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Sunflower Management and Capital Budgeting

Abstract

In organizations, it is often necessary to engage in costly delegation of ideas; such delegation seeks to efficiently aggregate multiple information signals. What this paper shows is that those who delegate often find it impossible to separate the evaluation of the ideas they delegate from the evaluation of the *abilities* of those who are delegated the task of assessing these ideas. This commingling of the assessment of the idea with that of the individual agent generates a tendency for the agent to ignore his own information and instead attempt to confirm the superior's prior belief. We refer to this as sunflower management. Beyond characterizing the effects of sunflower management on the delegation process, our analysis also allows us to extract implications of sunflower management for the use of centralized versus decentralized capital budgeting systems, and to explain why firms may overinvest capital even when managers have no innate preference for "empire building".

1 Introduction

> Gentlemen, I take it we are all in complete agreement on the decision here... Then I propose we postpone further discussion of this matter until our next meeting to give ourselves time to develop disagreement and perhaps gain some understanding of what the decision is all about.
>
> Alfred P. Sloan, Jr.

A sunflower always turns toward the sun, seeking nourishment for its survival. Many managers in organizations behave similarly. They look up at their bosses, trying to figure out what they are thinking, so that their actions will match the expectations and beliefs of their bosses. We call such behavior "sunflower management". Why do people behave like this and what are the consequences of such behavior for how capital is allocated in organizations?

We argue that the answer to this question lies in the interaction of managerial career concerns and project delegation. In organizations, it is often necessary to engage in costly delegation of the assessment of ideas to take advantage of the specialized skills of those at lower levels or simply to aggregate multiple *independent* assessments of ideas. A classic example of this is a capital budgeting system in which senior executives ask junior financial analysts to evaluate projects. Such delegation may be viewed as empowerment, a way for a boss to free up time to pursue more strategic tasks while making the subordinate accountable for the delegated task. The study of delegation is thus an essential part of understanding the structure and economic function of organizational hierarchies.[1]

While delegation has potential benefits, it also has costs. These are of three types. First, there is the direct cost of delegation. By delegating a decision to a subordinate, there is an added cost of communication as well as motivating a possibly effort-averse subordinate (e.g., Mirrlees (1976) and Prendergast (1993)). Second, there is possibly a cost of less efficient decisionmaking if the subordinate is not as skilled as the boss. And third, the delegation to a subordinate induces an agency problem. In particular, the subordinate may engage in gaming behavior due to career concerns, which may distort decisions. In this paper, we focus on this third cost. The benefit of delegation in our model comes from aggregating multiple independent signals, while the cost is due to the distortions arising from the subordinate's career concerns. We show that these career concerns cause the subordinate to engage in sunflower management, tending to agree with his boss' prior assessment even when his analysis says otherwise.

[1] See Aghion and Tirole (1997) and Harris and Raviv (1998) for recent models of organizational hierarchies.

Although our analysis of this question has fairly wide organizational implications, our central focus is on capital budgeting. This focus motivates our model setup and allows us to address questions about various aspects of the design of capital budgeting systems, in particular the desired degree of decentralization in capital budgeting.

To fix concepts, let us consider an example. Think of a typical organization in which a vice president (VP) generates an idea for a new project. Suppose the VP passes the project down for investigation by an analyst. Now, the analyst may recommend that the project be rejected for one of two reasons. One is that the project is truly bad upon further inspection. But the other is that the analyst is not very good at estimating the project's value, and hence his high estimation error has resulted in a type-I error in his recommendation. *A priori* the VP can't disentangle the first possibility from the second. However, the more confident the VP is about her positive assessment of the project's value, the more likely she is to believe that an analyst recommending project rejection is a poor analyst.

The astute analyst recognizes this commingling in the VP's potential inference. In particular, he sees that the VP's assessment of the project investigated by the analyst is inseparable from her assessment of the analyst himself. When the VP is seen as being *a priori* favorable about the project, the analyst's privately-optimal response is to sometimes recommend acceptance of projects that his analysis reveals are bad bets. Similarly, when the VP is seen as being *a priori* pessimistic, the analyst may tend to recommend rejection even though his analysis tells him the project is good. That is, the analyst strives to provide the VP with consensus rather than an independent assessment.

When the VP knows that the analyst is disregarding his own information, the value of delegating investigation of the project to the analyst declines. To the extent that project delegation has a direct organizational cost, the benefit of delegation, net of this cost, is decreasing in the analyst's propensity to provide consensus. Viewing project delegation as an essential element of decentralized capital budgeting, our analysis permits us to address a key question in capital budgeting: *what determines the degree of decentralization of a capital budgeting system?*

Our analysis suggests that the optimal degree of decentralization of capital budgeting depends on the interaction between the direct cost of project delegation (which can also be interpreted as the direct cost of decentralization), the marginal value of information generated via delegation, and the career concerns of those generating this information. As career concerns increase, the marginal value of information generated at lower levels in the organization decreases and decentralization becomes less attractive. Because career concerns may be influenced by a host of factors such as corporate culture, the external "marketability" of the analyst's human capital, and the extent to which senior executives are prone to "tip their hand" about projects before they are formally evaluated, we would expect the degree of decentralization of capital budgeting to vary widely across organizations. And even within a given organization, it should vary depending on the project. For example, our analysis suggests that projects about which the VP has a very strong prior belief (either favorable or unfavorable) should be decided upon in a centralized capital budgeting system, whereas other projects should be processed through decentralized capital budgeting. An important goal of our analysis is to explore the determinants of the *scope* of decentralized capital budgeting. In addition to examining the organization of capital budgeting, our analysis also identifies conditions under which there is overinvestment of capital.

Our theory of sunflower management is related to four strands of the literature. The first is the literature on delegation and empowerment in hierarchies, in which Aghion and Tirole (1997) and Milgrom (1988) are major contributors.[2] While we also examine delegation, our focus on the sunflower management aspects of capital budgeting takes our analysis in a different direction.

The second strand is the modern capital budgeting literature. Harris and Raviv (1998) examine the managerial tradeoff between investigating projects, which provide private benefits of control if they are undertaken, and delegating them to a lower part of the hierarchy to save on (privately) costly project investigation. They find that project delegation is more prevalent when the effort cost of project investigation is relatively high. Thakor (1990) shows how the wedge between the costs of external and internal financing affects the kinds of projects the firm chooses. Bernardo, Cai, and Luo (2000) jointly consider the capital allocation and compensation scheme in a decentralized firm where managers may misrepresent project quality as well as shirk on investigative efforts. The primary difference between our model and these papers is that we consider the effects of career concerns and do not assume managerial effort aversion, private benefits of control, or external market frictions.

The third strand is the literature on career concerns. Chevalier and Ellison (1999), Fama (1980), Gibbons and Murphy (1992), Hirshleifer and Thakor (1992), Holmstrom (1999), Holmstrom and Ricart i Costa (1986), Milbourn, Shockley and Thakor (2001), Narayanan (1985), Prendergast and Stole (1996), and others have shown how effort and investment incentives of agents are influenced by their career concerns. Holmstrom and Ricart i Costa (1986), in particular, show that when

[2]Milgrom (1988) examines "influence costs" that arise when there are incentives for subordinates to influence the decisions of those in authority. Aghion and Tirole (1997) examine the delegation of formal and real authority and its effects on the subordinate's incentives to collect information and the superior's ultimate control. Harris and Raviv (1998) examine the problem of whether corporate headquarters should delegate control over the allocation of capital to the lower divisions.

downward-rigid wage contracts are used for risk-averse agents, they may overinvest. We abstract from risk-sharing considerations and show that career concerns can lead to both overinvestment and underinvestment.

The fourth strand of the literature to which our work is most directly related is that on conformity, particularly Prendergast (1993).[3] Other examples are Banerjee and Besley (1990), Bernheim (1994), Bikhchandani, Hirshleifer, and Welch (1992), Brandenburger and Polak (1996), Morris (1999), Scharfstein and Stein (1990) and Zwiebel (1995). The fundamental insight shared by these papers is that conformity is generated by a desire to distinguish oneself from the "type" that one wishes *not* to be identified with. This insight is an important aspect of sunflower management as well since the analyst agrees with the VP to avoid being identified as untalented in estimating project values. What distinguishes our work from this literature is our focus on the commingling of the assessment of the agent with the assessment of the project, and in particular, the emphasis we put on the *interaction* between career concerns and conformity in the context of capital budgeting.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 contains the equilibrium analysis of the optimal project delegation policy and characterizes the distortions due to sunflower management. In Section 4, we use our analysis to explore the optimal degree of decentralization in capital budgeting, and Section 5 concludes. All proofs are in the Appendix.

2 Model Setup

We model a firm in which there is one Vice President (VP) overseeing analysts of varying ability. All agents are assumed to be risk neutral. The VP generates project ideas and delegates some of these projects to the analyst for financial analysis. We want to examine the distortions that arise when projects are delegated to analysts for investigation. We let the analyst investigate the delegated project and make a "reject/accept" report to the VP based on his *private* signal. The VP then decides whether to invest capital.

[3] Prendergast (1993) develops a model with an effort-averse worker who must be motivated to work to produce a signal, with the motivation provided by an outcome-contingent wage. The problem is that there are no objective measures of output, so the worker's output can be judged only relative to his boss' own information about the signal. This makes the worker misreport his signal, telling his boss what he believes will coincide with the boss' information. The differences between Prendergast's model and ours are that we allow for objective measures of the analyst's output (the terminal payoff on a chosen project is observed ex post), model career concerns rather than effort aversion, and focus on capital budgeting applications.

2.1 Projects and Delegation

The VP generates ideas for projects which can be either good or bad, and these are denoted G and B, respectively. The commonly-known quality of the project idea is the prior probability that the idea is good, defined as $\theta \in [0,1]$. That is, for a given project idea,

$$\begin{aligned}\Pr(G) &= \theta \\ \Pr(B) &= 1-\theta.\end{aligned} \tag{1}$$

Both types of projects require an investment $I > 0$ at date $t = 1$. Projects that are accepted pay off at $t = 2$; rejected projects never generate payoffs. Good (G) projects pay off a positive amount $H > I$ for sure, while bad (B) projects always pay off zero.

The VP has the option to send the project down to an analyst for investigation. We assume that the firm incurs a delegation cost $C > 0$ on all projects that the analyst investigates. As a consequence, it may not be optimal for the VP to delegate all projects to the analyst. Intuitively, if the VP observes a θ very close to zero or very close to one for a project, she may choose not to have the project investigated. For such a project, the marginal value of the analyst's investigation (even it there was no misrepresentation) is outweighed by the delegation cost C. In Section 3, we formally define the VP's optimal delegation policy under a variety of informational assumptions.

2.2 Analysts and their Signals

Analysts are *ex ante* observationally identical, but can be either Talented (T) or Untalented (U), where:

$$\Pr(T) = \beta \in (0,1). \tag{2}$$

Each analyst privately knows his own type, but the VP must learn about it through time.

If the analyst is delegated a project, he observes a signal at $t = 1$ that is related to the project's type. Talented analysts observe precise signals, while untalented analysts observe noisy, yet informative signals. The signal that the analyst observes about the project under review is given by $s \in \{s_G, s_B\}$, where s_G is the good signal and s_B the bad signal. The underlying signal-generation process for the talented analyst is given by

$$\begin{aligned}\Pr(s_G|\text{ good project, T}) &= \Pr(s_B|\text{ bad project, T}) = 1 \\ \Pr(s_G|\text{ bad project, T}) &= \Pr(s_B|\text{ good project, T}) = 0.\end{aligned} \tag{3}$$

For untalented analysts, the signal-generation process is given by

$$\begin{aligned}\Pr(s_G|\text{ good project, U}) &= \Pr(s_B|\text{ bad project, U}) = 1-\varepsilon \\ \Pr(s_G|\text{ bad project, U}) &= \Pr(s_B|\text{ good project, U}) = \varepsilon,\end{aligned} \tag{4}$$

where $\varepsilon \in (0, \frac{1}{2})$. Thus, as ε increases, the untalented analyst is more prone to receiving erroneous signals.

Given an observation of the signal s, the analyst uses Bayes' rule to revise his estimate that the project is good. Thus, talented analysts (using (3) and (1)) form their posterior belief according to

$$\Pr(G|s_G, T) = \frac{1 \times \theta}{1 \times \theta + 0 \times (1-\theta)} = 1 \equiv \mu_{TG}. \tag{5}$$

Untalented analysts (using (4) and (1)) form their posterior belief according to

$$\Pr(G|s_G, U) = \frac{(1-\varepsilon)\,\theta}{(1-\varepsilon)\,\theta + \varepsilon(1-\theta)} \equiv \mu_{UG}. \tag{6}$$

Once the analyst has investigated the project delegated to him and updated his prior belief, he submits a recommendation of acceptance (A) or rejection (R) to the VP.

2.3 Wages and Information Structure

Analysts are assumed to have utility functions that are strictly increasing in the VP's perception that they are talented. Thus, this could be interpreted as the analysts being paid reputation-contingent wages at dates $t = 1$ and $t = 2$. We let an analyst's wage at any date t be given by

$$W_t = \Pr(T_t|\{\Omega_t\}), \tag{7}$$

where $\{\Omega_t\}$ represents the VP's information set at date t. At date $t = 1$, the VP knows the priors over both project type (θ) and analyst type (β), and can observe the analyst's acceptance/rejection recommendation. However, the VP does not see the analyst's signal. At date $t = 2$, the VP recalls all of the information from date $t = 1$, and observes the payoffs on all accepted projects. Rejected projects reveal no information at date $t = 2$. The analyst's equilibrium behavior will be given by the strategy that maximizes the likelihood that the VP believes he is talented across the two periods. Thus, the analyst seeks to maximize

$$E(U) = W_1 + \delta W_2, \tag{8}$$

where $\delta \in [0, 1]$ is the analyst's intertemporal discount factor.

As in Holmstrom and Ricart i Costa (1986), we are assuming that the analyst is paid a fixed wage each period. At $t = 1$, the wage depends on the VP's commonly-known priors about the analyst's type, and at $t = 2$ the analyst's wage depends on the VP's posterior beliefs about his type. The assumption is that the labor market observes what the VP sees, so paying the analyst less than what he could obtain in the market is not feasible.

There are two other plausible alternatives to this wage structure. One is to pay the analyst a flat wage in both periods that is *independent* of his perceived type. With this the analyst will make the first-best investment choice since misrepresentation does not benefit him. However, such a wage contract is *not* renegotiation-proof. If the analyst is paid less at $t = 2$ than the posterior assessment of his type indicates he should be paid, he will quit unless the VP renegotiates his wage upward. If the analyst is paid more at $t = 2$ than the posterior assessment of his type indicates he should be paid, the VP will want to fire him unless he accepts a lower wage.

The other possible wage structure is one that would induce separation of untalented analysts from talented analysts. Using the Revelation Principle, we can ask each analyst to truthfully report his type and then give the analyst a wage contract contingent on the report.[4] However, such a wage contract requires *precommitment* by the VP. Once the analyst has submitted a report, the VP knows the analyst's type, so it may be mutually beneficial to revert to a set of contracts that generate higher surplus. Moreover, the addition of another piece of private information on the part of the analyst would frustrate the separating mechanism being used, requiring a more complex set of contracts to sort out agents possessing two-dimensional private information. In general, we think of wage structures such as (8) as representing situations where the feasible number of contracting variables based on which agents can be separated via self selection is smaller than the number of variables about which agents are potentially privately informed.

3 Equilibrium analysis

In this section, we will examine the equilibrium in the game between the VP and the analyst under both symmetric and asymmetric information. With symmetric information, the VP knows both the analyst's type and observes his signal. We define this as first best. We then consider two cases of asymmetric information. In the first, the VP can observe the analyst's signal, but can't identify the analyst's type. In the second, which is the primary focus of our analysis, the VP can't

[4] This obviously assumes that the conditions for the Revelation Principle to hold are satisfied. See Persons (1997) for an analysis of misrepresentation incentives when these conditions do not hold.

observe either the analyst's type or his signal. It is in this situation that the analyst may engage in gaming behavior. In all three scenarios we will characterize the VP's optimal delegation policy, and, in particular, we will analyze its comparative statics when the analyst is privately informed about both his type and his signal.

3.1 Symmetric Information: First Best

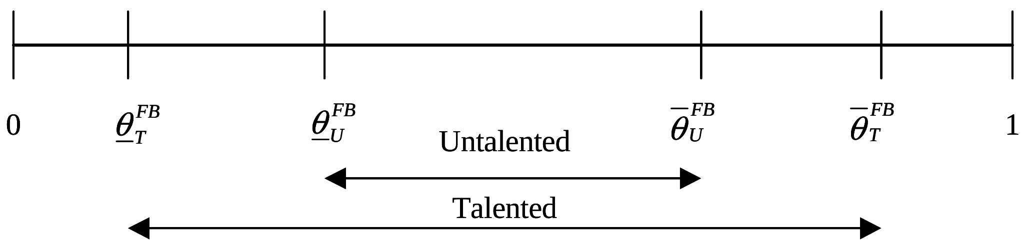
When the VP knows the analyst's type and observes his signal, there is no opportunity for the analyst to distort his report. In equilibrium, the VP will delegate projects for analysis whenever the expected net present value (NPV) of delegation is both positive and greater than the NPV of investing solely on the basis of her prior θ. Since the precision of the signal varies by analyst type, the first-best delegation policy is type-dependent. The two delegation regions are described in the following result.

Theorem 1

There are two first-best, type-dependent delegation regions, denoted by $\left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right] \subset [0,1]$ *and* $\left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right] \subset [0,1]$. *If the analyst is talented, the VP delegates all projects for which her prior belief is that the probability of the project being good is* $\theta \in \left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right]$. *If the analyst is untalented, the VP delegates all projects for which* $\theta \in \left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right]$. *Projects for which* $\theta < \underline{\theta}_j^{FB}$, *for* $j \in \{T, U\}$, *are optimally rejected without delegation and projects for which* $\theta > \overline{\theta}_j^{FB}$, *for* $j \in \{T, U\}$, *are optimally accepted without delegation. Moreover,* $\left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right] \subset \left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right]$.

The intuition is as follows. For sufficiently low (or high) values of θ, the VP believes the project is very likely to be bad (or good) and is unwilling to delegate because the *marginal* informational value of the analyst's signal to the VP's project acceptance decision is insufficient to overcome the delegation cost C. For intermediate values of the VP's prior belief, the *undistorted* information of the analyst has sufficient information value to cover the cost of delegation. Importantly, since the talented analyst observes more precise signals (see (3)) than the untalented analyst (see (4)), the marginal value of delegation for any prior θ is strictly greater for the talented analyst than for the untalented one. Thus, the optimal delegation region for an untalented analyst lies strictly in the interior of that of the talented analyst. In *Figure 1*, we depict the type-dependent, first-best delegation regions.

Figure 1: First-Best Project Delegation Region



3.2 Asymmetric Information: Analyst Type Unknown but Signal Observable

In this first case of asymmetric information, we assume that the VP can observe the analyst's signal but can't observe the analyst's type. The VP must now assess whether the signal she observes comes from the talented or the untalented analyst. Since the signal is observed by the VP, the analyst's recommendation based on it should be *type independent* or else the response would reveal the analyst's type. Consequently, both types of analysts behave identically. However, since the analyst's type is unknown, the VP can't condition on it, which means there is only one second-best delegation region.

Knowing the signal, but not the analyst's type, the VP's assessment of the likelihood that the project is good, conditional on observing s_G, is

$$\Pr(G|s_G) = \frac{(1-\varepsilon+\beta\varepsilon)\,\theta}{(1-2\varepsilon+2\beta\varepsilon)\,\theta+\varepsilon(1-\beta)} \equiv \mu_G. \tag{9}$$

It is readily verified that $\frac{\partial \mu_G}{\partial \theta} > 0$, $\frac{\partial \mu_G}{\partial \beta} > 0$, and $\frac{\partial \mu_G}{\partial \varepsilon} < 0$.

Theorem 2

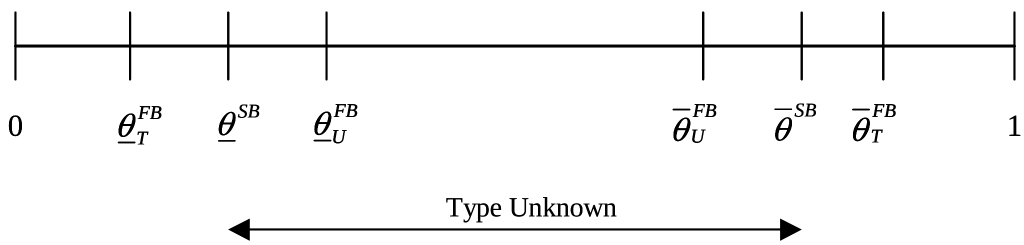
In the second-best equilibrium in which the analyst's type is unknown but his signal is observable, the VP delegates all projects for which her prior beliefs about the project, θ, lie in a single delegation region denoted by $\left[\underline{\theta}^{SB}, \overline{\theta}^{SB}\right] \subset [0,1]$. Projects for which $\theta < \underline{\theta}^{SB}$ are optimally rejected without delegation, and projects for which $\theta > \overline{\theta}^{SB}$ are optimally accepted without delegation. Moreover, $\left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right] \subset \left[\underline{\theta}^{SB}, \overline{\theta}^{SB}\right] \subset \left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right]$, where $\left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right]$ and $\left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right]$ are the first-best delegation regions corresponding to the untalented and talented analysts, respectively.

This theorem is intuitive.[5] Since the VP must assess the expected informativeness of the observed signal across analyst types, the marginal value of the signal for any given θ lies strictly

[5] In deriving *Theorem 2*, we have assumed that the delegation cost C is sufficiently large to insure that the untalented analyst's noisy signal can overcome the prior at the edges of the delegation region. Thus, even in the wider delegation region $\left[\underline{\theta}^{SB}, \overline{\theta}^{SB}\right]$, the signal of the untalented analyst should guide his recommendation.

between that of the untalented and talented analyst. Thus, the optimal delegation region now lies in-between the first-best delegation regions of the untalented and talented analysts identified in *Theorem 1*. In *Figure 2*, we depict the second-best delegation region compared to the type-dependent, first-best delegation regions.

Figure 2: Second-Best Delegation Region with Unknown Analyst Type



3.3 Asymmetric Information: Analyst Type Unknown and Signal Unobservable

We now turn to the main focus of our paper, which is the case in which the analyst's type and his signal are both unobservable to the VP. In the following analysis, we focus on Bayesian Perfect Nash equilibria.

Definition of (Third-Best) Bayesian-Perfect Nash Equilibrium:

1. The VP, unaware of the analyst's type, delegates project ideas to the analyst for investigation if her prior assessment of quality $\theta \in \Theta_D \subset [0,1]$, where Θ_D is the set of θ's for which the marginal value of the analyst investigating the project exceeds the delegation cost C, given the analyst's equilibrium behavior.[6]

2. The analyst, privately informed about his type, investigates the project and privately observes a signal $s \in \{s_G, s_B\}$. He then decides whether to recommend acceptance or rejection to maximize (8) considering the updating in (3) through (6), and (9).

3. The VP decides whether or not to undertake the project based on her updated belief about the project which is based on her prior belief and the analyst's recommendation.

4. The VP updates her prior belief that the analyst is talented using the information set $\{\Omega_1\}$ that includes the observed acceptance/rejection decision of the analyst. The wage W_1 is then determined.

[6]We will examine the VP's optimal delegation policy after establishing the analyst's equilibrium behavior.

5. After observing the output realization on an accepted project at $t = 2$, the VP again updates her belief about the type of the analyst. The VP's information set then becomes $\{\Omega_2\}$ and the resulting wage is W_2.

Analyst's Equilibrium Behavior

If the analyst is given a project for review at date $t = 1$, he investigates the project, and generates a signal according to (3) or (4), depending on whether he is talented or untalented. After observing the signal, the analyst comes up with a posterior belief about the value of the project, and must make a decision of whether to recommend "acceptance" or "rejection" to the VP. He will make the decision such that his expected intertemporal reputational wages given by (8) are maximized. From the definition of equilibrium, we can immediately establish the following.

Lemma 1

The third-best equilibrium can never be one in which all analysts always recommend acceptance or rejection of projects regardless of the signals they receive.

The intuition is straightforward. If the VP knows that the analyst never makes a recommendation based on the signal, delegation has no value, so there is no point in incurring the delegation cost C. We can now analyze the third-best equilibrium.

Theorem 3

The following constellation of strategies and beliefs constitute a unique (third-best) Bayesian-Perfect Nash Equilibrium. Define $\left[\underline{\theta}, \overline{\theta}\right] \subset [0, 1]$ as the third-best delegation region, such that for values of prior beliefs about project quality outside this region, the VP decides on projects without delegation. Then, for all $\theta \in \left[\underline{\theta}, \overline{\theta}\right]$:

1. *A talented analyst follows his signal and recommends acceptance whenever $s = s_G$ is observed, and recommends rejection whenever $s = s_B$ is observed.*

2. *For the untalented analyst, there exist two values of θ, say θ_L and θ_H, with $\theta_L < \theta_H$ such that, for $\theta \in [\theta_L, \theta_H]$, he recommends acceptance whenever $s = s_G$ is observed and rejection whenever $s = s_B$ is observed. That is, the untalented analyst does not misrepresent in equilibrium for such projects. Now define $\Theta \equiv \left[\underline{\theta}, \overline{\theta}\right] \setminus [\theta_L, \theta_H]$ as the set of prior beliefs that lie within the delegation region but outside of this truth-telling region. If Θ has zero*

measure, the analyst never evaluates a project on which his recommendation contradicts his signal. If Θ has positive measure, the untalented analyst behaves as follows:

For $\theta \in [\underline{\theta}, \theta_L)$, they recommend rejection whenever $s = s_B$ is observed, and recommend rejection with probability γ_R and acceptance with probability $1 - \gamma_R$ whenever $s = s_G$ is observed.

For $\theta \in (\theta_H, \overline{\theta}]$, they recommend acceptance whenever $s = s_G$ is observed, and recommend acceptance with probability γ_A and rejection with probability $1 - \gamma_A$ whenever $s = s_B$ is observed.

3. *Taking the equilibrium strategies of analysts as given, the VP updates her beliefs about the project and the analyst's type using Bayes' rule. There are no out-of-equilibrium moves by any type of analyst.*

This theorem establishes that sunflower management is practiced solely by untalented analysts; talented analysts never misrepresent in equilibrium. And while there exists a region ($\theta \in [\theta_L, \theta_H]$) in which the untalented analyst behaves according to first best, misrepresentation may occur outside this region. This misrepresentation takes the form of excessive acceptance of projects for which the VP has relatively high prior beliefs about project quality (i.e., $\theta \in (\theta_H, \overline{\theta}]$) and excessive rejection of projects for which the VP has relatively low prior beliefs about project quality (i.e., $\theta \in (\underline{\theta}, \theta_L]$).

We discuss the intuition in detail below. The basic idea is to first establish that it cannot be an equilibrium for the talented analyst to misrepresent either as part of a pure or mixed strategy, and to then show that in equilibrium when the untalented analyst has received a signal that is in contrast to the VP's (strong) prior, he will never follow a pure strategy of either truth-telling or misrepresentation. For weaker (intermediate) priors, both types of analysts are shown to follow a pure strategy of truth-telling.

First we discuss why the talented analyst never misrepresents. A talented analyst knows that his signal is perfect, so his reputational payoff at $t = 2$ is maximized in equilibrium by recommending in accordance with his signal. His reputational payoff at $t = 1$ *could* be maximized by going against his signal, depending on the VP's prior belief, but we argue now that this cannot happen in equilibrium. In particular, in equilibrium the talented analyst will not misrepresent either in pure or mixed strategies. Consider first pure strategies. Assume that at a particular θ, the talented analyst would recommend project acceptance (for high θ) or rejection (for low θ) regardless of the signal. Since the untalented analyst can never do better than mimic the talented analyst's pure strategy here (or perfectly reveal his type to the VP), it is clear that both analysts provide recommendations completely divorced from their signals and hence the VP would *never* delegate a project for such θs. Similarly, it cannot be an equilibrium for the talented analyst to misrepresent as part of a mixed strategy. To see this, consider first a low-θ project. If the signal is s_B, both types of analysts will recommend rejection. The reason is that rejection is consistent with both the analyst's signal and the VP's prior belief. But suppose the analyst receives an s_G signal. Assume *counterfactually* that the talented analyst is indifferent between the two recommendations at this θ value, and thus randomizes between recommending acceptance and rejection. However, since the untalented analyst's signal precision is lower, he will strictly prefer to recommend rejection, given the VP's low prior belief. The VP then knows that the probability that the analyst is talented is higher when there is an acceptance than when there is a rejection. Thus, $W_1(\theta, A) > W_1(\theta, R)$, where $W_1(\theta, i)$, $i \in \{A, R\}$, represents the analyst's date-1 wage, and A and R stand for acceptance and rejection, respectively. Moreover, since only the talented analyst recommends acceptance, we have $W_2(\theta, A, s_G, T) > W_2(\theta, R, s_G, T)$, where $W_2(\theta, i, s_j, \tau)$ represents the type-$\tau \in \{T, U\}$ analyst's expected date-2 wage, conditional upon his recommendation $i \in \{A, R\}$ and his signal s_j for $j \in \{G, B\}$. This – taken together with $W_1(\theta, A) > W_1(\theta, R)$ – means recommending acceptance is a strictly-preferred strategy for the talented analyst who observes s_G, contradicting our supposition that he randomizes. A similar argument shows that the talented analyst will not follow a mixed strategy for higher values of θ.

Now consider the untalented analyst. He would like to mimic the talented analyst and diminish the likelihood of being detected as untalented. Let us focus on the case in which the untalented analyst's truth-telling region lies strictly within the delegation region (i.e., $[\theta_L, \theta_H] \subset [\underline{\theta}, \overline{\theta}]$).[7] For $\theta \in [\theta_L, \theta_H]$, the untalented analyst strictly prefers truth-telling because his signal is never "inconsistent" with the VP's prior beliefs about project quality. But what about delegated projects outside of $[\theta_L, \theta_H]$? Suppose there is a project with a very low θ, say $\theta \in [\underline{\theta}, \theta_L)$. It is clear that both types of analysts will recommend rejection of this project if s_B is observed, since this is consistent with both the analyst's signal and the VP's priors. But suppose the analyst has received a signal s_G. The tradeoff for the untalented analyst can now be seen as follows. For a given value of θ, the analyst knows exactly what his date-1 wage will be if he recommends acceptance or rejection. Because the talented analyst receives a more precise signal than the untalented analyst, it is clear

[7] If $[\underline{\theta}, \overline{\theta}] \subseteq [\theta_L, \theta_H]$, there is no misrepresentation to consider.

that for all θ:

$$\begin{aligned}
W_2(\theta, A, s_G, T) &> W_2(\theta, A, s_G, U) \\
W_2(\theta, A, s_G, T) &> W_2(\theta, A, s_B, T) \\
W_2(\theta, R, s_B, T) &> W_2(\theta, A, s_B, T) \\
W_2(\theta, R, s_B, T) &= W_2(\theta, R, s_B, U).
\end{aligned}$$

That is, except when the project is rejected based on an s_B signal, the talented analyst's expected date-2 wage is *always higher* than that of the untalented analyst, and the talented analyst's date-2 expected wage is always higher if he recommends what his signal tells him to than if he goes against the signal. Given that the VP delegates, we have already established that the talented analyst never misrepresents. That is, $W_1(\theta, i) + \delta W_2(\theta, i, s_j, T)$ is always maximized with $i = A$ when $s_j = s_G$ and with $i = R$ when $s_j = s_B$. But the untalented analyst faces a different tradeoff. For a sufficiently low θ, given the relatively high probability that the talented analyst has received an s_B signal and that he will reject, the untalented analyst recognizes that $W_1(\theta, R) > W_1(\theta, A)$. Considering the noise in his signal, the analyst may then find that $W_1(\theta, i) + \delta W_2(\theta, i, s_G, U)$ is maximized with $i = R$, although for the talented analyst $W_1(\theta, i) + \delta W_2(\theta, i, s_G, T)$ is maximized with $i = A$. This would suggest that there could be a critical value of θ, say θ_L, such that the untalented analyst *may* ignore his signal and reject the project unconditionally for all $\theta \in [\underline{\theta}, \theta_L)$.

Note, however, that it cannot be an equilibrium for the untalented analyst to recommend rejection with probability one whenever $\theta \in [\underline{\theta}, \theta_L)$. To see this, suppose counterfactually that it were the case. Then, whenever the analyst rejects a project for which $\theta \in [\underline{\theta}, \theta_L)$, the VP knows at date 1 that the probability that the analyst is untalented is higher than if the analyst had recommended acceptance; this is because both types of analysts reject if s_B is observed, but only the talented analyst accepts if s_G is observed. Hence, W_1 will be *lower* if the analyst rejects than if he accepts. Moreover, since only the talented analyst recommends acceptance, $W_1(\theta, A) = W_2(\theta, A, s_G, \tau) > W_2(\theta, R, s_G, \tau) = W_1(\theta, R)$ for all $\tau \in \{T, U\}$. This means that $W_1(\theta, A) + \delta W_2(\theta, A, s_G, U) > W_1(\theta, R) + \delta W_2(\theta, R, s_G, U)$ and it would be privately suboptimal for the untalented analyst to reject the project with probability one.

But it cannot be an equilibrium for the untalented analyst to recommend acceptance with probability one either. Again, let us suppose counterfactually that he always accepts when s_G is observed and $\theta \in [\underline{\theta}, \theta_L)$. Then the VP recognizes that the probability that the analyst is untalented is higher if he accepts than if he rejects. The reason is as follows. Both types of analysts are recommending acceptance for s_G and rejection for s_B. However, given the VP's low prior belief that the project is good, she believes that the probability that a good signal will be received in this case is higher for an untalented analyst (with lower signal precision) than for a talented analyst. This commingling of the assessments of the project and the analyst means that the analyst's wage W_1 at $t = 1$ will be lower if he accepts than if he rejects. It will now be the case that $W_1(\theta, i) + \delta W_2(\theta, i, s_G, U)$ will be maximized with $i = R$.

So, conditional on observing s_G for a project for which the VP's prior belief is $\theta \in [\underline{\theta}, \theta_L)$, the untalented analyst *cannot* have a pure strategy of either project acceptance or rejection. The probability with which he chooses to recommend rejection of the project as part of a mixed strategy (γ_R) is such that, conditional on the VP using *that* probability in combination with the pure strategy of the talented analyst to compute her posterior beliefs about the type of the analyst recommending acceptance and the anticipated effect of the output realization at $t = 2$, the untalented analyst is indifferent between recommending acceptance and rejection of the project when s_G is observed. Similar intuition holds for the mixed strategy of excessively recommending acceptance when $s = s_B$ is observed when $\theta \in (\theta_H, \overline{\theta}]$.

In the following corollary, we describe how the probabilities with which the untalented analyst plays his mixed strategies are affected by the VP's prior belief that the project being delegated is good.

Corollary 1

The distortions γ_A (excessive acceptance recommendations for $\theta > \theta_H$ values) and γ_R (excessive rejection recommendations for $\theta < \theta_L$) are monotonic in θ over their respective regions, and greatest for extremely high and low values of θ. That is, $\frac{\partial \gamma_A}{\partial \theta} > 0$ for $\theta \in \left(\theta_H, \overline{\theta}\right)$, and $\frac{\partial \gamma_R}{\partial \theta} < 0$ for $\theta \in (\underline{\theta}, \theta_L)$, with $\gamma_A|_{\theta=\theta_H} = 0$ and $\gamma_R|_{\theta=\theta_L} = 0$.

The intuition for this corollary is that at very high or very low values of the prior belief θ, the "sunflower incentives" are most severe for untalented analysts because the negative reputational consequences of going against the VP's prior beliefs are the greatest.

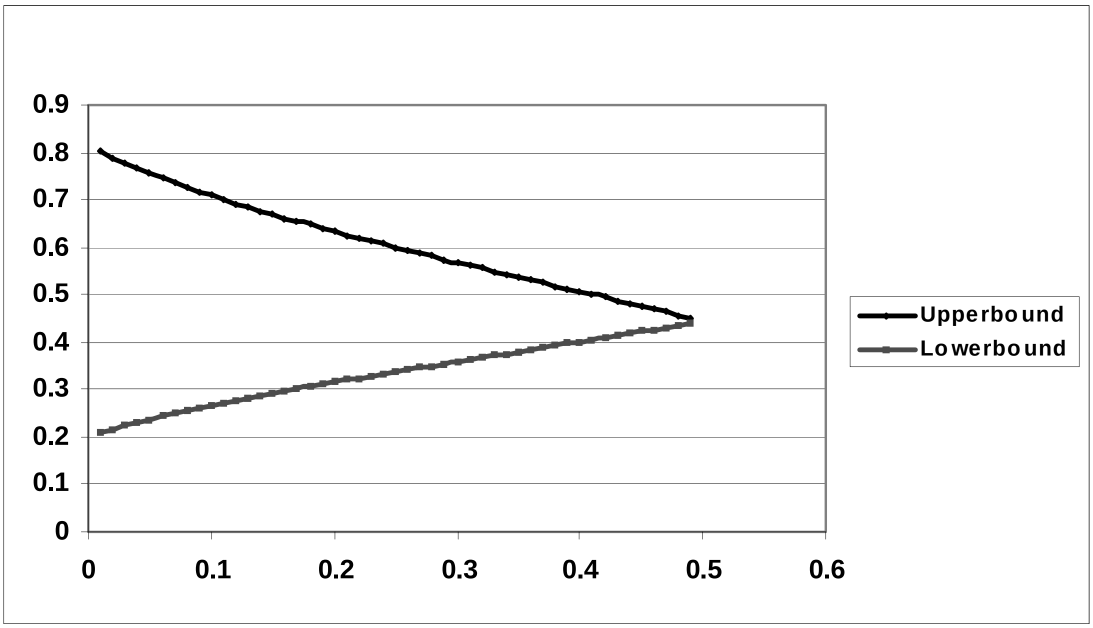
VP's Optimal Delegation Region

With the characterization of the third-best equilibrium, we can now return to the VP's optimal delegation policy in light of the distortionary behavior of the untalented analysts. As summarized in the following corollary, the third-best delegation region is a function of β, ε, δ, and C.

Corollary 2

Over an extensive range of exogenous parameter values, the lower and upper bounds of the third-best delegation region behave as follows: the lower bound ($\underline{\theta}$) is increasing in ε, δ, and C, and decreasing in β; the upper bound ($\overline{\theta}$) is decreasing in ε and C, and increasing in β and δ.[8]

Figure 3: Delegation as a Function of Epsilon



[8]The baseline parameters for this corollary are $H = 2.25$ and $I = 1.0$. Moreover, when a variable is not involved in the numerical comparative static, it takes a fixed numerical value. These values are: $\varepsilon = 0.25$, $\delta = 0.5$, $\beta = 0.45$, and $C = 0.25$.

Figure 4: Delegation as a Function of Cost

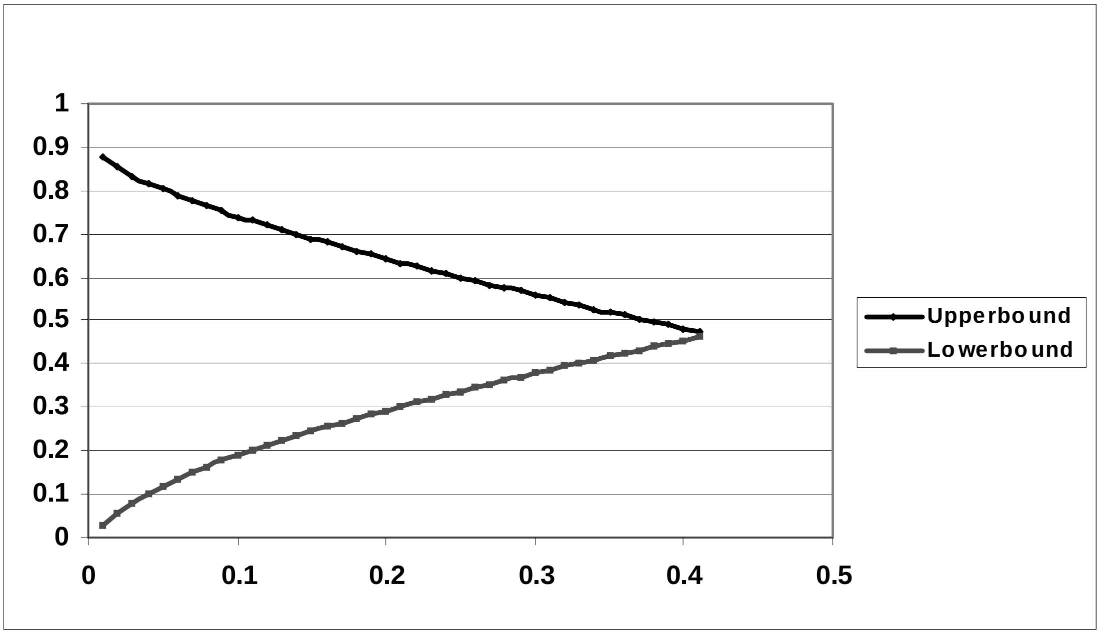


Figure 5: Delegation as a Function of Beta

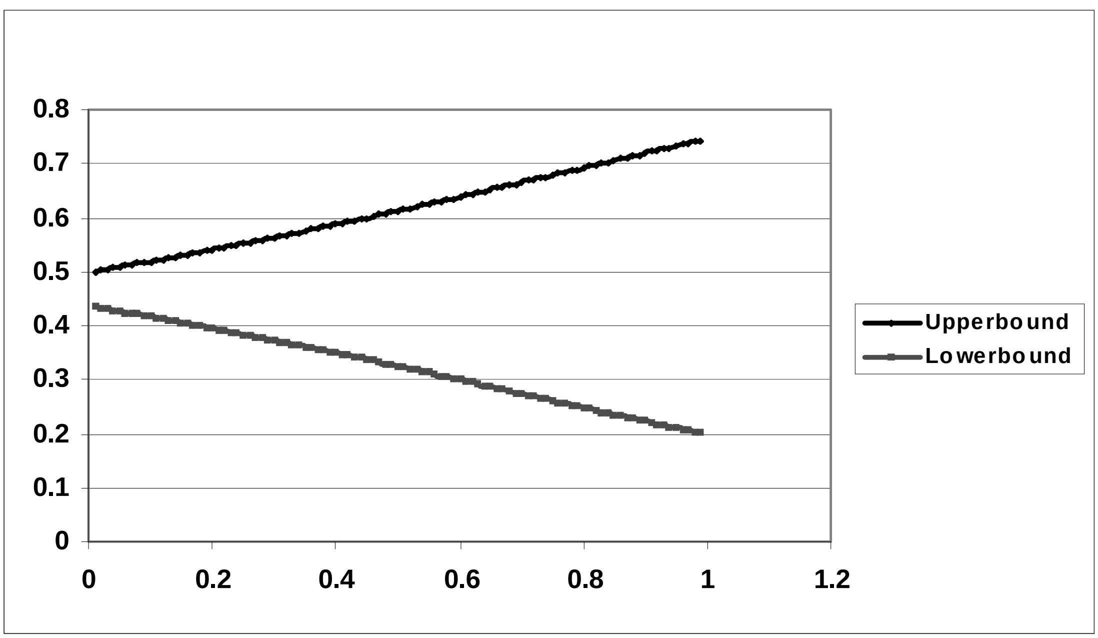
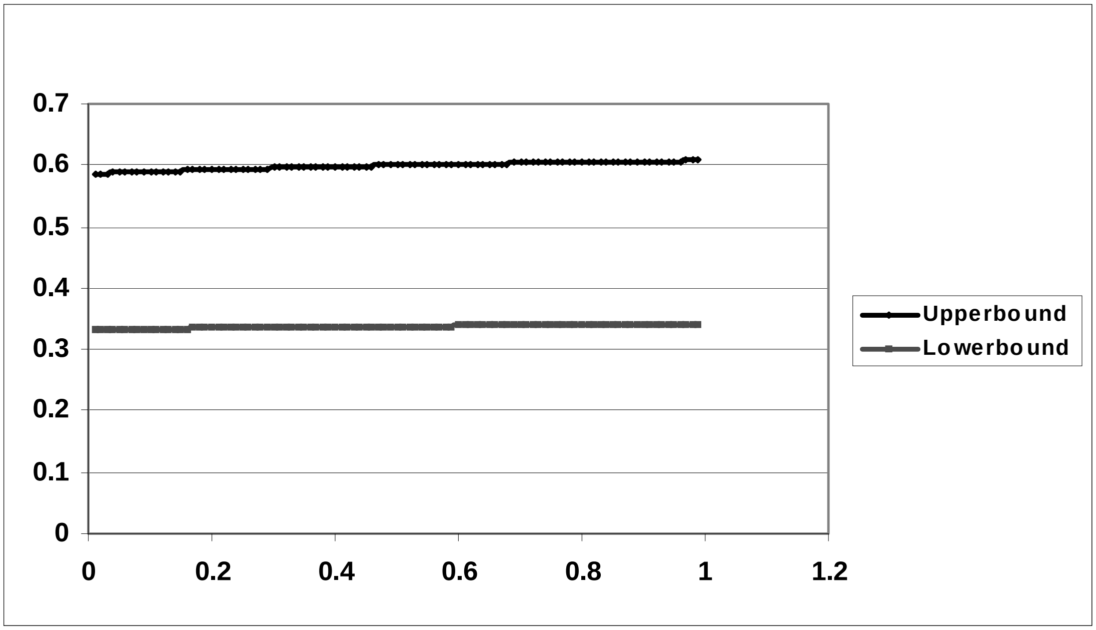


Figure 6: Delegation as a Function of Delta



This corollary is established using extensive numerical analysis because the analytics of the comparative statics are messy. However, the numerical analysis yields intuitively appealing results. First consider ε, the probability that an untalented analyst received an erroneous signal. As ε increases, the untalented analyst recognizes that his signal is less reliable, so the attractiveness of sunflower management increases. This causes the delegation region to shrink because the VP attaches lesser value to the analyst's report for relatively low and high values of her prior belief about project quality.

Next consider C, the direct cost of delegation. As C increases, it obviously makes delegation less attractive since the marginal value of delegation is unaffected, but the cost goes up. Hence, the delegation region shrinks.

The behavior of the delegation region with respect to β, the prior probability that the analyst is talented, is also intuitive. Since it is only the untalented analyst who practices sunflower management, an increase in β connotes a probabilistic decrease in sunflower management and hence an increase in the delegation region.

Finally, consider δ, the weight attached by the analyst to his terminal reputational payoff. As δ increases, the entire delegation region shifts to the right. It is clear why the upper end-point of the region, $\overline{\theta}$, increases. Because the analyst cares more about the terminal payoff (as δ increases)and this payoff depends on whether he recommends in accordance with his informative signal, the analyst is less prone to recommending project acceptance regardless of his signal simply because the VP has high priors about project quality.

But why does the lower bound of the delegation region, $\underline{\theta}$, increase, resulting in fewer delegated projects when the VP has relatively low priors about project quality? The reason is that there is an asymmetry of observability in our model. The VP only observes payoffs on accepted projects and not on rejected projects (see Milbourn, Shockley, and Thakor (2001) for an extensive examination of the implications of this assumption). As the terminal reputational payoff becomes more important, the consequence of making an incorrect *acceptance* recommendation becomes larger for the analyst. However, if he recommends rejection of the project, the underlying merits of this decision are never observed. This asymmetry in project payoff observability means that the analyst becomes more prone to reject projects for which the VP has lower priors when the terminal reputational payoff increases in importance. Hence, the VP delegates fewer projects for which she has relatively low prior beliefs.

4 Capital Budgeting Implications of Sunflower Management

Our analysis leads to implications for the design of capital budgeting systems, in particular the choice between centralized and decentralized capital budgeting. In most organizations, what we observe are *hybrid* capital budgeting systems. Some projects have to be approved by top management (centralized capital budgeting), whereas others can be approved at lower levels (decentralized capital budgeting). We discuss below the implications of our analysis for this choice.

4.1 Centralized versus Decentralized Capital Budgeting

In our model, when the VP delegates a project to the analyst, she always accepts his recommendation. An equivalent scheme would be one in which the VP simply delegates the project-selection decision to the analyst. This can be viewed as a decentralized capital budgeting system. For projects that lie outside the delegation region, the VP decides on her own whether to invest. We can view this as centralized capital budgeting. Our model, particularly the comparative statics analysis, thus implies that the key factors that will affect whether one uses centralized or decentralized capital budgeting are: the VP's prior beliefs about project quality, the analyst's concern with his future reputation (which may depend on his expected job duration), the difficulty of evaluating the project, and the VP's prior belief about the analyst's talent in evaluating projects.

Centralized capital budgeting will be used for projects about which the VP has strong prior beliefs, i.e., projects that are *a priori* viewed as being of very high or low quality. For relatively high-quality projects, it will also be used when analysts have relatively short job durations and hence a low concern with future reputation in this firm, i.e., a low δ.[9] In the case of relatively low-quality projects, centralized capital budgeting may be used regardless of the weight the analyst attaches to his future reputation. Further, centralized capital budgeting will be used for projects that are difficult for the analyst to evaluate (such as new ventures) because the untalented analyst's ε (probability of receiving an erroneous signal) will be high for such projects. Finally, centralized capital budgeting will also be used when the VP has a high prior belief that the analyst is untalented (β is low), because it is the untalented analyst who practices sunflower management.

Decentralized capital budgeting will be used when the VP is relatively unsure of project quality, but believes that the analyst is sufficiently talented in assessing project quality and, for high-quality projects, the analyst has a relatively long expected duration on the job. Moreover, decentralized capital budgeting will be used more for high-quality projects when analyst's wages are more performance-sensitive, i.e., depend more explicitly on observed project performance than on subjective measures of performance. Thus, whenever a firm faces a variety of project opportunities, we should expect "mixed" capital budgeting systems, with centralized capital budgeting being used for some kinds of projects and decentralized capital budgeting for others.

4.2 Overinvestment Propensity

In our analysis, we have considered projects for which the VP has low prior beliefs about quality as well as those for which she has high prior beliefs. In practice, the VP must *prescreen* multiple projects to determine which to delegate for analysis. With scarce organizational resources – particularly the time available for evaluating projects – the VP may be forced to *ration* projects sent to analysts. What effect will this have on capital budgeting?

To address the question, consider a VP faced with the task of determining which of two mutually-exclusive projects she should have evaluated, one with a relatively low θ, say θ_1, and one with a relatively high θ, say θ_2, with $\theta_1 < \theta_2$. Both θ_1 and θ_2 are in the interior of the third-best delegation region $\left[\underline{\theta}, \overline{\theta}\right]$. Each project has the same direct cost of delegation, C. The availability of analysts' time is such that only one project can be evaluated, and the organization requires an analyst's assessment before the VP can invest in the project.

[9]This is not to say that the analyst is not career-conscious. It simply reflects the fact that it is unlikely he will be in *this* firm and have the project payoff affect his reputation.

Theorem 4

If projects cannot be accepted without evaluation and the VP can have only one of two mutually-exclusive projects investigated, with prior beliefs given by θ_1 and θ_2, with $\underline{\theta} < \theta_1 < \theta_2 < \overline{\theta}$, then she will prefer to delegate the project with θ_2 down for evaluation by the analyst.

The intuition is as follows. Consider first projects with $\theta \in [\theta_L, \theta_H]$; in this region, both types of analysts always report truthfully. Hence, the expected value of the higher-θ project exceeds that of the lower-θ project, and the VP prefers to have the former investigated. However, the intuition is less obvious when one of the θs, say θ_1, lies in the truth-telling region $[\theta_L, \theta_H]$, and θ_2 lies outside it, say in $(\theta_H, \overline{\theta}]$. Although the θ_2-project has a higher expected value in the first-best case, there is now a loss due to possible misrepresentation by the untalented analyst. This loss is associated with only the θ_2-project, since the θ_1-project lies in $[\theta_L, \theta_H]$. What is surprising about *Theorem 4* is that the VP's preference for the θ_2-project is unaffected by the expected loss in value due to possible misrepresentation in the third-best equilibrium. The reason is that the difference in prior beliefs about project quality creates a first-order effect on expected value, whereas the reporting distortion is a second-order effect that is always dominated.

Theorem 4 implies that a paucity of organizational project-evaluation resources can create a bias in favor of projects about which the VP has high prior beliefs. We know from our analysis that in such cases sunflower management leads to overinvestment. Thus, when the firm increases the amount of capital available for investment, we would expect a concomitant increase in the expected losses due to overinvestment. Note that this overinvestment arises despite the fact that neither the VP nor the analyst has any innate desire for capital or "empire building". The two conditions needed for overinvestment are that the analyst has career concerns and that project-evaluation resources are constrained. Thus, if a firm increases the amount of capital available for investment but does not expand the project-evaluation resources, these resources will become more constrained, leading to an overinvestment distortion that will plague not only the incremental projects being financed with the additional capital, but also all other projects. This may shed some light on the somewhat surprising empirical finding that every type of external financing leads to long-run underperformance by the firm, i.e., overinvestment seems to accompany the raising of additional capital to finance investments.[10]

[10] As documented by Billett, Flannery, and Garfinkel (2001), even bank financing raised for capital investments – which is the only type of external finance for which the stock price announcement return is pervasively positive across numerous empirical studies – ultimately leads to three-year *underperformance* for the borrowing firm's shareholders.

5 Conclusion

We have developed a model in which the interaction between project delegation and career concerns produces a phenomenon we call "sunflower management". Simply put, sunflower management is the inclination for employees to act in a manner that produces consensus between their own views and the views they ascribe to their superiors. This diminishes the value of delegation and is value-dissipating because the organization explicitly dedicates resources to generate *multiple* signals about business situations. Thus, when employees disregard the information conveyed by their signals to produce recommendations that agree with the prior beliefs of the people they report to, the damage done to the organization exceeds not just the cost associated with the loss of information aggregation. In particular, bad projects may be chosen and good projects may be discarded. We have used this analysis to explain the tradeoffs inherent in the choice between centralized and decentralized capital budgeting.

6 Appendix

6.1 Proof of Theorem 1

We prove this theorem in two steps for the first-best case. First, we establish that there exist two θ's, defined as $\overline{\theta}_T^{FB}$ and $\overline{\theta}_U^{FB}$, such that the VP optimally invests in any project without delegation for which $\theta > \overline{\theta}_T^{FB}$ if the analyst is talented, and for $\theta > \overline{\theta}_U^{FB}$ if the analyst is untalented. We also will show that $\overline{\theta}_U^{FB} < \overline{\theta}_T^{FB}$. Second, we establish that there exist two θ's, defined as $\underline{\theta}_T^{FB}$ and $\underline{\theta}_U^{FB}$, such that the VP optimally rejects any project without delegation for which $\theta < \underline{\theta}_T^{FB}$ if the analyst is talented, and for $\theta < \underline{\theta}_U^{FB}$ if the analyst is untalented. We will also show that $\underline{\theta}_T^{FB} < \underline{\theta}_U^{FB}$.

Consider first a talented analyst. To establish the existence of $\overline{\theta}_T^{FB}$, we derive the θ such that the VP is indifferent between investing in the project without delegation and with delegating the project. That is, $\theta = \overline{\theta}_T^{FB}$ is the solution to

$$\begin{aligned}
\theta H - I &= E[NPV \text{ of delegation}] - C \\
\theta H - I &= \begin{bmatrix} \Pr(G) \times \Pr(s = s_G | G, T) \times [H - I] \\ + \Pr(B) \times \Pr(s = s_G | B, T) \times [-I] \end{bmatrix} - C \\
\theta H - I &= \begin{bmatrix} \theta \times 1 \times [H - I] \\ + [1 - \theta] \times 0 \times [-I] \end{bmatrix} - C.
\end{aligned}$$

We can simplify the above expression to see that $\overline{\theta}_T^{FB} = \frac{I-C}{I}$. A similar analysis obtains for the untalented analyst, for which his signal is imperfectly informative. In the derivation that follows, we use the result that the untalented analyst only gets delegated projects for which his (noisy) signal is strong enough to overcome the prior. That is, the first-best reporting strategy of the untalented analyst is to recommend in accordance with his signal. Thus, $\theta = \overline{\theta}_U^{FB}$ is the solution to

$$\begin{aligned}
\theta H - I &= E[NPV \text{ of delegation}] - C \\
\theta H - I &= \begin{bmatrix} \Pr(G) \times \Pr(s = s_G | G, U) \times [H - I] \\ + \Pr(B) \times \Pr(s = s_G | B, U) \times [-I] \end{bmatrix} - C \\
\theta H - I &= \begin{bmatrix} \theta \times [1 - \varepsilon] \times [H - I] \\ + [1 - \theta] \times [\varepsilon] \times [-I] \end{bmatrix} - C.
\end{aligned}$$

We can simplify the above expression to see that $\overline{\theta}_U^{FB} = \frac{I[1-\varepsilon]-C}{\varepsilon H + I[1-2\varepsilon]}$. It can easily be established that $\overline{\theta}_U^{FB} < \overline{\theta}_T^{FB}$ owing to the fact that $\varepsilon \in \left(0, \frac{1}{2}\right)$.

To establish the lower bound of the delegation region for the talented analyst, we observe that $\theta = \underline{\theta}_T^{FB}$ is the solution to

$$0 = \begin{bmatrix} \theta \times 1 \times [H - I] \\ +[1-\theta] \times 0 \times [-I] \end{bmatrix} - C,$$

which is given by $\underline{\theta}_T^{FB} = \frac{C}{H-I}$. For the untalented analyst, $\theta = \underline{\theta}_U^{FB}$ is the solution to

$$\begin{aligned} 0 &= E[NPV \text{ of delegation}] - C \\ 0 &= \begin{bmatrix} \theta \times [1-\varepsilon] \times [H - I] \\ +[1-\theta] \times [\varepsilon] \times [-I] \end{bmatrix} - C, \end{aligned}$$

which is given by $\underline{\theta}_U^{FB} = \frac{C+\varepsilon I}{\varepsilon I + [1-\varepsilon][H-I]}$. Again, given that $\varepsilon \in \left(0, \frac{1}{2}\right)$, we see that $\underline{\theta}_T^{FB} < \underline{\theta}_U^{FB}$. Therefore, $\left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right] \subset \left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right]$. ■

6.2 Proof of Theorem 2

Like *Theorem 1*, we prove this theorem in two steps for the second-best case. First, we establish the existence of a θ, defined as $\overline{\theta}^{SB}$, such that the VP optimally invests in any project without delegation for which $\theta > \overline{\theta}^{SB}$ if the analyst's type is unknown. We also will show that $\overline{\theta}_U^{FB} < \overline{\theta}^{SB} < \overline{\theta}_T^{FB}$. Second, we establish the existence of a θ, defined as $\underline{\theta}^{FB}$, such that the VP optimally rejects any project without delegation for which $\theta < \underline{\theta}^{SB}$ if the analyst's type is unknown. We will also show that $\underline{\theta}_T^{FB} < \underline{\theta}^{SB} < \underline{\theta}_U^{FB}$.

To establish the existence of $\overline{\theta}^{SB}$, we derive the θ such that the VP is indifferent between investing in the project without delegation and delegating the project. As in *Theorem 1*, we have the analyst recommending in accordance with his signal. That is, within the delegation region, the signal of both types of analysts is sufficiently precise to overcome the prior. Since we now derive a joint delegation region for the talented and untalented analysts together, we need to assume a sufficiently sizeable delegation cost (see also footnote 5). That is, $\theta = \overline{\theta}^{SB}$ is the solution to

$$\begin{aligned} \theta H - I &= E[NPV \text{ of delegation}] - C \\ \theta H - I &= \begin{bmatrix} \Pr(G) \times \Pr(s = s_G|G) \times [H - I] \\ +\Pr(B) \times \Pr(s = s_G|B) \times [-I] \end{bmatrix} - C \\ \theta H - I &= \begin{bmatrix} \theta\,[\Pr(s = s_G|G,T)\Pr(T) + \Pr(s = s_G|G,U)\Pr(U)]\,[H - I] \\ +[1-\theta]\,[\Pr(s = s_G|B,T)\Pr(T) + \Pr(s = s_G|B,U)\Pr(U)]\,[-I] \\ -C \end{bmatrix} \\ \theta H - I &= \begin{bmatrix} \theta\,[1 \times \beta + [1-\varepsilon]\,[1-\beta]]\,[H - I] \\ +[1-\theta]\,[0 \times \beta + \varepsilon \times [1-\beta]]\,[-I] \end{bmatrix} - C. \end{aligned}$$

We can simplify the above expression to see that $\overline{\theta}^{SB} = \frac{I[1-\varepsilon[1-\beta]]-C}{H[1-[\beta+[1-\beta][1-\varepsilon]]]+I[1-\beta][1-2\varepsilon]}$. It can easily be established that $\overline{\theta}_U^{FB} < \overline{\theta}^{SB} < \overline{\theta}_T^{FB}$ owing to the fact that $\varepsilon \in \left(0, \frac{1}{2}\right)$ and $\beta \in (0,1)$.

To establish the lower bound of the delegation region when the analyst's type is unknown, we observe that $\underline{\theta}^{SB}$ is the solution to

$$0 = \left[\begin{array}{c} \theta\left[1 \times \beta + [1-\varepsilon]\left[1-\beta\right]\right][H-I] \\ +[1-\theta]\left[0 \times \beta + \varepsilon \times [1-\beta]\right][-I] \end{array}\right] - C,$$

which is given by $\underline{\theta}^{SB} = \frac{C+\varepsilon[1-\beta]I}{\varepsilon[1-\beta]I+[\beta+[1-\varepsilon][1-\beta]][H-I]}$. Again, given that $\varepsilon \in \left(0, \frac{1}{2}\right)$ and $\beta \in (0,1)$, we see that $\underline{\theta}_T^{FB} < \underline{\theta}^{SB} < \underline{\theta}_U^{FB}$. Therefore, $\left[\underline{\theta}_U^{FB}, \overline{\theta}_U^{FB}\right] \subset \left[\underline{\theta}^{SB}, \overline{\theta}^{SB}\right] \subset \left[\underline{\theta}_T^{FB}, \overline{\theta}_T^{FB}\right]$. ■

6.3 Proof of Lemma 1

If all analysts always recommend rejection or acceptance regardless of their signal, delegation has no value to the VP. Given the cost of delegation C, she will optimally choose not to delegate.[11] ■

6.4 Proof of Theorem 3

The proof is in five steps. The first two steps establish that the talented analyst never misreports. That is, he never goes against his signal using either a pure strategy or a mixed strategy. The third through fifth steps derive the VP's posterior beliefs in various states and verify the misreporting incentives of the untalented analyst as well as the different regions of prior beliefs about project quality that are distinguished by the reporting incentives of the analyst.

Step One: The Talented Analyst Does Not Misreport in Equilibrium as Part of a Pure Strategy:

First, observe that we cannot have an equilibrium in which the talented analyst follows a pure strategy of making recommendations that go against his signal. That is, if for a low θ and the signal s_G the talented analyst recommends rejection regardless of the signal, then the untalented analyst would also choose to always reject (recommending acceptance would perfectly reveal his type to the VP). Given this reporting strategy, delegation has no value. For any positive delegation

[11] Observe that, in the absence of a delegation cost, always recommending acceptance and/or rejection are Bayesian perfect Nash equilibria. The equilibrium where everyone rejects regardless of the signal can be supported by the (implausible) off-the-equilibrium path belief that an analyst is untalented with probability one if he chooses to recommend acceptance. Similarly, the equilibrium where all analysts recommend acceptance regardless of the signal observed can be supported by the off-the-equilibrium path belief that an analyst is untalented with probability one if he recommends rejection. However, as stated above, given a positive delegation cost, no delegation will occur once these candidate equilibria are anticipated.

cost, the VP would then choose not to delegate. The same argument holds for high θ and the signal s_B.

Step Two: The Talented Analyst Does Not Misrepresent in Equilibrium as Part of a Mixed Strategy:

Second, we can establish that the talented analyst will not follow a mixed strategy in equilibrium. To see this, again consider a low θ project and the signal s_G and assume counterfactually that the talented analyst is indifferent between A and R, so he randomizes between the two. It follows now that the untalented analyst strictly prefers to recommend rejection. That is, the noisy signal makes recommending acceptance strictly worse for the untalented analyst than for the talented analyst; recommending rejection gives both types of analysts the same intertemporal utility. Hence, once the talented analyst chooses to randomize, the untalented analyst strictly prefers to reject. What this implies is that *only* talented analysts ever recommend acceptance, hence $W_1(\theta, R) < W_1(\theta, A)$ and $W_1(\theta, A) = W_2(\theta, A, s_G, T) = E(W_2(\theta, A, s_G, T))$ (only the talented analyst recommends acceptance, thus there is no further updating of beliefs over type by the VP after date $t = 1$). We now have $(1+\delta)W_1(\theta, R) < W_1(\theta, A) + \delta E(W_2(\theta, A, s_G, T))$. This, however, contradicts the conjectured indifference of the talented analyst between recommending rejection and acceptance. Thus, the equilibrium cannot be one in which that talented analyst plays a mixed strategy in equilibrium. A similar proof holds for high θ and the signal s_B.

Observe also that for signals that "match" the priors of the VP, no reporting distortions occur. That is, recommendations are always in accordance with the signal when θ is relatively low and the signal is s_B, or when θ is relatively high and the signal is s_G.

Before we can characterize the equilibrium (distorted) choices of the untalented analyst, we need to examine how the analyst's reputation evolves. Since the untalented analyst's conjectured equilibrium behavior is dependent on the VP's prior θ, we first derive the VP's posterior assessments of ability at dates $t = 1$ and $t = 2$ for $\theta < \theta_L$ and $\theta > \theta_H$ separately, with $0 < \theta_L < \theta_H < 1$.

Step Three: The Analyst's Reputation (VP's Posterior Belief about his Ability) in the Conjectured Equilibrium:

Projects for Which $\theta \in [\underline{\theta}, \theta_L)$: For these projects, we know that the talented analyst recommends in accordance with his signal, whereas the untalented analyst is conjectured to always recommend rejection when $s = s_B$ is observed, and recommend rejection with probability γ_R and acceptance with probability $1-\gamma_R$ if $s=s_G$ is observed. If the analyst recommends rejection of the project, the posterior assessment of his ability at both dates $t=1$ and $t=2$ is thus given by[12]

$$\Pr(T_1|R)=\Pr(T_2|R)=\frac{\beta(1-\theta)}{\beta(1-\theta)+(1-\beta)(((1-\varepsilon)\theta+\varepsilon(1-\theta))\gamma_R+(\varepsilon\theta+(1-\varepsilon)(1-\theta)))}. \quad (10)$$

And if the analyst recommends acceptance, the posterior assessment of his ability at $t=1$ is given by

$$\Pr(T_1|A)=\frac{\beta\theta}{\beta\theta+(1-\beta)((1-\varepsilon)\theta+\varepsilon(1-\theta))(1-\gamma_R)}. \quad (11)$$

At date $t=2$, his reputation varies based on whether the project pays off a positive amount H or zero. These two reputations are given by

$$\Pr(T_2|A,H)=\frac{\beta}{\beta+(1-\beta)(1-\varepsilon)(1-\gamma_R)} \quad (12)$$

and

$$\Pr(T_2|A,Zero)=0. \quad (13)$$

Projects for Which $\theta\in(\theta_H,\overline{\theta}]$: For these projects, the talented analyst recommends in accordance with his signal, whereas the untalented analyst is conjectured to always recommend acceptance when $s=s_G$ is observed, and recommends acceptance with probability γ_A and rejection with probability $1-\gamma_A$ if $s=s_B$ is observed. If the analyst recommends rejection of the project, the posterior assessment of his ability at both dates $t=1$ and $t=2$ is given by

$$\Pr(T_1|R)=\Pr(T_2|R)=\frac{\beta(1-\theta)}{\beta(1-\theta)+(1-\beta)(\varepsilon\theta+(1-\varepsilon)(1-\theta))(1-\gamma_A)}. \quad (14)$$

Alternatively, if the analyst recommends acceptance, the posterior ability assessment at $t=1$ is given by

$$\Pr(T_1|A)=\frac{\beta\theta}{\beta\theta+(1-\beta)(((1-\varepsilon)\theta+\varepsilon(1-\theta))+(\varepsilon\theta+(1-\varepsilon)(1-\theta))\gamma_A)}. \quad (15)$$

At date $t=2$, his reputation varies based on whether the project pays off H or zero. These two reputations are given by

$$\Pr(T_2|A,H)=\frac{\beta}{\beta+(1-\beta)((1-\varepsilon)+\varepsilon\gamma_A)} \quad (16)$$

and

$$\Pr(T_2|A,Zero)=0. \quad (17)$$

[12]Recall that rejected projects produce no additional information.

Step Four: Verifying the Conjectured Equilibrium Behavior of the Talented and Untalented Analysts:

For the purpose of the proof, define $\tau \in \{T_G, T_B, U_G, U_B\}$ as the set of "composite types", where T and U indicate the type of the analyst, and G and B the signal they received (e.g., T_G is a talented analyst that received the good signal $s = s_G$).

There are just two possible actions: recommend rejection (R) or recommend acceptance (A). We will verify that U_G and/or U_B may randomize across these two actions depending on the value of the prior θ, but T_G and T_B always prefer to follow their signal and hence adhere to a pure strategy. We prove this as follows. First, we identify the mixed strategy (randomization) for high and low values of θ. Then we identify the θ ranges.

(i) Type U_B Randomizes for High Values of θ: Assume T_G, T_B and U_G follow their conjectured equilibrium strategies, and let U_B recommend acceptance with probability γ_A and rejection with probability $1 - \gamma_A$. In the conjectured equilibrium, U_B should be indifferent between recommending acceptance and rejection, hence

$$\Pr(T_1|A) + \delta \begin{bmatrix} \Pr(H|s_B, U) \Pr(T_2|A, H) \\ + \Pr(0|s_B, U) \Pr(T_2|A, 0) \end{bmatrix} = (1 + \delta) \Pr(T_1|R), \tag{18}$$

where

$$\Pr(H|s_B, U) = \frac{\varepsilon\theta}{\varepsilon\theta + (1 - \varepsilon)(1 - \theta)} \tag{19}$$

and

$$\Pr(0|s_B, U) = \frac{(1 - \varepsilon)(1 - \theta)}{\varepsilon\theta + (1 - \varepsilon)(1 - \theta)}. \tag{20}$$

From (18), the following result can be established immediately.

Result 1: The left hand side (LHS) of (18) is monotonically increasing in γ_A, while the RHS is monotonically decreasing in γ_A.

We now show that the equality in (18) can only hold for an interior $\gamma_A \in (0, 1)$, provided that θ is sufficiently high (i.e., $\theta > \theta_H$). First, observe using (14) through (17), (19) and (20) that at $\gamma_A = 0$, $\Pr(T_1|A) > \Pr(T_1|R)$ and $\Pr(H|s_B, U) \times \Pr(T_2|A, H) > \Pr(T_1|R)$ provided that θ is sufficiently high. Hence, the LHS of (18) is strictly less than the RHS. Thus, by Result 1, equality in (18) requires that $\gamma_A > 0$. Now, evaluate (18) at $\gamma_A = 1$. It immediately follows that the LHS of (18) exceeds the RHS. Thus, by Result 1, we now have $0 < \gamma_A < 1$.

(ii) Types T_G, T_B and U_G Recommend According to Their Respective Signals for High Values of θ: Given equality in (18) for U_B, it is easy to show that T_B strictly prefers to follow his signal (i.e., recommend rejection). This immediately follows from the fact that $\Pr(H|s_B, T) < \Pr(H|s_B, U)$. Thus, T_B has strictly less to gain from recommending acceptance than U_B (note that the probabilities $\Pr(0|s_B, T)$ and $\Pr(0|s_B, U)$ do not matter because they are multiplied by a factor that equals zero). For T_G and U_G, it is easy to show that they always recommend acceptance (observe that $\Pr(H|s_G, T) > \Pr(H|s_G, U) > \Pr(H|s_B, U)$.

(iii) Type U_G Randomizes for Low Values of θ: The proof of this mirrors the previous arguments, now using (10) through (13), (19) and (20). U_G now recommends rejection with probability γ_R, and this is in the interior of $(0,1)$ if θ is sufficiently low. In the conjectured equilibrium we have

$$\Pr(T_1|A) + \delta \left[\begin{array}{c} \Pr(H|s_G, U)\Pr(T_2|A, H) \\ +\Pr(0|s_G, U)\Pr(T_2|A, 0) \end{array} \right] = (1+\delta)\Pr(T_1|R) \tag{21}$$

Following arguments analogous to those above, we can show that $0 < \gamma_R < 1$.

(iv) Types T_G, T_B and U_B Follow Their Respective Signals for Low Values of θ: Again, similar arguments to those under (ii) verify this claim. Given the equality for U_G in (21), T_G strictly prefers to recommend acceptance given that $\Pr(H|s_G, T) > \Pr(H|s_G, U)$. Similarly, T_B and U_B always recommend rejection since $\Pr(H|s_B, T) < \Pr(H|s_B, U) < \Pr(H|s_G, U)$.

Step Five: Establishing the Distinct θ Ranges:

Define $\theta = \theta_H$ as the value of θ for which (18) holds for $\gamma_A = 0$. Similarly, define $\theta = \theta_L$ as the value of θ for which (21) holds for $\gamma_R = 0$. First, we can show after some tedious algebra that $\frac{\partial \gamma_A}{\partial \theta} > 0$ and $\frac{\partial \gamma_R}{\partial \theta} < 0$. Also, from (18) and (21) we see that in the limit as $\theta \longrightarrow 1$, we have $\gamma_A = 1$, and as $\theta \longrightarrow 0$, we have $\gamma_R = 1$. Thus, in the range $(\theta_H, 1)$, we have excessive acceptance recommendations ($\gamma_A > 0$), and in the range $(0, \theta_L)$, we have excessive rejection recommendations.

We now show that $\theta_L < \theta_H$, and hence a region $[\theta_L, \theta_H]$ of positive measure exists where there is no misreporting by the untalented analyst. At $\theta = \theta_L$ (substitute $\gamma_R = 0$ in (10) through (13)), the equality (21) is identical to (18) (here substitute $\gamma_A = 0$ in (14) through (17)) *except* for the respective probabilities of $\Pr(H|s_G, U)$ and $\Pr(H|s_B, U)$. Since $\Pr(H|s_G, U) > \Pr(H|s_B, U)$, equality in (21), respectively (18), requires that $\theta_L < \theta_H$.

■

6.5 Proof of Corollary 1

The proof is contained within the proof of *Theorem 3*. ■

6.6 Proof of Corollary 2

In the numerical analysis, we establish the value of the lower bound ($\underline{\theta}$) and upper bound ($\overline{\theta}$) of the third-best delegation regions analogously to the proof of *Theorem 2*. However, the addition of the untalented analyst's distortionary behavior over some regions of project quality reduces the marginal value of delegation.

To establish the value of $\overline{\theta}$, we derive the θ such that the VP is indifferent between investing in the project without delegation and delegating the project. That is, $\theta = \overline{\theta}$ is the solution to

$$\begin{aligned}
\theta H - I &= E[NPV \text{ of delegation}] - C \\
\theta H - I &= \begin{bmatrix} \Pr(G) \times \Pr(A|G) \times [H-I] \\ +\Pr(B) \times \Pr(A|B) \times [-I] \end{bmatrix} - C \\
\theta H - I &= \begin{bmatrix} \theta \begin{bmatrix} \Pr(s=s_G|G,T)\Pr(T) \\ + \begin{bmatrix} \Pr(s=s_G|G,U) \\ +\Pr(s=s_B|G,U)\gamma_A \end{bmatrix} \Pr(U) \end{bmatrix} [H-I] \\ +[1-\theta] \begin{bmatrix} \Pr(s=s_G|B,T)\Pr(T) \\ + \begin{bmatrix} \Pr(s=s_G|B,U) \\ +\Pr(s=s_B|B,U)\gamma_A \end{bmatrix} \Pr(U) \end{bmatrix} [-I] \end{bmatrix} - C \\
\theta H - I &= \begin{bmatrix} \theta\left[\beta + (1-\beta)(1-\varepsilon+\varepsilon\gamma_A)\right][H-I] \\ +(1-\theta)(1-\beta)\left[\varepsilon + (1-\varepsilon)\gamma_A\right][-I] \end{bmatrix} - C,
\end{aligned}$$

where γ_A is given by the solution to (18).

To establish the value of $\underline{\theta}$, we estimate it as the solution to

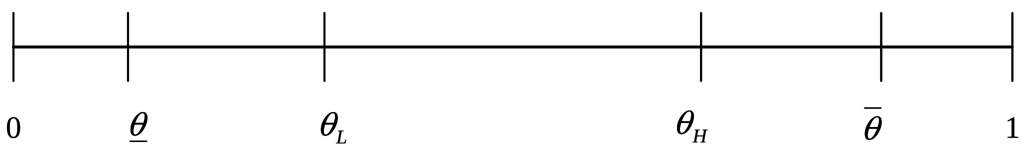
$$\begin{aligned}
0 &= E[NPV \text{ of delegation}] - C \\
0 &= \begin{bmatrix} \Pr(G) \times \Pr(A|G) \times [H-I] \\ +\Pr(B) \times \Pr(A|B) \times [-I] \end{bmatrix} - C \\
0 &= \begin{bmatrix} \theta \begin{bmatrix} \Pr(s=s_G|G,T)\Pr(T) \\ +[\Pr(s=s_G|G,U)[1-\gamma_R]]\Pr(U) \end{bmatrix} [H-I] \\ +[1-\theta] \begin{bmatrix} \Pr(s=s_G|B,T)\Pr(T) \\ +[\Pr(s=s_G|B,U)[1-\gamma_R]]\Pr(U) \end{bmatrix} [-I] \end{bmatrix} - C
\end{aligned}$$

$$0 = \left[\begin{array}{c} \theta\left[\beta + (1-\beta)(1-\varepsilon)(1-\gamma_R)\right][H - I] \\ +(1-\theta)(1-\beta)(1-\gamma_R)\varepsilon\,[-I] \end{array} \right] - C,$$

where γ_A is given by the solution to (21). ■

6.7 Proof of Theorem 4

The theorem can be proven as follows. Consider the following regions, as depicted in the following figure:



It is sufficient to show that delegating θ_2 rather than θ_1, where $\theta_1 < \theta_2$, is preferred by the VP in each of the following cases:

$i.)$ $\theta_1, \theta_2 \in [\underline{\theta}, \theta_L)$,

$ii.)$ $\theta_1 \in [\underline{\theta}, \theta_L), \theta_2 \in [\theta_L, \theta_H]$,

$iii.)$ $\theta_1 \in [\underline{\theta}, \theta_L), \theta_2 \in (\theta_H, \overline{\theta}]$,

$iv.)$ $\theta_1, \theta_2 \in [\theta_L, \theta_H]$,

$v.)$ $\theta_1 \in [\theta_L, \theta_H], \theta_2 \in (\theta_H, \overline{\theta}]$,

$vi.)$ $\theta_1, \theta_2 \in (\theta_H, \overline{\theta}]$.

Case i. Since there is no misreporting by the talented analyst, we know that the value of the θ_2-project is higher than that of the θ_1-project if the analyst is talented. So let us consider the untalented analyst. Let V_G be the value of the good project and V_B the value of the bad project, net of the investment I. Given the conjectured equilibrium behavior of the untalented analyst in this region, we know that upon observing the good signal s_G, he recommends rejection with probability $\gamma_R(\theta)$ and acceptance with probability $1-\gamma_R(\theta)$. If he observes the bad signal s_B, the untalented analyst does not misreport, and rightfully recommends rejection.

What we want to show is that

$$\left[\begin{array}{c} [1-\gamma_R(\theta_2)]\,\theta_2 \Pr(s_G|G,U)V_G \\ +[1-\gamma_R(\theta_2)]\,[1-\theta_2]\Pr(s_G|B,U)V_B \end{array} \right] > \left[\begin{array}{c} [1-\gamma_R(\theta_1)]\,\theta_1 \Pr(s_G|G,U)V_G \\ +[1-\gamma_R(\theta_1)]\,[1-\theta_1]\Pr(s_G|B,U)V_B \end{array} \right]. \quad (22)$$

With a little algebra, we can rearrange (22) as:

$$[[1-\gamma_R(\theta_2)]\,\theta_2 - [1-\gamma_R(\theta_1)]\,\theta_1]\left[\begin{array}{c}\Pr(s_G|G,U)V_G \\ -\Pr(s_G|B,U)V_B\end{array}\right] > \Pr(s_G|B,U)V_B\,[\gamma_R(\theta_2)-\gamma_R(\theta_1)] \quad ,$$

which holds since $\frac{\partial\gamma_R(\theta)}{\partial\theta} < 0$, $\theta_1 < \theta_2$, and $\Pr(s_G|G,U)V_G - \Pr(s_G|B,U)V_B > 0$.

Case ii. The θ_2-project is of higher intrinsic quality ($\theta_1 < \theta_2$) and lies in the region of no distortion (i.e., $\theta_2 \in [\theta_L, \theta_H]$). Thus, the θ_2-project is preferred.

Case iii. This case can be shown to hold in the following way. We will use the fact that in case v, the θ_2-project is preferred, and verify here that this automatically implies the same is true in case iii. To see that this is sufficient, note that case v is the more difficult case because there $\theta_1 \in [\theta_L, \theta_H]$, which is strictly better (see case ii) than $\theta_1 \in [\underline{\theta}, \theta_L)$. Thus, this establishes that the θ_2-project is preferred.

Case iv. In this case, there is no distortion in delegation, and hence the intrinsically "better" θ_2-project is preferred.

Case v. Observe that there is no distortion in θ_1 by the untalented analyst given that $\theta_1 \in [\theta_L, \theta_H]$. The distortion in the delegation of the intrinsically "better" project θ_2 is that an untalented analyst will recommend the acceptance of some projects for which he observes the bad signal s_B. However, delegating the θ_2-project could still be preferred if

$$\left[\begin{array}{c}\theta_1\,[\Pr(s_G|G,U)]\,V_G \\ +[1-\theta_1]\,[\Pr(s_G|B,U)]\,V_B\end{array}\right] < \left[\begin{array}{c}\theta_2\,[\Pr(s_G|G,U)+\Pr(s_B|G,U)\gamma_A]\,V_G \\ +[1-\theta_2]\,[\Pr(s_G|B,U)+\Pr(s_B|B,U)\gamma_A]\,V_B\end{array}\right].$$

Observe that the expression above focuses only on the untalented analyst. Obviously, in the case of the talented analyst, θ_2 is by definition better than θ_1 because there is no distortion in his recommendation and no error in his evaluation. On the LHS, we have the total surplus for the θ_1-project (only distortion is due to the noisy signal). On the RHS is the surplus for the θ_2-project. Distortions occur here from both the noise and the distorted recommendations. The above expression can be rewritten as

$$[\theta_1\,[\Pr(s_G|G,U)V_G - \Pr(s_G|B,U)V_B]] < \left[\begin{array}{c}\theta_2\,[\Pr(s_G|G,U)V_G - \Pr(s_G|B,U)V_B] \\ +[1-\theta_2]\,\gamma_A\Pr(s_B|B,U)V_B + \theta_2\gamma_A\Pr(s_B|G,U)V_G\end{array}\right],$$

which is always true given that $\theta_2 > \theta_1$. Thus, the θ_2-project is preferred.

Case vi. In case v, we showed that a θ_2-project has a higher value than a θ_1-project even if there is misreporting by the untalented analyst for the θ_2-project and truthful reporting for the θ_1-project. Since the value of the θ_1-project is higher with truthful reporting than with misreporting, it follows that the value of the θ_2-project (with misreporting) is higher than the value of the θ_1-project (with misreporting) when $\theta_1, \theta_2 \in (\theta_H, \overline{\theta}]$. Thus, the θ_2-project will be delegated for evaluation. ■

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