods. The Blue Player is assigned newly drawn Methods.
2. Stage I
 - 2.1. The Blue Player chooses a method.
 - 2.2. The Blue Player receives a payment as follows:

- In the first period of a group interaction, the Blue Player receives: ((OM & OMR: the Limit Price of the item minus 111 if Method 1: Sure is used OR the Limit Price minus 51 if Method 2: Mixed is used.
 - ((DMR: 0 if Method 1: Sure is used.))
 - ((DMR: 60 if Method 2: Mixed is used.))
- In the second period of a group interaction, the Blue Player receives:
 - ((OM: 58)) ((OMR: 81)) ((DMR: 30)) if a Round item was produced in Period 1 and Method 1: Sure is used in Period 2.
 - ((OM: 118)) ((OMR: 141)) ((DMR: 90)) if a Round item was produced in Period 1 and Method 2: Mixed is used in Period 2.
 - ((OM: 0 if a Square item was produced in Period 1.))
 - ((OMR: 24 if a Square item was produced in Period 1 and Method 1: Sure is used in Period 2.))
 - ((OMR: 84 if a Square item was produced in Period 1 and Method 2: Mixed is used in Period 2.))
 - ((DMR: 0 if a Square item was produced in Period 1 and Method 1: Sure is used in Period 2.))
 - ((DMR: 0 if a Square item was produced in Period 1 and Method 2: Mixed is used in Period 2.))

3. Stage II

- 3.1. The Green Player receives working capital of 1,000 each period.
- 3.2. The Green Player will be told whether Methods have been newly drawn, re-drawn or be restricted to a single method from the prior period.
- 3.3. Prices are determined:
 - The Green Player decides the most he or she is willing to pay for the item and sets the Limit Price.
 - The computer draws a random Discounted Price between 0 and 1,000.
 - If the Discounted Price is less than or equal to the Limit Price, the Green Player will buy the item at the Discounted Price and receive the Redemption Value (1000 for Round and 0 for Square).
- 3.4. In all cases, the Green Player returns 75% of the working capital (750).

You are free to make as much money as you can according to these rules.

References

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- Erev, Ido and Alvin E Roth, “Predicting how people play games: Reinforcement learning in experimental games with unique, mixed strategy equilibria,” *American Economic Review*, 1998, pp. 848–881.