Federal Deposit Insurance Corporation • Center for Financial Research

Working Paper Series

Short-Termism of Executive Compensation

Jonathan Pogach

Federal Deposit Insurance Corporation

Current Version: December 2015

FDIC CFR WP 2016-01

fdic.gov/cfr

Short-Termism of Executive Compensation *†

JONATHAN POGACH‡

December 23, 2015

Abstract

This paper presents an optimal contracting theory of short-term firm behavior. Contracts inducing short-sighted managerial behavior arise as shareholders' response to conflicting intergenerational managerial incentives. High-return projects may last longer than the tenure of managers who implement them. Consequently, inducing managers to act in the long-term interests of the firms requires the alignment of incentives across multiple managers. Such action comes at greater costs than providing incentives for a single manager and, as a result, leads to contracts that favor short-term behavior. Long-term firm value maximization is further impeded when only the quality of accepted projects–but not those of declined projects–is public. In that case, shareholders find it costly to induce long-term project selection among managers who can earn all information rents from short-term projects but must sacrifice information rents from long-term projects to future managers.

Keywords and phrases *Executive Compensation, Short-Termism*

*This document is a draft. Please do not cite or distribute.

†Contact: jpogach@fdic.gov. The author thanks Indraneel Chakraborty, Antonio Falato, Levent Güntay, Troy Kravitz, Paul Kupiec, Haluk Ünal, and Jun Yang for their valuable comments and suggestions. Any remaining errors are solely the author's.

‡Federal Deposit Insurance Corporation; the views and opinions expressed here are those of the authors and do not necessarily reflect the views of the FDIC.

1 Introduction

In many instances, firms are thought to behave in a myopic manner, taking on projects or strategies that yield short-term profits at the expense of long-term firm value. Concerns about "short-termism" came to the fore during the 2008 global financial crisis, and have persisted since and across financial and nonfinancial firms alike. Regarding the financial sector, policymakers[1] and academics[2] have argued that bonuses based on short-term performance and unrestricted equity holdings induce short-sighted decisions at the expense of long-term economic performance. Industrial firms have also faced criticism on short-termism. *The Economist*[3] laments that "loaded up with stock options, managers acted like hired guns ... massaging the share price so as to boost their incomes." A *Harvard Business Review* article argues that "companies are less able to invest and build value for the long term, undermining broad economic growth and lowering returns on investment for savers." The author cites evidence from a McKinsey study that even CEOs recognized the detriment of their own short-term decision making–43 percent of CEOs have a planning horizon of three years or less, despite 73 percent of CEOs feeling that this was too short.[4] The question is why contracts that award myopia at the firm's expense arise in the first place.

This paper presents one theory regarding the origins of short-term contracts.[5] The theory suggests that short-term contracts arise as shareholders' profit-maximizing response to a conflict of different managers' incentives across time. The theory relies on the observation that firms and the projects that make them profitable may be longer lived than the tenure of managers (or other employees) who select and implement projects. The theory demonstrates that the nature of the firm as a sequence of different managers causes contracts to be written that favor the short term. This intrinsic property of firms implies that while alternative compensation schemes might mitigate

[1]E.g. Sheila Bair, Washington Post Editorial, July 6, 2011.

[2]E.g. Thanassoulis (2012)

[3]"Reinventing the company", October 24, 2015.

[4]https://hbr.org/2014/01/focusing-capital-on-the-long-term/ar/1

[5]Throughout the paper, the term "short-term contract" is used to refer to any contract induces managers to choose low-return short-term projects at the expense of high-return long-term projects.

short-term incentives for managers, such incentives cannot be eliminated entirely.

Consistent with the theory presented in this paper is the finding of Dechow and Sloan (1991) that in firms with significant ongoing research and development activities, CEOs spend less on these activities during their final years in office. Furthermore, Jenter and Lewellen (2011) show distinct differences between mergers when the acquired firm's CEO is younger or older than the "retirement" age of 65. Such a discrete difference around retirement age suggests that firms cannot adequately compensate CEOs so as to maximize firm value without considering the intergenerational nature of its managers.[6]

The baseline model captures the intergenerational nature of managerial decision making. The baseline model features two time periods and two managers. In the first period, the manager chooses between undertaking a short-term project or a long-term project. Both projects consist of two effort decisions by managers with short-term project effort choices occurring within a period and the long-term project effort choices occurring across periods. In short-term projects, shareholders and Manager 1 (she) first observe the *ex-ante* quality of the project. Shareholders make an investment into the project and Manager 1 makes an unobserved effort decision. As the project progresses, Manager 1 learns more about the project's prospects and she makes her second unobserved effort decision that further increases output. An *ex-ante* identical short-term project is then undertaken by Manager 2. The structure of long-term projects is identical to the structure of a short-term project, except that after Manager 1 makes her first effort decision, she retires and Manager 2 (he) takes over the firm. The second effort decision is then made by Manager 2 after he learns about the project's prospects. This paper assumes that long-term and short-term projects are mutually exclusive so that, over the two periods, either one long-term project or two short-term projects are implemented. This paper then examines the conditions under which shareholders prefer Manager 1 to choose short-term and long-term projects when the quality of both

[6] Through the paper, intergenerational decision-making is used to refer to decisions that happen across different managers and time periods. Intragenerational decision-making is used to refer to decisions that happen under the tenure of a single manager and time period.

projects is publicly observed.

The difference between intergenerational and intragenerational decision making for long-term and short-term projects has important implications on project selection. In particular, so long as undertaking the project is profitable, for a given project quality the short-term project always generates higher expected profits than long-term projects. The underlying rationale for short-term bias is that when Manager 1 makes all relevant decisions, shareholders design contracts to best tease out from each output observation a "luck" component and an "effort" component. The better that shareholders can separate effort from luck, the more cheaply they can provide incentives for Manager 1 and extract profit. For short-term projects, a contract that offers high wages to Manager 1 for high final output provides her with incentives to exert effort in both stages of the project. In long-term projects where Manager 1 and Manager 2 each make decisions affecting output, shareholders must assess from each possible output observation a "luck" component and *separate* the component of effort attributable to Manager 1 from that of Manager 2. Because the optimal contract requires this additional separation of incentives between Manager 1 and Manager 2, shareholders' profits are reduced. Offering high wages to Manager 1 for high final output does nothing for Manager 2's incentives. This added friction is the source of short-term bias.[7]

In an extension to the baseline model, this paper assumes that only Manager 1 observes the quality of the projects that she turns down. This makes compensation contracts even more biased toward the short term. The reason for this is as follows. In the baseline case, Manager 1 earns no information rents from long-term projects because she and the shareholders are equally informed on the project's return when her decision is made; only Manager 2 obtains an information advantage over shareholders. However, Manager 1 *can* earn information rents if a short-term project is chosen, as she makes the second effort decision after acquiring an information advantage. This

[7]This logic may also be relevant in politics. If politicians care about getting recognized for accomplishments, they will lean toward short-term projects where their efforts are more easily recognized. Undertaking long-term projects, whose successes require the efforts of future politicians, makes it difficult for voters to appropriately assign credit.

implies that a contract that induces Manager 1 to choose long-term projects comes at an additional cost to shareholders. A contract can induce long-term project selection either by having shareholders share more surplus with Manager 1 or by reducing Manager 1's surplus conditional on short-term project selection. The latter requires a reduction in the amount of effort conditional on short-term project selection. In either case, implementing long-term projects comes as an extra cost to shareholders, leading to a larger short-term bias.

The mechanisms driving the short-term bias are not driven simply by the complexity of having multiple individuals contributing to a project, but rather the temporal revelation of information across those individuals. The costly nature of long-term projects arises because the second manager makes an effort decision after learning information unavailable to the first manager when she undertook the project. Indeed, Holmström (1982) shows that the ability of the principal to break the balanced budget condition enables efficient effort in a team project with *simultaneous* unobservable effort. Similarly, in the model presented here, the principal could capture equivalent rents in simple (one manager) and team (two manager) projects if the managers act simultaneously with the same information.

In addition to the contracting literature in which one principal contracts with multiple agents, this paper relates to a rich literature on short-termism. Existing theories on short-termism rely on preference differentials, e.g. Narayan (1985) and Froot, Scharfstein, and Stein (1992); signaling motives, e.g. Holmström and Ricart I Costa (1986) and Holmström (1999); or commitment problems, e.g. Von Thadden (1995). In contrast, this paper explains short-termism through the lens of incentive conflicts, which arise in the presence of managerial effort across multiple generations. A fuller literature review is provided in Section 7.

The model is broadly applicable to many corporate finance problems in which managers must choose among shorter-term and longer-term projects. One example is firms that have large research and development activity. In these firms, the return of research and development projects may require the efforts of both the undertaking manager as well as future managers. The extent that a project's success cannot be separately allocated across generations may then lead to under-investment of these longer-term projects. Another example may be the relationship between an investor and a money management firm. While the first-best investment strategy may have a long-term horizon, the inability of the investor to separately reward managers across generations of managers for successful execution of the strategy inhibits implementation. Consequently, the second-best contract may dictate that investors reward money managers for short-term results, inducing more myopic investment strategies.

The remainder of the paper is organized as follows. Section 2 discusses two simple hidden effort problems with one action and one manager to highlight the issues driving the results in the more complicated models. Sections 3 and 4 discuss the profit-maximizing contracts to implement long-term and short-term projects. Section 5 compares profits for long-term and short-term projects when the projects' returns differ and are publicly observable. Section 6 extends the model by allowing only the manager to observe the returns of rejected projects, while shareholders may only observe the returns of the project that is ultimately chosen. Section 7 discusses how this paper relates to the broader literature. Section 8 concludes.

2 Two Simple Models With Unobservable Effort

This section covers two trivial models in which a manager's effort cannot be observed. The models highlight the central elements underlying the models in Sections 3 and 4. In both models, agents are risk neutral and effort is unobservable. In the first model, a manager makes an effort decision that, combined with luck, determines a projects return. To provide incentives for effort, shareholders reward the manager only in the event that output is high. This is because high output is the best indication that the manager exerted effort. In this model, the manager extracts no information rents, the first-best outcome can be implemented, and the shareholders extract all the surplus.

In the second model, the assumptions are similar. The only difference is that the manager makes her effort decision after privately observing the project's idiosyncratic return. In this case, to induce effort the manager must earn wages even for intermediate output observations. Depending on the project's returns to effort, implementing the first-best outcome may or may not be the most profitable for the shareholders. This follows from the fact that in this model, the manager can extract information rents. This will play an important role in the models of subsequent sections.

2.1 Moral Hazard Model 1

Consider a manager whose effort cannot be observed. At the beginning of a period, a manager can choose to exert effort or not. The decision is represented by $\hat{e} \in \{0, 1\}$. A manager who exerts effort ($\hat{e} = 1$) incurs a non-pecuniary cost of c and zero cost otherwise. The choice of effort increases the output of the firm by $\theta > c$ so that it is efficient for the manager to exert effort.

Shareholders invest θ into the project. Furthermore, the (gross) return of the project is risky and can take on values $y = \theta + \theta\hat{e} + \eta$. Meanwhile, $\eta \in H \equiv \{-\theta, 0, \theta\}$ and takes on these values with equal probability.

Then, the incentive compatibility constraint for the manager to exert effort is given by:

$$\frac{1}{3}\left[x(3\theta) + x(2\theta) + x(\theta)\right] - c \geq \frac{1}{3}\left[x(2\theta) + x(\theta) + x(0)\right]$$

where $x(y)$ is the wage paid to the manager given observed output y. Assuming limited liability (i.e. $x(y) \geq 0$ for all y), this condition implies that the optimal contract offers $x(3\theta) = 3c$ and $x(y) = 0$ otherwise. The contract induces the efficient outcome whenever $\theta \geq c$.

The manager's surplus in this model is given by $\frac{1}{3}[3c] - c = 0$. Meanwhile, the expected profit of the shareholders is $\frac{1}{3}[3\theta - 3c + 2\theta + \theta] - \theta = \theta - c$, equivalent to the entire surplus generated by the manager's effort.

2.2 Moral Hazard Model 2

Consider instead a manager whose effort cannot be observed and who also observes privately the idiosyncratic project return η before deciding to exert effort. In this case the manager's decision is represented by $\hat{e} : H \to \{0, 1\}$ which maps observed η into the manager's effort decision. Otherwise, the model is the same as in Section 2.1.

Incentive compatibility constraints for the manager to exert effort at each state are given by:

$$x(3\theta) - c \geq x(2\theta) \text{ if } \hat{e}(\theta) = 1 \quad (1)$$

$$x(2\theta) - c \geq x(\theta) \text{ if } \hat{e}(0) = 1 \quad (2)$$

$$x(\theta) - c \geq x(0) \text{ if } \hat{e}(-\theta) = 1 \quad (3)$$

where $x(y)$ is the wage paid to the manager given observed output y and $\hat{e}(\eta)$ is the manager's decision contingent on observing shock η. Assuming limited liability on the manager, the manager can be induced to exert effort in each case so long as each additional θ observed output is compensated with an additional wage of at least c. This implies that efficient outcome can be induced by offering a wage schedule $x(3\theta) = 3c$, $x(2\theta) = 2c$, $x(\theta) = c$ and $x(0) = 0$. Note that in this model the manager earns information rents whereas she did not in the previous model, thereby reducing shareholder profits for a given θ.

3 Long-Term Projects

Consider now a sequence of managers who undertake a project. Manager 1 (she) faces an environment similar to the first moral hazard problem and Manager 2 (he) faces an environment similar to the second environment. Namely, Manager 1 undertakes projects and makes an effort choice ($\hat{e}_1$), not yet knowing the idiosyncratic project return, and then retires with the project still incomplete. Manager 2 then takes control of the project and observes the interim quality of the project following an idiosyncratic

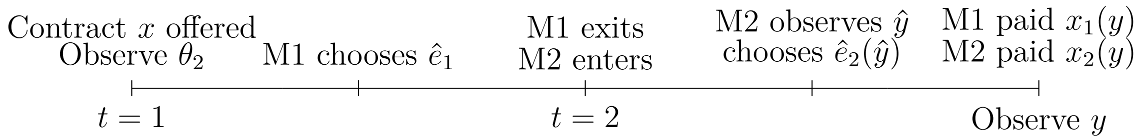

Figure 1: Long-Term Projects - Two Managers

project shock, η, before making an effort decision. Given Manager 1's decision, the Manager 2's environment is exactly that of Section 2.2. The timeline for the project is given by Figure 1.

As before, the gross return of the project is risky and can now take on values

$$y(\eta, \hat{e}_1, \hat{e}_2) = \theta + \theta\hat{e}_2(\hat{y}) + \theta\hat{e}_1 + \eta.$$

Again η is a random variable with, $\eta \in \{-\theta, 0, \theta\}$ and is uniformly distributed. For ease of notation, discounting is ignored.

Manager 2 makes his decision on whether to exert effort after observing a status report $\hat{y} = \theta + \theta\hat{e}_1 + \eta$. Given the different values of η and $\hat{e}_1$, Manager 2's decision is described by $\hat{e}_2(\hat{y}) : \{0, \theta, 2\theta, 3\theta\} \to \{0, 1\}$. Suppose that Manager 1 exerts effort, then the incentive compatibility constraints for Manager 2 at each realization of $\hat{y}$ are:

$$\begin{aligned}
(IC_{2,L}) \qquad x_2(4\theta) - c &\geq x_2(3\theta) \text{ if } \hat{e}_2(3\theta) = 1 \\
x_2(3\theta) - c &\geq x_2(2\theta) \text{ if } \hat{e}_2(2\theta) = 1 \\
x_2(2\theta) - c &\geq x_2(\theta) \text{ if } \hat{e}_2(\theta) = 1
\end{aligned}$$

where $x_2(y)$ is the wage paid to Manager 2 given observed output y and the inequalities must hold to induce effort in the θ, 0, and $-\theta$ cases, respectively.

To implement effort for all $\hat{y}$ (conditional on Manage 1 effort), the optimal wage contract offers $x_2(4\theta) = 3c$, $x_2(3\theta) = 2c$, $x_2(2\theta) = c$ and $x_2(y) = 0$ otherwise. To implement effort for each $\hat{y} \in \{2\theta, 3\theta\}$, the optimal wage contract offers $x_2(4\theta) = 2c$, $x_2(3\theta) = c$, $x_2(y) = 0$ otherwise. Finally, to implement effort for $\hat{y} = 3\theta$ the optimal wage contract offers $x_2(4\theta) = c$ and $x_2(y) = 0$ otherwise.[8]

For each of the cases above, Manager 1's incentive constraint can be written as:

$$
\begin{aligned}
(IC_{1,L}) \quad & \frac{1}{3}\left[x_1(y(\theta, 1, \hat{e}_2(3\theta))) + x_1(y(0, 1, \hat{e}_2(2\theta))) + x_1(y(-\theta, 1, \hat{e}_2(\theta)))\right] - c \\
& \geq \frac{1}{3}\left[x_1(y(\theta, 0, \hat{e}_2(2\theta))) + x_1(y(0, 0, \hat{e}_2(\theta))) + x_1(y(-\theta, 0, \hat{e}_2(0)))\right]
\end{aligned}
$$

where $x_1(y)$ is the wage paid to Manager 1 given observed output y and $\hat{e}_2(\cdot)$ is Manager 2's decision contingent on observing the status report $\hat{y}$. Note that the production function dictates that $y(\eta, 1, \hat{e}_2(\cdot)) = y(\eta + \theta, 0, \hat{e}_2(\cdot))$. Therefore, the above inequality reduces to:

$$x_1(y(\theta, 1, \hat{e}_2(3\theta))) - 3e \geq x_1(y(-\theta, 0, \hat{e}_2(0))).$$

This implies that as in Section 2.1, Manager 1 is evaluated only on the basis of whether or not the highest output ($y = 4\theta$, given that Manager 2 exerts effort in at least one state) is attained. Assuming limited liability, it follows that the optimal wage contract to Manager 1 offers $x_1(4\theta) = 3c$ and $x_1(y) = 0$ otherwise. Let $z^2(\bar{H}, y) = (z_1^2(\bar{H}, y), z_2^2(\bar{H}, y))$ denote the profit-maximizing wage contract offered to Manager 1 and Manager 2 given the set of states $\bar{H}$ on which shareholders intend to induce effort from Manager 2. Note that for $z^2(\bar{H}, y)$, the shareholders continue to observe only y and not the set of states $\bar{H}$, on which Manager 2 actually exerts effort. For example,

$$
z_1^2(\{0, \theta\}, y) = \left\{ \begin{array}{c|l} 3c & \text{if } y = 4\theta \\ 0 & \text{otherwise} \end{array} \right. , \quad z_2^2(\{0, \theta\}, y) = \left\{ \begin{array}{c|l} 2c & \text{if } y = 4\theta \\ c & \text{if } y = 3\theta \\ 0 & \text{otherwise} \end{array} \right.
$$

Thus, writing $x(y) = z^2(\{0, \theta\}, y)$ is simply the shorthand for saying that a contract x that specifies compensation according to $z^2(\{0, \theta\}, y)$ above.

[8] It is straightforward to show that for $\theta > c$, it is always optimal for Manager 1 to exert effort. This follows naturally from the fact that Manager 1's effort contributes θ to output at a cost c and, as in Section 2.1, Manager 1's rents can be driven to 0.

3.1 Optimal Contract

The optimal contract and the states for which the shareholders choose to induce effort from Manager 2 depend on the relationship between θ and c. The previous subsection demonstrated that conditional on inducing effort for three, two, and one states of η, shareholder profits are $2\theta - 3c$, $\frac{5}{3}\theta - 2c$, and $\frac{4}{3}\theta - \frac{4}{3}c$, respectively. This analysis yields the following:

Proposition 1. *The profit-maximizing contract implementing a long-term project can be written as*

$$x^*(\theta, y) = \begin{cases} z^2(\{-\theta, 0, \theta\}, y) & \theta \geq 3c \\ z^2(\{0, \theta\}, y) & 3c > \theta \geq 2c \\ z^2(\{\theta\}, y) & 2c > \theta \geq c \end{cases}$$

When $\theta \geq 3c$, the profit-maximizing contracts induces effort from Manager 2 for all values of $\hat{y}$ conditional on Manager 1 exerting effort. Meanwhile, when $3c > \theta \geq 2c$, the shareholders find it optimal to induce effort from Manager 2 only when $\hat{y} \in \{2\theta, 3\theta\}$, conditional on Manager 1 exerting effort. Finally, the profit-maximizing contract induces effort only if $\hat{y} = 3\theta$ when $2c > \theta \geq c$, conditional on Manager 1 exerting effort. These conditions can naturally be understood by analyzing the marginal revenue and marginal cost of inducing effort for an additional state. The marginal expected output of inducing effort in an additional state is $\frac{1}{3}\theta$. On the other hand, the marginal cost of inducing effort in another state is $\frac{1}{3}kc$, where k is the number of states on which Manager 2 is induced to take effort. This is because inducing effort for an additional realization of $\hat{y}$ requires that shareholders pay additional wages for other states $\hat{\hat{y}} \geq \hat{y}$ to maintain incentives at $\hat{\hat{y}}$.

Shareholder profits can be written as:

$$\pi_2(\theta) = \begin{cases} 2\theta - 3c & \theta \geq 3c \\ \frac{5}{3}\theta - 2c & 3c > \theta \geq 2c \\ \frac{4}{3}\theta - \frac{4}{3}c & 2c > \theta \geq c \end{cases}$$

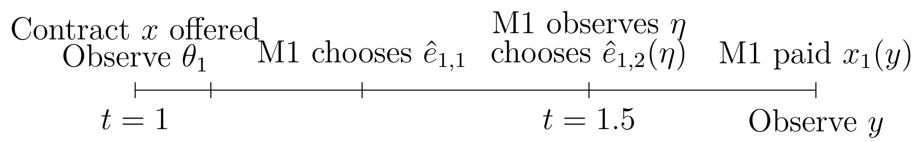

Figure 2: Short-Term Projects - One Manager

Notice that as in Section 2.1, the Manager 1's surplus is again 0 as she exerts effort and earns a wage $x_1(4\theta) = 3c$ with probability of 1/3. Depending on the number of states η on which Manager 2 is induced to exert effort, he earns information rents consistent with those in the model of Section 2.2.

4 Short-Term Projects

In this section, the paper considers an identical setup to the previous section, except that the setup takes place under a single manager's tenure, whose timeline is represented by Figure 2.

To what extent are the results above the consequence of project structure rather than management structure? Suppose a single manager controls the project from beginning to end, making an effort choice at time period 1 before the realization of η and again at time period 2 after the realization of η. The effort choice in Period 1 is represented by $\hat{e}_{1,1} \in \{0, 1\}$ while the effort choice[9] in Period 2 is represented by $\hat{e}_{1,2}(\hat{y}) : \{0, \theta, 2\theta, 3\theta\} \to \{0, 1\}$. Output is given by

$$y(\eta, \hat{e}_{1,1}, \hat{e}_{1,2}(\hat{y})) = \theta + \theta\hat{e}_{1,2}(\hat{y}) + \theta\hat{e}_{1,1} + \eta.$$

Using subgame perfection as an equilibrium concept, conditional on his initial effort decision, Manager 1's incentive compatibility constraints after observing η are given

[9] Assuming perfect recall, Manager 1's strategy is a function of his Period 1 choice $\hat{e}_{1,1}$ and η rather than their sum. However, as noted later, subgame perfection implies that his Period 2 decision depends only on the sum.

by:

$$
\begin{aligned}
(IC_{2,S}) \quad x_1(4\theta) - c &\geq x_1(3\theta) \text{ if } \hat{e}_{1,2}(3\theta) = 1 \\
x_1(3\theta) - c &\geq x_1(2\theta) \text{ if } \hat{e}_{1,2}(2\theta) = 1 \\
x_1(2\theta) - c &\geq x_1(\theta) \text{ if } \hat{e}_{1,2}(\theta) = 1 \\
x_1(\theta) - c &\geq x_1(0) \text{ if } \hat{e}_{1,2}(0) = 1
\end{aligned}
$$

where $x_1(\cdot)$ is the wage schedule for the manager and $\hat{e}_{1,2}$ is the manager's decision to exert effort in Period 2.

Given a wage schedule x_1, the manager's optimal decision in Period 2 will be independent of his decision in Period 1. In particular, she will exert effort if and only if the appropriate constraint above is satisfied. Given her optimal decision in Period 2, we evaluate the necessary and sufficient condition for the manager to exert effort in Period 1.

$$
\begin{aligned}
(IC_{1,S}) \quad \mathbf{E}\left[x_1(y) - c\hat{e}_{1,2}(\hat{y}(\eta,1))|\hat{e}_{1,1} = 1\right] - c &\geq \mathbf{E}\left[x_1(y) - c\hat{e}_{1,2}(\hat{y}(\eta,0))|\hat{e}_{1,1} = 0\right] \\
\mathbf{E}\left[x_1(y) - c\hat{e}_{1,2}(\hat{y}(\eta,1))|\hat{e}_{1,1} = 1\right] &= \frac{1}{3}\left[x_1(y(\theta,1,\hat{e}_{1,2}(3\theta))) + x_1(y(0,1,\hat{e}_{1,2}(2\theta))\right. \\
&\quad \left. + x_1(y(-\theta,1,\hat{e}_{1,2}(\theta)) - c(\hat{e}_{1,2}(3\theta) + \hat{e}_{1,2}(2\theta) + \hat{e}_{1,2}(\theta))\right] \\
\mathbf{E}\left[x_1(y) - c\hat{e}_{1,2}(\hat{y}(\eta,0))|\hat{e}_{1,1} = 0\right] &= \frac{1}{3}\left[x_1(y(\theta,0,\hat{e}_{1,2}(2\theta))) + x_1(y(0,0,\hat{e}_{1,2}(\theta)))\right. \\
&\quad \left. + x_1(y(-\theta,0,\hat{e}_{1,2}(0))) - c(\hat{e}_{1,2}(2\theta) + \hat{e}_{1,2}(\theta) + \hat{e}_{1,2}(0))\right]
\end{aligned}
$$

Note that for $\eta \in \{-\theta, 0\}$ and for any value of $\hat{y}$, it is the case that $y(\eta, 1, \hat{e}_{1,1}(\hat{y})) = y(\eta + \theta, 0, \hat{e}_{1,1}(\hat{y}))$. From the above inequality, it is clear that Period 1 effort can be induced so long as $x_1(y(\theta, 1, \hat{e}_{1,2}(3\theta))) \geq 3c + c\hat{e}_{1,2}(3\theta)$. This arises from the fact that the manager can best signal effort through an observation of high output. Thus, it is most efficient to reward effort in this case and no other, giving rise to the $3c$ term. Additionally, the optimal contract must prevent against a "double" deviation in which Manager 1 chooses to shirk in Period 1 and then again in Period 2. Assuming that it is optimal to induce effort for at least one state (which without loss of generality is assumed to be $\eta = \theta$), the ability of the manager to jointly deviate requires that he be further compensated by c in the high output case. This implies that the optimal contract requires $x_1(4\theta) = 4c$.

Given $x_1(4\theta) = 4c$ and the incentive compatibility conditions for Period 2, the optimal wage schedule conditional on inducing output in all three states is $x_1(4\theta) = 4c$, $x_1(3\theta) = 2c$, $x_1(2\theta) = c$ and $x(y) = 0$ otherwise. To induce effort only in the medium and high state, the optimal wage schedule is $x_1(4\theta) = 4c$, $x_1(3\theta) = c$, and $x(y) = 0$ otherwise. The optimal wage schedule conditional on inducing effort only when $\eta = \theta$ is given by $x_1(4\theta) = 4c$ and $x(y) = 0$ otherwise. Note that in providing Period 1 incentives, the incentive constraints to induce effort for $\eta = \theta$ are relaxed and non-binding. Let $z_1^1(\bar{H}, y)$ denote the profit-maximizing wage contract offered to Manager 1 conditional on inducing effort for states $\bar{H} \subseteq H$. For example,

$$z_1^1(\{0,\theta\}, y) = \begin{cases} 4c & \text{if } y = 4\theta \\ c & \text{if } y = 3\theta \\ 0 & \text{otherwise} \end{cases}$$

4.1 Optimal Contract

Shareholder profits from inducing effort for three, two, and one states of η are then $2\theta - \frac{7}{3}c$, $\frac{5}{3}\theta - \frac{5}{3}c$, and $\frac{4}{3}\theta - \frac{4}{3}c$, respectively. Note that the shareholder profits are never maximized by inducing effort for just one state. This analysis leads to the following:

Proposition 2. *The profit-maximizing contract for implementing short-term projects can be written as*

$$x^*(\theta, y) = \begin{cases} z^1(\{-\theta, 0, \theta\}, y) & \theta \geq 2c \\ z^1(\{0, \theta\}, y) & c < \theta < 2c \end{cases}$$

The profits of the firm can be written as:

$$\pi_1(\theta) = \left\{ \begin{array}{l|l} 2\theta - \frac{7}{3}c & \theta \geq 2c \\ \frac{5}{3}\theta - \frac{5}{3}c & 2c > \theta \geq c \end{array} \right.$$

In this case, the optimal contract always features inducing effort whenever $\eta \in \{0, \theta\}$ and features effort in all three cases when θ is sufficiently large.

Notice that the Manager 1's surplus is greater than 0 if effort is exerted for all η and zero otherwise. In the case where effort is exerted for all states, she exerts effort of $2c$ across the two periods and earns wages of $\frac{1}{3}[4c+2c+c] = \frac{7}{3}c$ for an expected surplus of $\frac{1}{3}c$. However, in the case where effort is exerted only for $\eta \in \{0, \theta\}$, her expected cost of effort are $c + \frac{2}{3}c$ from exerting effort in Period 1 and in two states of Period 2. This is exactly her expected wage $\frac{1}{3}[4c + c]$ yielding 0 surplus.

5 Profits Under Long-Term and Short-Term Projects

Consider a situation in which the firm is two-period lived and managers work for one period. Let *short-term* projects have return θ_1 and *long-term* projects have return θ_2. Short-term projects are as described in Section 4 with effort costs given by $\frac{c}{2}$ and returns given by $\frac{\theta_1}{2}$. Short-term projects are compressed so that they occur over one period and are implemented in Period 1 by Manager 1 and again in Period 2 by Manager 2. Expected profits from implementing consecutive short-term projects are therefore the same scale as the previous analysis. Long-term projects occur over two periods and are as described in Section 3. Short-term project returns are perfectly correlated across periods so that cumulative returns for consecutive short-term projects are given by θ_1. Assume no discounting and mutually exclusive projects. Together, these assumptions imply that without information frictions (i.e., in the first-best case), short-term projects are more profitable than long-term projects if and only if $\theta_2 < \theta_1$.

If the shareholders can observe both projects, then what returns must the long-term project yield for the shareholders to prefer it over two short-term projects? Comparing the profits across long-term and short-term projects immediately yields the following

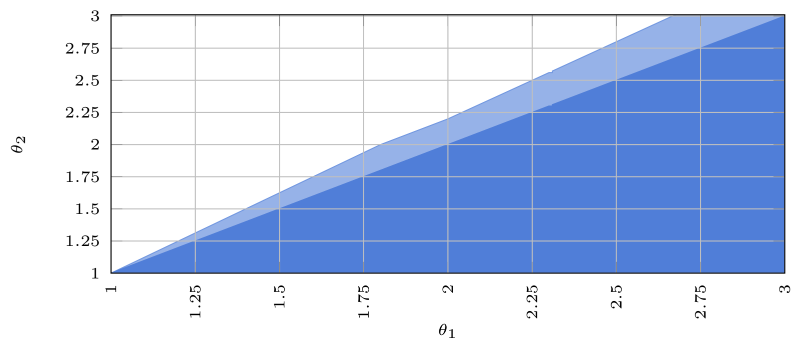

Figure 3: Short-Term/Long-Term Project Selection With Observable θ

proposition:

Proposition 3. *Shareholders prefer long-term projects to short-term projects if and only if:*

$$\theta_2 \geq f(\theta_1) \equiv \begin{cases} \frac{5}{4}\theta_1 - \frac{1}{4}c & \frac{9}{5}c > \theta_1 \geq c \\ \theta_1 + \frac{1}{5}c & 2c > \theta_1 \geq \frac{9}{5}c \\ \frac{6}{5}\theta_1 - \frac{1}{5}c & \frac{8}{3}c > \theta_1 \geq 2c \\ \theta_1 + \frac{1}{3}c & \theta_1 \geq \frac{8}{3}c \end{cases}$$

What does this imply about the relative returns of projects? Figure 3 shows the relative profitability of long- and short-term projects for different values of θ_1 and θ_2. For $\theta_1 < c$ ($\theta_2 < c$), the short-term project (long-term project) would not be taken in the first-best case, and we focus only on the case where returns are sufficient to justify the project. The darker region is bounded above by the 45^0 line. Therefore, in the dark region the short-term project would be chosen in the first-best case and the shareholders direct managers to take short-term projects in this case as well.

Above the dark region the long-term projects would be chosen in the first-best case. However, the incentive conflict of long-term projects results in reduced profits for shareholders relative to the short-term project case. Consequently, the lightly shaded region reflects the set of values for which $\theta_2 > \theta_1$ and yet the shareholder prefers that the initial manager choose the short-term project.

The premium required on long-term projects can be significant. Clearly, when

$\theta_1 = c$, the short-term project is not profitable even in the first-best case. Because the shareholders can always extract some profit from long-term projects when $\theta_2 > c$, no premium is necessary for the selection of long-term projects.

However, as short-term projects become profitable, long-term projects can be chosen only when they can be undertaken at a premium. The additional return necessary for long-term projects to be chosen increases to over 10 percent as the shorter-term projects enable shareholders to capture a larger proportion of a smaller surplus.

6 Project Selection Under Asymmetric Information

The previous section discussed profits and induced project selection when shareholders could observe all projects available to Manager 1. This section evaluates the nature of the optimal contract when shareholders can only observe the quality of projects chosen and not those that are turned down.

At the beginning of Period 1, Manager 1 learns the returns of the short-term and long-term projects, θ_1 and θ_2. Shareholders, however, only learn the return of the project that is ultimately chosen. This creates an additional layer of agency problems. As in Section 3, all of the information rents in the long-term project are obtained by Manager 2. From Manager 1's standpoint, this places a strong incentive to choose shorter-term projects where she earns the information rents, as in Section 4. Therefore, to induce Manager 1 to select long-term projects, shareholders must increase Manager 1's rents for long-term projects or decrease them for short-term projects.

Assume for the remainder of the paper that $(\theta_1, \theta_2) \sim F(\cdot) \equiv U([c, 3c] \times [c, 3c])$. Note that the upper bound on θ_2 implies that it is never optimal to induce effort for all η under long-term projects. While a uniform distribution is necessary for computation of the optimal contract, the structure of the contract does not depend on this assumption. In particular, Lemmas 3 and 4 hold even with a more general distribution of returns.

6.1 The Shareholder's Problem

In addition to her effort decisions conditional on long- and short-term project selection—as described in Sections 3 and 4—Manager 1 must also select a project. This choice was trivial when returns of both projects could be observed, as shareholders essentially chose the project after observing the quality of both long-term and short-term projects. In the case of asymmetric information of project quality, Manager 1 observes $(\theta_1, \theta_2) = \theta \in \Theta_1 \times \Theta_2$ and makes a project decision. The project decision is represented by $d : \Theta_1 \times \Theta_2 \to \{1, 2\}$, mapping observed project returns into a choice of project, where 1 denotes short-term project selection and 2 denotes long-term project selection. For simplicity, the paper assumes that any contract that implements a short-term project written for Manager 1 is the exact same as is offered to Manager 2. Assume further that all variables are scaled down by half for short-term projects relative to long-term projects. This implies that two short-term projects are directly comparable to one long-term project.[10] Let $x = (x_1, x_2)$ denote a contract, with $x_t : Y \times \Theta \times \{1, 2\} \to \mathbb{R}_+$ for $t = 1, 2$ being the wage schedule for Manager t and where $Y \equiv \{0, \theta, 2\theta, 3\theta, 4\theta\}$. In contrast to the problem in Section 5, the contract now specifies payment to each manager contingent on the public observation of output, the return of the project chosen, and whether the project chosen was short term or long term. Assuming pure strategies, the shareholder problem can be written as:

[10] Because this paper studies the different incentives between intergenerational and intergenerational contracts, the elements of the model that are a direct result of the two period finite-time horizon are held constant to the extent possible. As Manager 2 makes no project decision, the ability to contract differently with him would quantitatively alter the results. In particular, the assumption forces shareholders to satisfy the PS constraint below for Manager 2 even though the environment dictates that this constraint should exist only for Manager 1. Nevertheless, removing this restriction should not affect the qualitative results.

$$\max_{x,d,\hat{e}_1,\hat{e}_2,\hat{e}_{1,1},\hat{e}_{1,2}} \frac{1}{3}\sum_{\eta}\int_{\theta|d(\theta)=S}[y(\eta,\hat{e}_{1,1},\hat{e}_{1,2}(\eta)) - x_1(y(\cdot),\theta_1,1)]\,dF(\theta)$$

$$+\frac{1}{3}\sum_{\eta}\int_{\theta|d(\theta)=L}[y(\eta,\hat{e}_1,\hat{e}_2(\eta)) - x_1(y(\cdot),\theta_2,2) - x_2(y(\cdot),\theta_2,2)]\,dF(\theta)$$

$$\text{s.t. } (PS_S) \quad \frac{1}{2}\frac{1}{3}\sum_{\eta}[x_1(y(\cdot),\theta_1,1) - c\hat{e}_{1,1} - c\hat{e}_{1,2}(\eta)] \geq \frac{1}{3}\sum_{\eta}[x_1(y(\cdot),\theta_2,1) - c\hat{e}_1] \text{ if } d=1$$

$$(PS_L) \quad \frac{1}{2}\frac{1}{3}\sum_{\eta}[x_1(y(\cdot),\theta_1,1) - c\hat{e}_{1,1} - c\hat{e}_{1,2}(\eta)] \leq \frac{1}{3}\sum_{\eta}[x_1(y(\cdot),\theta_2,2) - c\hat{e}_1] \text{ if } d=2$$

$IC_{1,S}$ hold if $d = 1$

$IC_{2,S}$ hold if $d = 1$

$IC_{1,L}$ hold if $d = 2$

$IC_{2,L}$ hold if $d = 2$

The Project Selection (PS) constraints dictate that faced with $\theta = (\theta_1, \theta_2)$, Manager 1 must earn her maximum expected surplus from choosing $d(\theta)$. The incentive compatibility constraints are the usual conditions that guarantee that effort is chosen when the contract requires it. The objective function is the shareholders' expected profits.

The following lemma states that the optimal contract can be divided into two components: a fixed wage and a performance bonus. The performance bonus is structured to induce effort in the same way that compensation induced effort from the previous sections. Meanwhile, the fixed wage component exists to induce Manager 1 to choose the desired contract. Thus, we can think of the performance bonus component of pay as being the portion used to satisfy the IC constraints, while the fixed wage component is the portion used to satisfy the PS constraints. Consequently, conditional on the states η for which effort is induced and the project chosen, the contracts are identical to that of the earlier sections up to a constant.

Lemma 1. *For a given θ and d, suppose that the optimal contract x^* induces effort for $\bar{H}$. Then, there is an equally profitable contract x^{**} in which $x_1^{**}(y, \theta_{d(\theta)}, d(\theta)) =$*

$z_1^{d(\theta)}(y, \theta_{d(\theta)}, d(\theta)) + w(d(\theta), \theta_{d(\theta)})$ *for some* w *and all* y.

Proof. From Sections 3 and 4, we know that when θ is observable, profit maximization conditional on inducing effort for states $\bar{H}$ is given by $z^{d(\theta)}$. Conditional on θ, the constraints in this environment are identical to that of the case of perfectly observable with the exception of the PS constraints. Let $w = \mathbf{E}[x_1^*(\cdot) - z_1^{d(\theta)}(\cdot)]$ denote the difference in expected wage between the optimal contract and $z_1^{d(\theta)}$, noting that Manager 1's effort choices are identical by assumption. This implies that if the PS constraints held under x^*, they continue to hold. The construction of $z_1^{d(\theta)}$ also implies that IC constraints hold and profits are at a maximum. □

The following lemmas establishes that a fixed wage (w from the previous lemma) is offered only when the long-term projects is selected and is equal to $w = \frac{1}{6}c$, if offered. The logic for this is as follows. Conditional on the type of project selection decision and the states on which effort is exerted after observing η, incentives are provided most cheaply by the z^1 and z^2 given implementation of short- and long-term projects, respectively. Manager 1 earns information rents from these contracts if and only if $z^1(H)$ is offered. Therefore, the profit-maximizing contract should offer a fixed wage w to Manager 1 only in the case where shareholders wish to induce long-term project selection over some θ_1 where $z^1(H)$ is offered. Furthermore, because Manager 1 can never earn information rents greater than $\frac{1}{6}c$, it is never optimal to offer a wage greater than this value.

Lemma 2. $w > 0$ *only for long-term projects and effort is induced for all* $\eta \in \{0, \theta\}$. *Furthermore, if* $w > 0$ *then* $w = \frac{1}{6}c$.

Given the previous lemmas, this paper now shows that conditional on short-term project selection, the number of effort states is (weakly) increasing with the return of the project.

Lemma 3. *If the optimal contract induces effort for all* η *when a short-term project of* θ_1' *is chosen then for all* $\theta_1'' > \theta_1$, *it also induces effort for all* η.

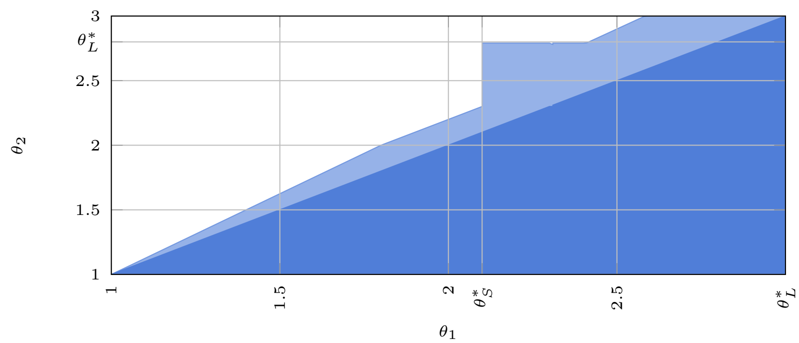

Figure 4: Short-Term/Long-Term Project Selection With Unobservable θ for Given Values of θ_S^* and θ_L^*

All omitted proofs appear in the appendix.

Furthermore, the paper shows that Manager 1's rents on long-term projects are also weakly increasing in the return of long-term projects.

Lemma 4. *If shareholders pay Manager 1 in part through fixed wage (i.e.* $\mathbf{E}[x_1] > 3c$*) for* θ_2'*, then they also pay Manager 1 in part through a fixed wage for any* $\theta_2'' > \theta_2'$*.*

Given Lemmas 3 and 4, the optimal contract amounts to choosing a θ_S^* and θ_L^*. This project-selection decision induced by the contract is represented by Figure 4, with the white region representing the duples (θ_1, θ_2) for which long-term projects are chosen. The first term, θ_S^*, represents the minimum θ_1 such that the manager chooses to induce effort for all realizations of η. This value is of critical importance because it marks the region in which Manager 1 earns information rents. The second term, θ_L^*, represents the minimum value of θ_2 such that the shareholders pay rents to Manager 1 for long-term projects. In paying rents to Manager 1, the shareholders make Manager 1 indifferent between selecting a long-term project and a short-term project in which effort is induced for all η. As before, in the first-best case the short-term project is selected if and only if returns are such that (θ_1, θ_2) lies in the dark region.

Lemma 5. *In the optimal contract, short-term projects are chosen whenever* $\theta_1 \geq \frac{31}{12}e$ *and effort is induced for all* η*.*

Consequently, when choosing between a long-term project of return θ_2 and a short-term project in which effort is induced for each realization of η, Manager 1 must be given additional compensation to be induced to choose the long-term project. Suppose that for some $\hat{\theta}_2$, the shareholders wish to induce the manager to select the long-term project even for some states in which short-term projects yield information rents to the manager. Let $\hat{\Theta}_2$ be the set of all $\hat{\theta}_2$ for which there is some short-term $\hat{\theta}_1 > 2c$ such that a manager confronted with $(\hat{\theta}_1, \hat{\theta}_2)$ will choose the long-term project. For this to be the case, it must be that the conditional output to the shareholders is $\pi(\hat{\theta}_2) = \frac{5}{3}\hat{\theta}_2 - 2c - \frac{1}{6}c$, where the last term represents the fixed compensation to the manager necessary to induce him to choose the long-term project from Lemma 2. Because only the return of the long-term project is observed, this return must be independent of the short-term return.

Given the fixed wage associated with any $\hat{\theta}_2 \in \hat{\Theta}$, managers will strictly prefer long-term projects whenever $\theta_1 \leq \theta_S^*$ and will be indifferent otherwise. Consequently, for any $\hat{\theta}_2 \in \hat{\Theta}$, the shareholders will induce whichever project yields the greater return. The additional wage payment associated with long-term projects implies that shareholders prefer long-term projects if and only if:

$$
\begin{aligned}
2\theta_1 - \frac{7}{3}c &\leq \frac{5}{3}\hat{\theta}_2 - \frac{13}{6}c && (4)\\
\Rightarrow \theta_1 &\leq \frac{5}{6}\hat{\theta}_2 + \frac{1}{12}c. && (5)
\end{aligned}
$$

The fixed compensation component necessary for inducing a manager to select a profitable long-term project has the negative consequence of requiring wage payments to a manager even when the short-term project was not sufficiently high for the manager to earn information rents. In particular, when $\theta_1 < \theta_S^*$, Manager 1 cannot earn rents in choosing a short-term project. However, because the shareholders cannot observe the return of projects not selected, even such a manager would receive these rents of $\frac{1}{6}c$ if choosing the long-term project.

Alternatively, for $\theta_2 \notin \hat{\Theta}$, it is impossible to induce a Manager 1 with a high-return short-term project to choose a long-term project, even if such a project would be preferable in the case when the returns are perfectly observed by all parties. In

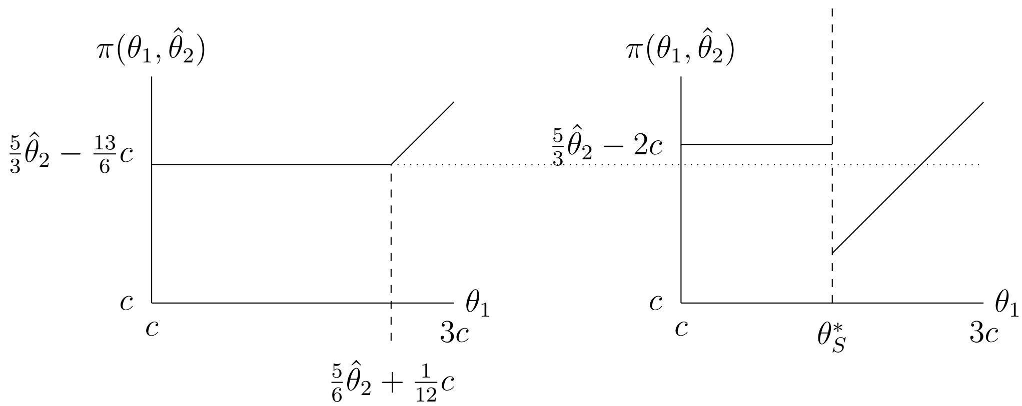

Figure 5: Shareholder Profits for Given $\hat{\theta}_2$

this case, Manager 1 will select short-term projects whenever $\theta_1 \geq \theta_S^*$ and is indifferent between short-term projects and long-term projects otherwise.

Figure 5 makes clear the costs and benefits associated with allowing for more long-term project selection. Consider a fixed θ_S^* so that Manager 1 earns information rents when $\theta_1 \geq \theta_S^*$. The left graph depicts profits for a given $\hat{\theta}_2$ and different possible short-term returns when shareholders offer a fixed wage to induce long-term project selection. The right graph similarly depicts profits when shareholders provide no incentives to select long-term projects. By offering a fixed wage for long-term project selection, shareholders earn lower profits (by $\frac{1}{12}c$) when the long-term project is selected. That is, when $\theta_1 < \theta_S^*$. However, when $\frac{5}{6}\hat{\theta}_2 + \frac{1}{12}c > \theta_1 > \theta_S^*$, Manager 1 chooses the more profitable long-term project when the fixed wage component is offered. When $\theta_1 > \frac{5}{6}\hat{\theta}_2 + \frac{1}{12}c$, short-term projects are more profitable than long-term projects whether or not the fixed wage is offered. In the left graph, Manager 1 is indifferent between projects and is willing to choose whichever is more profitable to shareholders. In the case where without the fixed wage (right graph), Manager 2 continues to choose the surplus maximizing short-term project. Together, the decision by shareholders to offer compensation for choosing long-term projects depends on the tradeoff between lower profits conditional on long-term project selection versus more frequent high-return long-term project selection.

Figure 6 demonstrates the tradeoff between inducing effort for all η versus $\eta \in \{0, \theta\}$

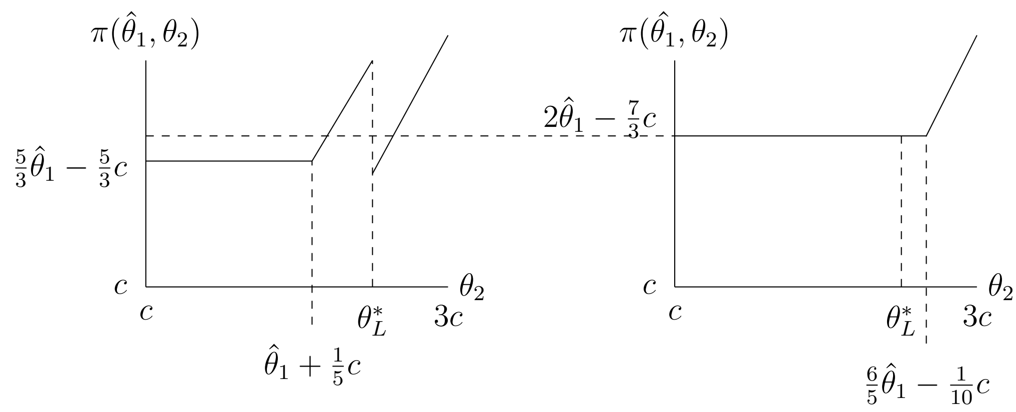

Figure 6: Shareholder Profits for Given $\hat{\theta}_1$

for a given $\hat{\theta}_1 > 2c$ and a fixed θ_L^*. The left graph depicts the profits for varying levels of θ_2 from inducing effort for $\eta \in \{0, \theta\}$, while the right graph similarly depicts profits conditional on inducing effort in all states. From Section 5 we know that conditional on choosing the short-term project with return $\hat{\theta}_1$, the shareholders' profits are higher when effort is induced for all η ($\pi = 2\hat{\theta}_1 - \frac{7}{3}c$) than when effort is induced on the smaller set of η ($\pi = \frac{5}{3}\theta_1 - \frac{5}{3}c$). In the case where effort is induced for all η, Manager 1 earns a surplus of $\frac{1}{6}c$. Consequently whenever $\theta_2 > \theta_L^*$, shareholders can trivially induce Manager 1 to choose the more profitable of the short-term and long-term projects because the Manager 1 earns equal surplus in the two cases. In this case, long-term projects are more profitable when $\theta_2 > \frac{6}{5}\hat{\theta}_1 - \frac{1}{10}c$. On the other hand, when $\theta_2 > \theta_L^*$ and effort is not induced in all states, Manager 1 earns surplus only from long-term projects and will choose them accordingly. When $\theta_2 < \theta_L^*$ and effort is induced for all η, Manager 1 will always choose the short-term project as long-term projects yield him no surplus. This holds even though long-term projects may be more profitable (e.g. for values of θ_2 just below θ_L^*). Conversely, when effort is not induced on all states, Manager 1 earns 0 surplus for both long- and short-term projects whenever $\theta_2 < \theta_L^*$, and is willing to induce whichever is more profitable to the shareholders. In this case, long-term projects are more profitable when $\theta_2 > \hat{\theta}_1 + \frac{1}{5}c$.

6.2 Shareholder Profits

Given Figure 6 the expression for shareholder profits can be derived by integrating over the $\theta_1 \times \theta_2$ space. Thus, the expression for shareholder profits from the contract can be written as:

$$\begin{aligned}
\pi &= \frac{6}{5}c\int_{\theta_S^*}^{3e}\left[2\theta_1-\frac{7}{3}c\right]d\theta_1+\frac{6}{5}c\int_{2c}^{\theta_S^*}\left[\frac{5}{3}\theta_1-\frac{5}{3}c\right]d\theta_1+\\
&\quad c\int_{\frac{11}{5}c}^{\theta_L^*}\left[\frac{5}{3}\theta_2-2c\right]d\theta_2+c\int_{\theta_L^*}^{3c}\left[\frac{5}{3}\theta_2-\frac{13}{6}c\right]d\theta_2+\\
&\quad \int_{2c}^{\theta_S^*}\int_{2c}^{\theta_1}\left[\frac{5}{3}\theta_1-\frac{5}{3}c\right]d\theta_2 d\theta_1+\int_{\frac{11}{5}c}^{\theta_S^*+\frac{1}{5}c}\int_{\frac{11}{5}c}^{\theta_2}\left[\frac{5}{3}\theta_2-2c\right]d\theta_1 d\theta_2+\\
&\quad \left(\frac{5}{6}\theta_L^*-\frac{23}{12}c\right)\int_{\theta_L^*}^{3c}\left[\frac{5}{3}\theta_2-\frac{13}{6}c\right]d\theta_2+(\theta_S^*-2c)\int_{\theta_S^*+\frac{1}{5}c}^{\theta_L^*}\left[\frac{5}{3}\theta_2-2c\right]d\theta_2\\
&\quad \int_{\theta_L^*}^{3c}\int_{\frac{5}{6}\theta_L^*+\frac{1}{12}c}^{\frac{5}{6}\theta_2+\frac{1}{12}c}\left[\frac{5}{3}\theta_L-\frac{13}{6}c\right]d\theta_1 d\theta_2+\int_{\frac{5}{6}\theta_L^*+\frac{1}{12}c}^{\frac{31}{12}c}\int_{\theta_L^*}^{\frac{6}{5}\theta_1-\frac{1}{10}c}\left[2\theta_1-\frac{7}{3}c\right]d\theta_2 d\theta_1+\\
&\quad \left(\theta_L^*-\frac{11}{5}\right)\int_{\theta_S^*}^{\frac{31}{12}c}\left[2\theta_1-\frac{7}{3}c\right]d\theta_1+K
\end{aligned}$$

where K is a constant independent of the choice of θ_L^* and θ_S^*. In particular, K represents profits where $\theta_2 \le \frac{11}{5}c$ and $\theta_1 \le 2c$ plus the profits where $\theta_1 \ge \frac{31}{12}c$. These regions correspond to the portion on which the short-term profits are sufficiently high so that the short-term project will be chosen independently of the long-term return. Formally:

$$\begin{aligned}
K &= 2c\int_{\frac{31}{12}c}^{3c}\left[2\theta_1-\frac{7}{3}c\right]d\theta_1+\\
&\quad \int_{c}^{2c}\int_{c}^{f(\theta_1)}\pi_1(\theta_1)d\theta_2 d\theta_1+\int_{c}^{\frac{11}{5}c}\int_{c}^{f^{-1}(\theta_2)}\pi_2(\theta_2)d\theta_1 d\theta_2
\end{aligned}$$

The necessary (but not sufficient) first-order conditions for θ_S^* and θ_L^* for an interior solution are given by the following.

$$
\begin{aligned}
\frac{\partial \pi}{\partial \theta_S^*} &= -\frac{6}{5}c\left[2\theta_S^* - \frac{7}{3}c\right] + \frac{6}{5}c\left[\frac{5}{3}\theta_S^* - \frac{5}{3}c\right] + \left(\frac{5}{3}\theta_S^* - \frac{5}{3}c\right)(\theta_S^* - 2c) + \\
&\quad \frac{5}{3}\left(\theta_S^* - \frac{9}{5}c\right)(\theta_S^* - 2c) - \left(\theta_L^* - \frac{11}{5}c\right)\left(2\theta_S^* - \frac{7}{3}c\right) + \frac{5}{6}\left[(\theta_L^*)^2 - \left(\theta_S^* + \frac{1}{5}c\right)^2\right] \\
&\quad -2e\left(\theta_L^* - \theta_S^* - \frac{1}{5}c\right) - (\theta_S^* - 2c)\left(\frac{5}{3}\left(\theta_S^* + \frac{1}{5}c\right) - 2c\right) \\
&= \frac{5}{6}\theta_S^{*2} + \left(\frac{2}{3}c - 2\theta_L^*\right)\theta_S^* + \frac{5}{6}\theta_L^{*2} + \frac{1}{3}\theta_L^* c - \frac{19}{30}c^2 = 0 \qquad (6)
\end{aligned}
$$

Similarly for θ_L^*:

$$
\begin{aligned}
\frac{\partial \pi}{\partial \theta_L^*} &= c\left(\frac{5}{3}\theta_L^* - 2c\right) + c\left(\frac{5}{3}\theta_L^* - \frac{13}{6}c\right) - \left(\frac{5}{6}\theta_L^* - \frac{23}{12}c\right)\left(\frac{5}{3}\theta_L^* - \frac{13}{6}c\right) \\
&\quad + \left(-\theta_L^{*2} + \frac{7}{3}\theta_L^* c + \frac{31}{48}c^2\right) - \frac{5}{6}\left(\frac{5}{6}\left(9c^2 - \theta_L^{*2}\right) - \frac{13}{6}c\,(3c - \theta_L^*)\right) \\
&\quad - \left(2\left(\frac{31}{12}c\right)^2 - \left(\frac{5}{6}\theta_L^* + \frac{1}{12}c\right)^2 - \frac{7}{3}c\left(\frac{5}{2}c - \frac{5}{6}\theta_L^*\right)\right) + (\theta_S^* - 2c)\left(\frac{5}{3}\theta_L^* - 2c\right) \\
&= -\theta_S^{*2} + \frac{1}{3}\left(5\theta_L^* + c\right)\theta_S^* - \frac{25}{36}\theta_L^{*2} - \frac{5}{36}\theta_L^* c - \frac{25}{144}c^2 = 0 \qquad (7)
\end{aligned}
$$

Note that $\frac{\partial^3 \pi}{\partial \theta_S^{*3}} > 0$ while $\frac{\partial^3 \pi}{\partial \theta_L^{*3}} < 0$. This implies that if there is an interior solution, it must be the smaller value of θ_S^*, satisfying Equation 6 while it must be the larger value of θ_L^* satisfying Equation 7. This immediate leads to the following.

Lemma 6. *If in the profit-maximizing contract $\theta_S^* \in (2c, 3c)$, then*

$$
\theta_S^* = \phi_S(\theta_L^*) \equiv \frac{\left(2\theta_L^* - \frac{2}{3}c\right) - \sqrt{\left(2\theta_L^* - \frac{2}{3}c\right)^2 - \frac{10}{3}\left(\frac{5}{6}\theta_L^{*2} + \frac{1}{3}\theta_L^* c - \frac{19}{30}c^2\right)}}{\frac{5}{3}}
$$

If in the profit-maximizing contract $\theta_L^* \in (\frac{11}{5}c, 3c)$, then

$$
\theta_L^* = \phi_L(\theta_S^*) \equiv \frac{-\left(\frac{5}{36}c - \frac{5}{3}\theta_S^*\right) + \sqrt{\left(\frac{5}{36}c - \frac{5}{3}\theta_S^*\right)^2 - \frac{25}{9}\left(\theta_S^{*2} - \frac{1}{3}\theta_S^* c + \frac{25}{144}c^2\right)}}{\frac{25}{18}}
$$

6.3 Optimal Contract

Given the previous lemmas, we are now able to characterize the profit-maximizing contract and the project selection decision induced by the contract. In the profit-maximizing contract, the shareholders never offer a fixed wage to Manager 1 for selection of a long-term project. Therefore, Manager 1 always chooses the short-term project when doing so enables her to capture any positive surplus. This occurs whenever the contract induces effort for all realizations of η, which is true by definition whenever $\theta_1 \geq \theta_S^*$. Otherwise, Manager 1 earns zero rents and is indifferent between choosing long-term and short-term projects and chooses whichever yields the highest profits to shareholders.

Proposition 4. *The profit-maximizing contract can be written as the following, where*[11]*:*

$$x^*(y,\theta,d) = \begin{cases} z^1(\{-\theta,0,\theta\},y) & \text{if } d=1 \text{ and } \theta \geq \theta_S^* \\ z^1(\{0,\theta\},y) & \text{if } d=1 \text{ and } \theta_S^* > \theta > 2c \\ z^1(\{\theta\},y) & \text{if } d=1 \text{ and } \theta < 2c \\ z^2(\{0,\theta\},y) & \text{if } d=2 \text{ and } \theta_2 > 2c \\ z^2(\{\theta\},y) & \text{if } d=2 \text{ and } \theta_2 <= 2c \end{cases}$$

Meanwhile, Manager 1's decision rule is given by:

$$d(\theta_1,\theta_2) = \begin{cases} 1 & \text{if } \theta_1 > \theta_S^* \text{ or } \theta_1 \geq \max\left\{\theta_2 - \frac{1}{5}c, \frac{4}{5}\theta_2 + \frac{1}{5}c\right\} \\ 2 & \text{otherwise} \end{cases}$$

The project selection induced by the profit-maximizing contract is summarized in Figure 7. For the parameterization of the model, the shareholders never offer a fixed wage component to the contract. Rather, when short-term returns are sufficiently high and effort is induced at all states so that Manager 1 earns information rents, contracts induce the selection of the short-term project irrespective of the return offered by long-term projects. For this parameterization, $\theta_S^* = \frac{2}{5}\left(8-\sqrt{5}\right)c$.

[11] The exact expression for θ_S^* is given by $\theta_S^* = \phi_S(3c) = \frac{2}{5}\left(8-\sqrt{5}\right)c \approx 2.306c$

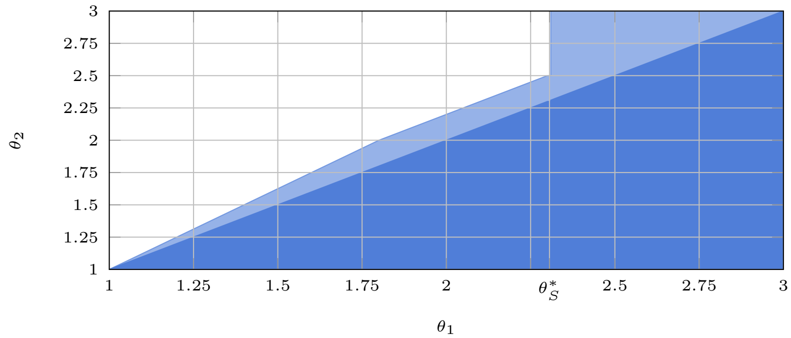

Figure 7: Profit-Maximizing Project Selection with Unobservable θ

Relative to the first-best case, in which long-term projects are selected 50 percent of the time (i.e., $\theta_2 > \theta_1$), Figure 7 shows a bias toward short-term projects. Intergenerational conflicts of interest imply that the profit-maximizing contract induces Manager 1 to choose long-term projects about 40 percent of the time. Furthermore, moderately high-return short-term projects (those in the 65^{th} percentile) are always chosen regardless of the long-term project's return. That is, even a long-term project with a return higher than any feasible alternative short-term project is not chosen 35 percent of the time.

7 Related Literature

This is not the first model to study incentive conflicts as the root of short-term bias in executive compensation. A range of theoretical papers evaluate short-term managerial myopia to the detriment of the firm, a concept often referred to as *short-termism* in the literature. However, a common thread across papers is an imposed preference for short-term projects by the manager and/or shareholders. This preference is sometimes implicit and occasionally manifests itself through the mismatch of information realization and managerial preferences or irrational behavior.[12] In this paper, managers are risk neutral and do not discount the future, so they are indifferent to the temporal payment of wages. As a result, shareholders may pay managers after all information

[12]See, for example, Brennan (1990), Myers and Majluf (1984), Shleifer and Vishny (1990), Stein (1988), Stein (1989), Bolton, Scheinkman, and Xiong (2006), among others.

is realized without affecting the manager's utility and incentives. Consequently, this paper demonstrates that even without risk or time preferences, contracts are likely to exhibit a short-term bias.

Early contributions to this literature focus on a manager who prefers short-term projects, *ceteris paribus*, because these projects have the capacity to improve the manager's reputation in a way that longer-term projects cannot. Narayan (1985) shows that suboptimal decisions from the firm's perspective arises because the manager chooses short-term projects to enhance his reputation earlier and increase his wages. Similarly, Holmström and Ricart I Costa (1986) and Holmström (1999) consider models in which managerial talent is not observed and firm outcomes serve as a rational basis for future productivity of a manager. Because the manager is primarily concerned with human capital and the firm owners with firm capital, contracting is necessary to align incentives. This paper shows that short-term bias exists even when owners may compensate managers after all information is realized, which would eliminate short-termism arising from the reputation channel.

Among the papers that study short-termism, this paper relates most to Von Thadden (1995), who also takes an optimal contracting approach to identifying a basis for short-term investment. The author shows that even when short-term debt is optimal, the optimal contract can induce short-term investment for three reasons. First, the cost of early termination of good projects from using short-term debt is lower for short-term projects than longer-term projects. Second, when project choice is private information, it may not be incentive compatible for decision maker to choose long-term projects. Finally, committing funds for long-term projects may not be renegotiation-proof after the observation of poor short-term results. However, this paper's approach differs in that it focuses on an intergenerational conflict of interest across successive managers and allows investors to commit to provision of funds.

This paper also shares a central feature of the moral hazard in teams literature, including Holmström (1982). In particular, he shows that moral hazard problems occur with multiple agents even when there is no uncertainty in output. As in this paper, his result is the consequence of the inability to identify an agent who cheats if joint output is the only observable indicator of inputs. Strausz (1999) extends the literature to show how efficiency can result in sequential partnerships without relying on unlimited liability or other conditions required in simultaneous action partnerships. In contrast, this paper studies a sequence of managers who rely on external funding and includes the resolution of uncertainty that occurs during the lifespan of intergenerational projects. Furthermore, while Strausz focuses on implementation of efficient effort, the focus of this paper is to compare profits to external investors of projects involving a sequence of managers against those guided by a single manager.

More recently, Acharya, Myers, and Rajan (2011) use the concept of overlapping generations of managers in a positive model of investment and dividend policy. This paper differs in that it takes an optimal contracting approach to the problem, while their paper solves for an equilibrium given a particular payment schedule to CEOs. Furthermore, information frictions are the driving agency friction in this paper's model, while their model is driven by a CEO's ability to consume funds that are not ring fenced for investment.

In the wake of the financial crisis, there has been a literature interested in devising mechanisms to align short-sighted incentives of managers with the long-term value of the firm. For example, Edmans and Liu (2011) and Rajan (2010)[13] advocate the use of inside debt as a mechanism that can align the shorter-term view of managers with the longer-term view of other stakeholders. Furthermore, clawback provisions passed in the wake of the financial crisis allow the Federal Deposit Insurance Corporation to recoup benefits paid to a bank executive whose risky decisions led to his firm's failure. While these mechanisms may help with incentives, this paper shows that *no* mechanism can entirely align short-term managerial incentives with those of the firm owners.

[13]This is in addition to empirical studies such as Bennett, Guntay, and Unal (2012), Sundaram and Yermack (2007), and Van Bekkem (2012), who all show decreased risk taking incentives with inside debt

8 Conclusion

Intergenerational conflicts of interest across managers present at least two reasons for shareholders to offer managers contracts that reward short-sighted behavior relative to the first-best case. First, shareholders can provide incentives for managers more cheaply when they can more easily assign blame or credit to firm outcomes. Because there are fewer managers involved in short-term projects, shareholders find short-term projects more profitable. Second, when shareholders can only observe returns of chosen projects and not those declined, managers choose projects that yield them the highest expected surplus. However, because a manager earns all information rents only for projects in which she is solely responsible, she will opt for short-term projects. Shareholders can deter this only by sharing the surplus of long-term projects or implementing less efficient effort and reducing information rents for short-term projects when they are chosen. Both of these induce a further short-term bias in contracts.

This paper took management tenure as given, though endogenous management tenure may interact in important ways with external constraints on tenure. In particular, higher turnover is likely to be associated with greater myopia. On the other hand, internal governance mechanisms, including internal promotions, may act as a countervailing force to short-termism. This paper might also provide insights on family-owned firms. More so than other firms, managers at family-owned firms value consumption of future managers. As a result, family-owned firms may deter short-termism relative to other firms via intergenerational linkages of utility across managers.

9 Appendix

Lemma 2:

Proof. Consider an optimal contract x^* with associated decision rule d^* and effort decisions. From Lemma 1 the wage schedule for Manager 1 can be written as $z_1^{d^*(\theta)} + w(d^*(\theta), \theta_{d^*(\theta)})$.

First, we prove the second statement and in addition that $w^*(\cdot) = 0$ for short-term projects in which effort is induced for all η. Suppose by way of contradiction that the statement did not hold and consider an alternative contract x' in which $w' = 0$ whenever $w^* \in [0, \frac{1}{6}c)$ and $w' = \frac{1}{6}c$ whenever $w^* > \frac{1}{6}c$. Furthermore, assume that when effort is induced for all η and $d(\theta) = 1$ that $w' = 0$. Otherwise, assume that x' is identical to x^*. So long as the constraints are satisfied, x' must yield profits as great as x^*.

Because IC conditions depend on z and not w^*, x' will induce the same effort decisions conditional on a particular project being selected. Therefore, it remains to be shown that the PS conditions hold. Given that $w' = 0$ when effort is induced at all states for short-term projects, Manager 1's surplus in this case is $\frac{1}{6}c$. Otherwise, her surplus for short-term projects is 0.

As her surplus can never be higher than $\frac{1}{6}c$ under x' from choosing long-term projects, if for a given θ it was the case that $d^*(\theta) = 1$ and effort was induced for all η the PS condition continues to hold. This is verified for five cases below encompassing all possible values of θ.

1. Suppose that for a given $\theta = (\theta_1, \theta_2)$, $d^*(\theta) = 2$ and $w^*(2, \theta_2) < \frac{1}{6}c$. Under the original contract, this implies that θ_2 is chosen if and only if under θ_1 effort is not induced for all η (where rents are at least $\frac{1}{6}c$) and $w^*(1, \theta_1) \leq w^*(2, \theta_2)\frac{1}{6}c$. Under the alternative contract, the PS condition continues to hold whenever these two conditions on θ_1 are true.

2. Suppose that for a given $\theta = (\theta_1, \theta_2)$, $d^*(\theta) = 2$ and $w^*(2, \theta_2) > \frac{1}{6}c$. Under the alternative contract, the wage for θ_1 implies that it is weakly preferred to all short-term contracts. Thus, the PS condition continues to hold.

3. Suppose that for a given $\theta = (\theta_1, \theta_2)$, $d^*(\theta) = 1$ and effort is induced for each state. Under the alternative contract, θ_1 is weakly preferred to all long-term projects. Therefore, the PS condition continues to hold for the alternative contract.

4. Suppose that for a given $\theta = (\theta_1, \theta_2)$, $d^*(\theta) = 1$, effort is not induced for all

states, and $w^*(1, \theta_1) < \frac{1}{6}c$. Under the original contract, this implies that θ_1 may be chosen over long-term projects only if $w^*(2, \theta_2) \leq w^*(1, \theta_1) < \frac{1}{6}c$. Under the alternative contract, the PS condition continues to hold.

5. Suppose that for a given $\theta = (\theta_1, \theta_2)$, $d^*(\theta) = 1$, effort is not induced for all states, and $w^*(1, \theta_1) > \frac{1}{6}c$. Under the alternative contract, θ_1 is weakly preferred to every long-term project and thus, the PS condition continues to hold.

To prove the first part of the statement that $w^*(1, \theta_1) = 0$ for all θ_1, suppose not by way of contradiction. First, there must be some θ_2 with $w^*(2, \theta_2) > 0$ such that $d(\theta_1, \theta_2) = 1$, otherwise shareholders would have no need to be $w^*(1, \theta_1) > 0$. Second, it must be that the profits generated from selection of θ_1 exceed those of selection of θ_2. That is,

$$\frac{5}{3}\theta_1 - \frac{5}{3}c \quad \geq \quad \max\{\frac{4}{3}\theta_2 - 43c, \frac{5}{3}\theta_2 - 2c\} \tag{8}$$

Meanwhile, for $w^*(2, \theta_2) > 0$, it must be the case that $d(\tilde{\theta}_1, \theta_2)$ for some $\tilde{\theta}_1$ for which effort is induced at all states. Otherwise, w^* could be reduced to 0 for all long-term and short-term projects without affect the PS condition. This implies that profits from θ_2 exceed those from $\tilde{\theta}_1$. That is,

$$2\tilde{\theta}_1 - \frac{7}{3}c \quad \leq \quad \max\{\frac{4}{3}\theta_2 - 43c, \frac{5}{3}\theta_2 - 2c\} - \frac{1}{6}c. \tag{9}$$

Together, these imply that

$$2\tilde{\theta}_1 - \frac{7}{3}c + \frac{1}{6}c \leq \frac{5}{3}\theta_1 - \frac{5}{3}c. \tag{10}$$

However, at θ_1 it must be that inducing effort for two states yields more profit than inducing it for all states, while at $\tilde{\theta}_1$ inducing effort at all states must yield greater profit. That is,

$$
\begin{aligned}
2\theta_1 - \frac{7}{3}c &\leq \tfrac{5}{3}\theta_1 - \tfrac{5}{3}c - \tfrac{1}{6}c \Leftrightarrow \tilde{\theta}_1 \geq \tfrac{3}{2}c \\
2\tilde{\theta}_1 - \frac{7}{3}c &\leq \tfrac{5}{3}\tilde{\theta}_1 - \tfrac{5}{3}c - \tfrac{1}{6}c \Leftrightarrow \theta_1 \leq \tfrac{3}{2}c.
\end{aligned}
$$

Plugging $\tilde{\theta}_1 > \theta_1$ into Equation 10 then contradicts the previous two inequalities.

□

Lemma 3:

Proof. First, note that it must be the case that $\theta_1' \geq 2c$. This follows directly from the observation that in the case where θs are observable it is optimal to induce effort for all η only when this condition holds.

Let $\Theta^* \equiv \{\theta_2 | \mathbf{E}[x_1] > c\}$ denote the set of long-term project returns for which the manager earns information rents. Consider not inducing effort for all η at θ_1', then shareholders will induce effort for $\eta \in \{0, \theta\}$ as in Section 5. Furthermore, because shareholders are not inducing effort for all η, the manager earns no information rent and will therefore choose long-term projects whenever $\theta_2 \in \Theta^*$. Whenever $\theta_2 \notin \Theta^*$, the manager is indifferent between long-term and short-term projects and is willing to choose whichever is more profitable to shareholders. Given that $\theta_1' \geq 2c$, short-term projects are more profitable if and only if $\theta_2 \leq \theta_1' + \frac{1}{5}c$. Supposing instead that at θ_1' effort is induced for all η, the manager earns rents from short-term projects and will therefore choose short-term projects whenever $\theta_2 \notin \Theta^*$. If $\theta_2 \in \Theta^*$, then the manager earns equal rents[14] from long- and short-term projects and is willing to implement whichever project is more profitable. Given that $\theta_1' \geq 2c$ short-term projects are more profitable if and only $\theta_2 \leq \frac{6}{5}\theta_1' - \frac{1}{10}c$.

Then, if inducing effort for all η is part of the optimal contract at θ_1', the profits that this generates (RHS) must be greater than the profits generated from inducing

[14]Given that the shareholders will pay wages only to induce long-term project selection, the manager's surplus must be at least as great as her rents from short-term projects, $\frac{1}{6}c$. Because a manager can never earn more rent than this offering, a higher surplus to the manager would be inefficient as it decreases shareholder profits without any effect on incentives.

effort only for states $\{0, \theta\}$ (LHS):

$$\int_{\theta_2 \in \Theta^*} \left[\frac{5}{3}\theta_2 - \frac{13}{6}c\right] d\theta_2 + \int_{\substack{\theta_1' + \frac{1}{5}c \\ \theta_2 \notin \Theta^*}}^{3e} \left[\frac{5}{3}\theta_2 - 2c\right] d\theta_2 + \int_{\substack{c \\ \theta_2 \notin \Theta^*}}^{\theta_1' + \frac{1}{5}c} \left[\frac{5}{3}\theta_1' - \frac{5}{3}c\right] d\theta_2 \leq$$

$$\int_{\substack{\frac{6}{5}\theta_1' - \frac{1}{10}c \\ \theta_2 \in \Theta^*}}^{3e} \left[\frac{5}{3}\theta_2 - \frac{13}{6}c\right] d\theta_2 + \int_{\substack{c \\ \theta_2 \in \Theta^*}}^{\frac{6}{5}\theta_1' - \frac{1}{10}c} \left[2\theta_1' - \frac{7}{3}c\right] d\theta_2 + \int_{\theta_2 \notin \Theta^*} \left[2\theta_1' - \frac{7}{3}c\right] d\theta_2$$

$$\Leftrightarrow 0 \leq \int_{\theta_2 \in \Theta^*} \max\left\{\left[2\theta_1' - \frac{7}{3}c\right] - \left[\frac{5}{3}\theta_2' - \frac{13}{6}c\right], 0\right\} d\theta_2 +$$

$$\int_{\theta_2 \notin \Theta^*} \left[2\theta_1' - \frac{7}{3}c - \max\left\{\frac{5}{3}\theta_1' - \frac{5}{3}c, \frac{5}{3}\theta_2 - 2c\right\}\right] d\theta_2$$

Noting that both the first and second integrand are increasing in θ_1' concludes the proof. □

Lemma 4:

Proof. From Lemma 3 there exists a threshold value $\theta_S^* > 2c$ of θ_1 below which Manager 1 earns no surplus for choosing short-term projects. I show first that this implies that $\theta_2' \geq \theta_S^* + \frac{1}{5}c$. Suppose not. This implies that Manager 1 strictly prefers θ_2' to short-term projects for any $\theta_1 < \theta_S^*$ and is indifferent between projects otherwise. Shareholder profits conditional on $\theta_1 > \theta_S^*$ being chosen are given by $2\theta_1 - \frac{7}{3}c$ and are less than $\frac{5}{3}\theta_2' - 2c$ conditional on the long-term project being chosen with a fixed wage. Thus, a lower bound on θ_2' to be more profitable for $\theta_1 > \theta_S^*$ is given by $\theta_2' \geq \theta_1 + \frac{1}{5}(\theta_1 - c) \geq \theta_1 + \frac{1}{5}c$. Consequently, long-term projects should never be induced when $\theta_1 > \theta_S^*$. However, for $\theta_1 < \theta_S^*$, Manager 1 earns no surplus and can therefore be induced to choose long-term projects without paying a fixed wage. This establishes that $\theta_2' > \theta_S^* + \frac{1}{5}c$.

For θ_2' to pay a fixed wage, it must be the case that this arrangement is more profitable than paying no fixed wage and allowing Manager 1 to choose short-term projects whenever $\theta_1 > \theta_1^*$. Then, the profits associated with offering a fixed wage or not offering a fixed wage are given by the left and right panels, respectively, of Figure

5. Mathematically,

$$\begin{aligned} & \int_c^{\theta_S^*}\left[\frac{5}{3}\theta_2-2c\right]d\theta_1+\int_{\theta_S^*}^{3e}\left[2\theta_1-\frac{7}{3}c\right]d\theta_1\leq \\ & \int_c^{\theta_S^*}\left[\frac{5}{3}\theta_2'-\frac{13}{6}c\right]d\theta_1+\int_{\theta_S^*}^{3c}\max\left\{2\theta_1-\frac{7}{3}c,\frac{5}{3}\theta_2'-\frac{13}{6}c\right\}d\theta_1 \\ \Leftrightarrow\quad & \frac{1}{6}c\int_c^{\theta_S^*}d\theta_1\leq\int_{\theta_S^*}^{3c}\max\left\{0,\left(\frac{5}{3}\theta_2'-\frac{13}{6}c\right)-\left(2\theta_1-\frac{7}{3}c\right)\right\}d\theta_1 \end{aligned}$$

The proof is concluded by noting that the LHS expression is constant and the RHS expression is increasing in θ_2'. □

Lemma 5:

Proof. First, to show that effort is induced for all η, suppose by way of contradiction that effort is not induced for all η. From Section 5, we know that effort for all η yields the maximum profit to shareholders when returns are observable. Not inducing effort at all states must then be desirable for the ability of the shareholders to induce long-term projects without the need to compensate Manager 1 for choosing them. As inducing effort for $\eta \in \{0, \theta\}$ is the next most profitable and yields no rents to Manager 1, it will be induced by shareholders. Given the profit function in Section 5 and the fact that Manager 1 receives no rents for either short-term or long-term project (by assumption), it will be optimal to induce long-term projects only if $\theta_2 \geq \theta_1 + \frac{1}{5}c$.

For $\theta_1 \geq \frac{31}{12}c$ this yields a maximum conditional expected payout of

$$\psi_1(\theta_1) \equiv \frac{1}{2c}\left[\left(\theta_1-\frac{4}{5}c\right)\left(\frac{5}{3}\theta_1-\frac{5}{3}c\right)+\int_{\theta_1+\frac{1}{5}c}^{3c}\left[\frac{5}{3}\theta_2-2c\right]d\theta_2\right]$$

, which occurs if shareholders never pay Manager 1 a fixed wage for long-term projects. This simplifies to $\frac{5}{6}\theta_1^2 - \frac{4}{5}\theta_1 c - \frac{1}{15}c^2$. Meanwhile, the minimum expected payout from inducing effort for each η for short-term projects of return θ_1 being chosen is $\psi_2 \equiv 2\theta_1 - \frac{7}{3}c$. It is straightforward to show that $\psi_1(\frac{31}{12}c) < \psi_2(\frac{31}{12}c)$ and that $\frac{\partial\psi_1}{d\theta_1} - \frac{\partial\psi_2}{d\theta_1} < 0$ on $[\frac{31}{12}c, 3c]$.

Given that effort is induced for all η when the short-term project is chosen and

$\theta_1 \geq \frac{31}{12}c$, it remains to be shown that the short-term project is always chosen over the long-term project. To induce Manager 1 to choose the long-term project she must receive an additional wage of $\frac{1}{6}c$ so that the profits from the long-term project are $\frac{5}{3}\theta_2 - \frac{13}{6}c$. The upper bound of $3c$ on θ_2 then yields the result.

□

Proposition 4:

Proof. The general structure of the contract follows directly from Lemmas 3 and 4. It remains to be shown that $\theta_L^* = 3c$ and $\theta_S^* = \theta_S^*(3c) = \frac{2}{5}\left(8 - \sqrt{5}\right)c$. From Equations 6 and 7, it is straightforward to show that $\frac{\partial \phi_L}{\partial \theta_S^*} > 0$ and $\frac{\partial \phi_S}{\partial \theta_L^*} > 0$. Given that π is cubic in θ_S^* (θ_L^*) with $\frac{\partial^3 \pi}{\theta_S^{3*}} > 0$ ($\frac{\partial^3 \pi}{\theta_S^{3*}} < 0$) it follows that $\phi_S(\theta_L^*)$ ($\phi_L(\theta_S^*)$) is a lower (upper) bound on θ_S^* (θ_L^*).

The following claim is first proven: θ_L^* is not in the interior of $[\frac{11}{5}c, 3c]$. First note that $\theta_S^* \geq 2c$. Evaluating $\phi_L(2c) = \frac{1}{10}(23 + \sqrt{24})c \approx 2.79c$. Given that $\phi_L' > 0$, this implies that $\phi_L(2c)$ is a lower bound of θ_L^* if it is interior. However, we know that ϕ_S is a lower bound of θ_S^*, implying that $\phi_S(\phi_L(2c)) \approx 2.2c$ is a lower bound of θ_S^*. Evaluating $\phi_L\left(\phi_S\left(\phi_L(2c)\right)\right)$ yields a value greater than $3c$, implying that θ_L^* cannot be interior.

Thus, it must be the case that either $\theta_L^* = \frac{11}{5}c$ or $\theta_L^* = 3c$. Suppose $\theta_L^* = \frac{11}{5}c$. First note that $\phi_S(\frac{11}{5}c) = 2c$ and that the larger root of Equation 6 is greater than $\frac{11}{5}c$, implying that profits are decreasing on $\theta_S^* \in [2c, \theta_L^*]$ and therefore $\theta_S^* = \phi_S = 2c$. From before we know that $\phi_L(2c) = \frac{1}{10}(23 + \sqrt{24})c \approx 2.79c$. Further, note that the smaller root of Equation 7 is less than $\frac{11}{5}c$, implying that π is increasing on $[\frac{11}{5}c, \phi_L(2c)]$. This contradicts that $\theta_L^* = \frac{11}{5}c$. Therefore $\theta_L^* = 3c$.

Given that $\theta_L^* = 3c$, it remains to be shown that $\theta_S^* = \phi_S(3c)$. This can be verified by noting that the larger root of Equation 6 is greater than $3c$ when $\theta_L^* = 3c$. Consequently, π is single peaked in θ_S^* fixing $\theta_L^* = 3c$ and the single peak occurs at the interior solution $\phi_S(3c)$. □

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