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Firm and Managerial Incentives to Manipulate the Timing of Project Resolution

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Firm and Managerial Incentives to Manipulate the Timing of Project Resolution

A manager who wants to be viewed favorably has an incentive to advance or delay the arrival of information about his firm's profitability. In the model, a high ability manager tries to advance resolution of a likely-favorable outcome, while a low ability manager may defer resolution. Such manipulation of information arrival causes greater investment in *execution projects* (which tend to resolve early) than *exploratory projects* (which tend to resolve late), and affects investment in hastening or retarding project resolution. In contrast with previous literature, in some cases managers may *secretly overinvest*. The model offers empirical implications about innovative versus conventional investments, associated stock price reactions, and corporate control. The theory also implies a perverse sorting of high ability managers to conventional activities and low ability managers to visionary enterprises.

1 Introduction

There has been much study of information revelation through signalling, wherein outsiders infer private information of the manager from direct observation of the manager's selected action. More generally, however, most substantive managerial decisions affect the timing and nature of other news arrival. Thus, regardless of whether the current action is visible to investors, they can draw inferences about manager or firm quality from the arrival or non-arrival of other news.

Consider, for example, a pharmaceutical firm deciding whether to develop a variant within its current family of medications, or to pursue a new class of medicines. The first option can be called an *execution* project, and is likely to be resolved quickly by arrival of news about project outcome. The latter option can be called an *exploratory* project, and is likely to have deferred resolution of uncertainty. Alternatively, the firm may face a choice between actions that hasten or retard the resolution of uncertainty about a *given* project. One example is the decision of how much to spend on R&D spending to accelerate the development of a new product.[1]

The ability to influence when news arrives gives managers an incentive to manipulate investment decisions in order to improve personal or firm reputation. This paper offers some general propositions about how managers and their firms choose investment strategies to manipulate information arrival, what the market infers, and associated empirical implications.

Our premise that managers are concerned with short-term reputation is plausible based either on a direct preference for prestige or for pecuniary reasons. High reputation is important to a manager who expects to change jobs, or who wants to have a potent threat of quitting in order to negotiate higher pay.[2] Similarly, favorable short-term perceptions of a firm can help its shareholders by raising the price at which the firm or its shareholders are able to sell shares, and by improving the terms in which it can deal with implicit stakeholders.

Our approach is related to a biblical directive for investment policy. According

[1] According to *Business Week* (pp. 66-8, 9/24/90), "Over 20 years, Warner-Lambert's record of getting new drugs from patent to FDA filing ranged from five years ... to 14 years ... Merck's range over the same period was three to eight years," that Warner-Lambert's CEO "Williams is attacking the problem with new recruits and more money," and reported an increase in Warner-Lambert's R&D expenditures relative to drug sales.

[2] When a realistic constraint on contracting (the manager's ability to quit) is taken into account, Holmstrom and Ricart i Costa (1986) have shown that under the optimal compensation contract the manager has an incentive to manipulate his project decision in order to build a favorable reputation.

to *Proverbs* 17:28, "Even a fool, when he holdeth his peace, is counted wise." In this spirit, a wise manager, one whose investments are usually successful, should obtain early public resolution of the outcome of his decisions; a foolish manager, one whose projects frequently fail, is better advised to "hold his peace" by allowing project outcome to remain in doubt longer.

There is a problem with this directive, however. A sophisticated observer who understands it will take the failure of public news to arrive early as itself as an adverse indicator of quality. Nevertheless, so long as there is some noise in the timing of information arrival, we show that the naive view retains a degree of validity. A foolish manager can defer resolution in the hope of being mistaken for a wise manager whose firm receives late resolution as a result of uncontrollable external circumstances. There will thus be a balance between the incentives of managers to seek early versus late resolution.

This reasoning suggests that the ability of a low quality firm or manager to get away with deferring resolution depends on imperfect control of timing by a high quality manager. Such lack of control introduces noise in resolution timing as an indicator of quality. Nature may interfere relatively little with the timing of resolution for relatively standard projects, such as natural resource extraction. However, a manager has a much looser grip on the resolution timing of innovative projects. Since much of the policy debate on alleged short-term managerial focus, takeover threats and restructuring has concerned their effects on innovation, it is important to analyze a context in which resolution timing cannot be perfectly controlled.

Since advancing or deferring resolution of uncertainty affects the timing of cash flows, a bias toward early or late public *resolution* indirectly causes a bias toward early or late *cash flows*— under- versus over-investment. This paper examines the conditions determining the equilibrium balance between early and late resolution, and its consequences for under- versus over-investment.

There is a previous literature on how a concern with short-term reputation can create incentives for advancing or deferring public resolution of uncertainty. These papers assume that capital markets are efficient, but find that corporate policies are distorted by the reputational concerns of managers or their firms. In several models of optimal disclosure policy, the market draws a skeptical inference about a non-disclosing firm, so the firm incurs a cost in order to resolve the market's uncertainty early (see, e.g., Verrecchia (1983) and Fishman and Hagerty (1989)). Perhaps the closest model is that of Titman and Trueman (1986), in which a firm with private information can effectively

advance information arrival by hiring a high quality auditor.[3] In consequence, auditor quality acts as a signal of firm value. However, the literature on disclosure and on auditor choice does not focus primarily on investment incentives. Also, our setting accommodates a greater range of possible outcomes because we do not assume that advancing resolution of uncertainty is always more costly than deferring resolution.[4]

Several papers consider specific applications involving resolution choices. Boot (1992) analyzed how managers may be reluctant to divest a division if this reveals to the market the failure of the investment project. DeMarzo and Duffie (1995) considered how the hedging decision of a manager can influence the rate of resolution of uncertainty through its effect on the perceived noisiness of earnings. Rajan (1994) analyzed the effects of banks extending the terms of bad loans and weakening covenants to avoid recognizing default. Our model differs from these applications in various respects, including its focus on corporate investment decisions.

In Holmstrom and Ricart i Costa (1986) and Holmstrom (1999), an uninformed risk averse manager may be reluctant to undertake a risky project because doing so can make his future wages riskier. The current paper examines manipulation of information arrival when the manager has information that outsiders do not have. Furthermore, the effects we describe are not based on risk aversion.

Most of the literature on reputation and investment choice has focused on one particular kind of news arrival about the firm, a report about current cash flow; and one particular way of manipulating news, boosting the current cash flow. In contrast, our approach focuses on whether relevant news (which may or may not take the form of a reported cash flow) arrives early versus late. Shifting future news arrival generally shifts cash through time, but does not *necessarily* shift current cash flow. For example, a firm that intensifies R&D spending to complete development of a hot new product advances resolution of uncertainty about the product's revenues, whereas one that spends

[3]Grinblatt, Masulis and Titman (1984) proposed the attention hypothesis of stock splits, wherein firms with favorable private information split to invite analysts to study the firm. Rajan and Winton (1995) analyzed how the collateral and covenant provisions that a borrower agrees to in its debt contract induces monitoring by creditors, and thus resolution of uncertainty. Nanda (1991) examined how equity carveouts resolve uncertainty about the parent as well as the subsidiary. Cornelli and Felli (1997) examined the design of bankruptcy procedures to provide creditors with incentives to generate information. Calomiris and Kahn (1991) argue that a banking contractual structure with demandable deposits encourages monitoring by depositors. Welch (1989) examined the effects of resolution of firm quality subsequent to IPO.

[4]Holmstrom (1999) shows that risk aversion or a nonlinear output technology can distort the investment decision of a manager who is concerned with reputation. Milbourn, Shockley, and Thakor (2000) examine managers' incentives to invest in obtaining a *private* signal in advance of a project decision.

the same amount of current cash devising a new exploratory opportunity is not. This illustrates the more general point that there is no general presumption about whether shifting cash flows forward in time advances or defers the arrival of future information.[5]

Within the literature on reputation, investment, and current cash flow, one set of papers assumes that the firm's action choice is hidden from outside observers. These papers predict that uninformed managers will secretly underinvest in order to enhance current cash flow, which is taken by the market as a favorable indicator of value (Narayanan (1985), Stein (1989)). This manipulation can be referred to as *signal enhancement*.

In a second set of papers, the action, investing, is visible; and the cost of a given investment choice is known up front. Firms have private information about the return on investment. In this setting, firms are predicted to overinvest in the hope of being viewed as having a high quality project (Trueman (1986), Bebchuk and Stole (1993)). These models based on what may be called *mimicry and avoidance*. A firm with a mediocre project invests to mimic the behavior of a firm with a good project, and a firm with a good project may overinvest to try to distinguish itself from such mimicry.

In a third set of papers, the action is also visible, but a given action can immediately generate different possible cash flow levels. These papers model *resolution timing*, in which the firm resolves uncertainty by selling an asset, and thereby converting it into a publicly observable cash flow. These models predict premature asset liquidation of undervalued assets ('latent assets') in order to demonstrate their value (Stein (1988), Brennan (1990)).

Although past literature has offered important insights about when under- versus overinvestment will occur, previous models do not seem to capture the full scope of resolution timing, especially with reference to innovative investments. For example, latent assets models allow a firm to advance resolution only through asset liquidation. This does not capture a situation where a pharmaceutical company accelerates resolution of a promising new medication by boosting R&D expenditures. Furthermore, resolution can be deferred only by holding on to an existing asset; this does not capture the notion that a manager can manipulate resolution by choosing a visionary, exploratory project instead of a routine, execution project.[6] Furthermore, such a models do not consider

[5]Suppose, for example, that a firm wishes to advance information arrival. Handheld Inc. can accelerate resolution of uncertainty about a new product such as a voice-recognizing Handheld PC by spending more rapidly on development now. Such expenditure *reduces* net cash flows in the short run. On the other hand, for given development expenditure, putting a voice-recognition product on the market now rather than later also advances public information arrival about the product's potential, but may *increase* short term revenue.

[6]GM's development of new technology for the Saturn model, billed as the car of the 21st century,

that a manager may not be able to control perfectly when a project resolves.

This paper allows for either visible or hidden actions by managers. In contrast with previous papers on hidden actions, our model is *not* based on signal enhancement. It does reflect both mimicry/avoidance effects and resolution timing. In contrast with the latent assets approch, we allow for imperfect controllability of resolution timing and a possible disconnect between resolution at a point in time and the cash flow level at that point in time.

These differences lead to very different implications for when under- versus over-investment will occur. Even when actions are hidden, there can be *over*investment. Regardless of whether actions are visible or not, there can be biases toward either exploratory or execution projects. In contrast with latent assets models, there can be a bias toward deferral rather than acceleration of resolution. From a policy standpoint, these points suggest that any attempt to use compensation, taxes, or takeover regulation to motivate managers or firms to invest more efficiently faces a much tougher problem of targeting than was obvious based on previous literature.

Furthermore, the model provides empirical implications involving comparative statics shifts in the weight that the firm places on short-term reputation. These implications describe how different forms of investment vary with changes in proxies such as institutional shareholding and probability of hostile takeover. For example, the model offers a possible explanation for some puzzling findings about the relation between takeover protection and R&D expenditures (see Subsection 5.2).

The 1980s saw a passionate debate about whether corporate "raiders" were pushing U.S. managers toward short-sighted decisions. Corporate managers subjected to takeover threats have frequently justified their records by arguing that they are following long-term strategies whose value has not been recognized by the stock market. Some theoretical research suggested that there was merit to concerns about excessive short-term focus. Consistent with past research, we find that takeover threats cause suboptimal behavior. However, this behavior does not necessarily take the form of underinvestment, nor lack of innovative activity.

The remainder of the paper is structured as follows. The next section gives the

under Chairman and CEO Roger Smith has been widely cited as an example of wasteful expenditure on innovation (see *Business Week*, 5/18/87, on "GM's meager profits, its falling market share, and its poor productivity...,", and the introduction of robotic production methods. *The Economist, 11/11/95* comments that "nearly $80 billion into new factories and equipment to reduce its dependence on its workers; its productivity gains were miniscule.") Smith was quoted as saying, "Don't write the book on me until I've been gone at least ten years. It's too early. You've got to wait and see," in Lee (1988, p. 1).

economic setting. Section 3 presents the model when the manager's resolution choice is hidden from the public. Section 4 examines the case in which the manager's decision is perfectly visible. Section 5 examines the comparative statics of varying reputational pressures, such as takeover threats. Section 6 concludes. Except as otherwise noted, proofs are given in the Appendix.

2 The Economic Setting

To the extent that a manager is concerned with persuading shareholders that he (or his firm) is of high quality (or value), it is ultimately information arrival, not cash flow arrival that matters.[7] Thus, the model offers basic results regarding manipulation of resolution timing rather than cash flow timing. The consequences of these basic results for under- versus over-investment in different applications will be listed as "Implications."

There are four dates. At date 0, the manager takes an action M which can influence the date ($s = 1$ or 2) at which uncertainty is resolved about project success. His choice to *advance* or *defer* resolution is denoted by M = A or M = D. At date 1, a public signal about the success of the project (good news, G or bad news, B) may arrive. The arrival of news at date 1 is referred to as early resolution, and non-arrival as late resolution. At date 2, conclusive information about the project outcome is revealed. At date 3 a terminal cash flow arrives.

The model is consistent with alternative interpretations of the manager's decision to advance or defer information arrival.

- A choice between distinct projects that have different tendencies toward early versus late resolution, *e.g.*, designing a new product (which will take time to bring to the market) versus modifying slightly an old one. This is the exploratory/execution project distinction mentioned in the introduction.[8]

- A choice of expenditure on a given project that advances resolution (by speeding up product development) or defers it (by slowing development or concealing

[7] Thakor's (1993) analysis might seem to suggest otherwise, in that a firm may benefit from receiving cash early in order to finance future projects through internally generated funds. However, once the uncertainty about cash flows of the old project is resolved, the firm could issue debt secured by assets in place, rendering the timing of the actual cash flows irrelevant. (This does not eliminate distortion, but shows that the problem he analyzes is still fundamentally one of resolution timing.) Related points are relevant for other research on cash flow timing and financing decisions; see, e.g., Goswami, Noe and Rebello (1995).

[8] In a real options setting, the contrast would be between a 'platform' project that promises to generate a future opportunity, versus the exercise of an option that is already present.

adverse outcomes). For example, for a new product design, parallel rather than sequential examination of alternatives requires more intense expenditure, but hastens resolution. This approach, known as 'concurrent engineering,' is a well-known method of reducing development time (see, e.g., Nelson (1962)).

Alternatively, a lender may roll over a loan to an insolvent borrower to avoid recognizing default, or a manufacturer can redesign a consumer appliance to avoid conceding that the concept is probably a dud.

Thus, in different specific contexts, the act of undertaking a project can either advance or defer resolution of uncertainty. Furthermore, depending on the context, the decision to advance resolution can either increase or decrease current cash flow.

We assume that a manager can always defer resolution successfully to date 2 if he chooses to do so. However, the attempt to advance resolution of uncertainty may be unsuccessful. For example, the success of a high-technology project may depend on a key technical problem whose resolution cannot be perfectly controlled. Similarly, approval or rejection of a new medicine may be delayed by slow regulatory evaluation.[9] We therefore assume that when the manager advances resolution, nature's intervention causes resolution at date 1 with probability $Pr(s = 1|\mathrm{A}) = r$ and at date 2 with probability $Pr(s = 2|\mathrm{A}) = 1 - r$.[10]

The manager is one of two types, high ability ($\Theta = \mathrm{H}$) and low ability ($\Theta = \mathrm{L}$). Outsiders assign a prior probability λ that the manager has high ability. We assume that the project outcome is determined solely by the manager's type. Therefore, the arrival of conclusive information about project outcome at date 2 is equivalent to revelation of the manager's type. The date 1 public signal of the project's outcome is either good (G) or bad (B). A high ability (H) manager is sure to get good news, $\gamma_{\mathrm{H}} \equiv Pr(\mathrm{G}|\mathrm{H}, s = 1) = 1$. A low ability manager has a probability $\gamma_{\mathrm{L}} \equiv Pr(\mathrm{G}|\mathrm{L}, s = 1) < 1$ of a good news.[11] The manager and outsiders both know these conditional probabilities, but the manager

[9]Instead of allowing nature to overule the manager's resolution choice, it could be assumed that nature chooses the expected returns on an early- and on a late-resolving project (see Thakor (1993)). If the manager cares about underlying firm value, this would still in effect "force" him sometimes to advance or defer resolution despite his other reasons for preferring early or late resolution. The "hidden" resolution choice regime would then correspond to the case in which the manager privately observes the expected payoffs from alternative projects; the "visible" regime to the case in which everyone knows expected payoffs. A model essentially equivalent to the one we present could be derived based on this approach.

[10]Generally similar results apply when the manager has imperfect ability to defer as well as to advance.

[11]This model also allows for the possibility that even a high ability manager may be uncertain of receiving a good outcome.

knows more about the likelihood of a good news than do outsiders by virtue of knowing his type (H or L). The probability of good news for the L manager is independent of his action and of the resolution date.

In addition to the project outcome, advancing or deferring resolution may affect profitability. For example, introducing a new product prematurely can reduce net discounted value, as can prolonging a project to conceal its failure. We therefore assume that the project pays a cash flow of $C(\Theta, \mathrm{M})$ if the manager is type Θ (high or low) and his choice is M (advance or defer), where

$$C(\Theta, M) \quad = \quad dI_{\mathrm{H}}(\Theta) - cI_{\mathrm{A}}(M), \tag{1}$$

and $I_{\mathrm{H}}(\Theta)$ is an indicator function for a high ability manager and $I_{\mathrm{A}}(M)$ is an indicator for advancing resolution. Thus, high ability raises profitability ($d > 0$); and when a manager advances resolution the firm incurs a positive or negative net cost of c.[12] Thus c is the difference in net discounted value between D and A. If A corresponds to undertaking a new execution project, and D to not undertaking it, then the cost of advancing c is the negative of the net discounted value of the project. Conversely, if D corresponds to undertaking a new exploratory project, and A to not undertaking it, then c is the net discounted value of undertaking the project.

We define the stocks prices at date 1 and 2 as the investors' expectations of cash-flow from the project. Given (1), the stock price at dates 1 depends upon the resolution date (1 or 2), the news (G or B) if public resolution has occurred, and the manager's action (A or D) if the action choice is visible. The date 2 stock price depends upon the resolution date (which may be informative about the manager's action if it is invisible) or the manager's action (if it is visible), and the manager's type.

The manager seeks to maximize the weighted sum of the expected date 1 and the date 2 stock prices of the firm, V_1 and V_2,

$$U^{\Theta} \equiv E_0[V_1 + \delta V_2 | \Theta], \tag{2}$$

where δ is a discount factor.[13] The assumed objective implies that an H manager would like his ability to become known, while an L manager would rather it remain concealed.

[12]The cash flow outcome does not directly depend on the good or bad news. However, good news still leads investors to value the firm more highly, because they assess the manager's ability more favorably. The cash flow also does not depend on the resolution date. Since the resolution date is (stochastically) advanced or deferred by the manager's decision A or D, such an effect is implicitly reflected in the cost of advancing, c. In a previous version of the paper, we have derived similar results in a model in which cash flows are increased by good news, and depend on the resolution date.

[13]A similar objective function reflecting a concern for the short-run stock price has been used in

(Alternatively, the *firm* may have either high or low productivity.) We assume that the manager learns his (or his firm's) type only after being hired.

The model attempts to capture some general effects that apply when managers can manipulate the timing of news arrival, rather than focusing on a particular mechanism for doing so. Because we wish to capture a range of different possible patterns of cash flow arrival, there are several alternative interpretations of the timing by which C arrives. Without loss of generality, let us assume a discount rate of zero. Then portions of C can arrive at any date, so long as the total is C, and the revelation of information through cash flow arrival is consistent with the model assumptions about when information is revealed.

3 Hidden Investment Choice

In many cases, a manager's decision to advance or defer resolution is hard for outsiders to detect immediately. For example, a manager may defer resolution by failing to perform an informative experiment, or by suppressing the outcome of an experiment. He can advance resolution secretly by substituting resources and time toward product development and away from equipment upkeep or customer service. The apparent cash flow initially visible to investors will be unchanged, even though true value is affected.

We assume in this section that the decision to advance or defer resolution is entirely hidden from investors (except possibly at the terminal date 3). Any up-front date 0 component of the total cash flow C that differs between A and D is temporarily invisible to investors–otherwise investors would be able to infer A versus D from the date 0 cash flow.

There are two ways to think of this invisibility. First, the action A or D may be financed by cutting some other date 0 expenditure in order to invest in the project associated with A or D. If the net cash flow at date 0 is the same for A and D, the action remains hidden. Different levels of cash may arrive at dates 1 and 2 depending on

financial signaling models (e.g., Harris and Raviv (1985)). The assumption that the manager is concerned with the stock price in the short term (date 1) reflects the possibility that the manager or old shareholders may sell shares (*e.g.*, when the firm is acquired by takeover). Alternatively, the manager's freedom to switch jobs may provide him an incentive to build a good personal reputation early. In a previous version of the paper, we have derived similar results under an objective function in which the manager is compensated based on his current and future personal reputation (the posterior probability assessed by outsiders that his ability is high) instead of the firm's value (see also Holmstrom (1999)). Such reputational considerations are indirectly captured by the stock price objective function, as the stock price reflects both cash flows and the market's assessment of the manager's ability.

whether there is early versus late resolution and depending on whether there is good or bad news. Thus, the date 0 decision commits the firm to a strategy which stochastically can involve investment (or disinvestment) at later dates.

Second, more broadly the invisibility assumption can be viewed as a way of approximating a more general model in which assets in place generate a stochastic net cash flow at date 0. If the firm spends part of that cash flow on an investment activity (such as paying a valued employee more in order to retain him), the market cannot infer perfectly whether the assets-in-place cash flow was low or if investment was high. (This assumes, as is the case, that financial statements cannot perfectly distinguish true economic 'costs' from 'investments'.) Presumably investors should be able to draw a Bayesian inference from observing the date 0 cash flow about the level of investment, but the stochastic assets-in-place cash flow makes this inference noisy, partially hiding the investment choice.

At date 1, investors update their prior beliefs about the profitability of the firm based on whether resolution occurred or not ($s = 1$ or 2), and, if resolution occurred ($s = 1$), whether the news was good or bad. At date 2, the updated beliefs will be based on the resolution date and the conclusive information about project outcome, which is equivalent to the manager's type.

To allow for either pure or mixed strategies, let θ denote the probability that a manager of type Θ advances resolution (M = A), and $1 - \theta$ the probability that he defers resolution (M = D). A high ability manager advances resolution with probability h and defers with probability $1 - h$, and a low ability manager chooses A and D with probabilities l and $1 - l$.

By inspection of Figure 1 the expected value of the date 1 and 2 stock prices V_1 and V_2 in (2) is

$$\begin{aligned} E_0[V_1 + \delta V_2|\Theta] &= \theta r[\gamma_\Theta V_1(G, s = 1) + (1 - \gamma_\Theta)V_1(B, s = 1) + \delta V_2(\Theta, s = 1)] \\ &+ (1 - \theta r)[V_1(s = 2) + \delta V_2(\Theta, s = 2)]. \end{aligned} \tag{3}$$

The possible stock price outcomes in (3) are calculated in the Appendix. In this setting the equilibria are as follows.

Proposition 1 *In the hidden action setting, there are four possible Perfect Bayesian Equilibria:*

(1) Both an H and an L manager always defer ($h^* = 0$, $l^* = 0$).

(2) An H manager always advances ($h^* = 1$) and an L manager always defers ($l^* = 0$).

(3) An H manager always advances ($h^* = 1$) and an L manager randomizes between advancing and deferring resolution ($0 < l^* < 1$).

(4) An H manager sometimes advances ($0 < h^* < 1$), and an L manager always defers ($l^* = 0$).

If the cost of advancing resolution is zero or negative ($c \leq 0$), then equilibria (1) and (4) never obtain, so a high ability manager always advances resolution.

The possible equilibria reflect the intuition that the benefit to advancing resolution is greater for an H than an L manager. An informative benchmark case occurs when the cost of advancing resolution c is zero. In this case the net discounted value from A or D is equal, so that a manager's decision to advance or defer is based solely upon reputational considerations. Since the reputational benefit of being perceived as H is positive, i.e., $d > 0$, equilibria (2) and (3), but not (1) or (4) are possible in this case. Thus, a high ability manager is always biased in favor of advancing resolution.

The pure strategy equilibrium (2) shows clearly, consistent with the biblical directive discussed in the introduction, that a manager who wants to conceal his low ability is biased in favor of deferring resolution. This result differs from the latent assets model, in which there is always a bias toward early resolution. For example, in Brennan's model, a firm always sacrifices discounted value in order to extract and sell gold prematurely. A latent assets model is a special case of our analysis in three respects. First, a low quality manager or firm is sure of failure (he knows it has high extraction cost). Second, nature is fully compliant with the manager's decision to advance or defer resolution. Third, favorable resolution always coincides with the arrival of a high cash flow. This leads to early realization of the latent asset. In our hidden action model, since advancing resolution is not immediately apparent, information will sometimes arrive late about a high quality manager or firm, so that late resolution does not in itself stigmatize the manager or firm. A low quality manager or firm will then be tempted to "hold its peace" by deferring resolution.

In the mixed strategy equilibrium (3) the cost of advancing resolution is so low that a high ability manager always advances. The benefit to a low ability manager of deferring what is likely to be an adverse resolution is balanced against the adverse inference about the manager drawn from late resolution *per se*.

It is useful to translate the propositions about A and D to implications about specific settings. The three implications that follow in the remainder of this section are common to the hidden resolution choice model and the model with visible resolution choice of Section 4.

Implication 1: *Managers may either overinvest or underinvest in innovative and in conventional projects, depending upon the manager's or firm's quality and on how advancing information arrival affects the timing of cash flows.*

In some models, managers boost short-term cash flows to boost their short-term reputation. Here firms sometimes overinvest even when investment choice is hidden. Implication 1 identifies some determinants of over- versus under-investment that have not received attention in the literature. First, early information arrival is better for a high quality manager or firm than for a low quality one. So different managers or firms will behave differently. Second, advancing information arrival can have the effect of either advancing or deferring cash flows (e.g., increasing product development activity may reduce short-run cash and yet advance resolution about products in the pipeline).

Specifically, it is crucial to distinguish project selection from project intensity. A high ability manager will tend to favor execution projects (which have early resolution) to exploratory projects. An execution project will often (but not always!) produce early cash flows. However, sometimes intensifying the rate of project investment (reducing short-term cash flows) can be used to resolve outcomes earlier. Thus, the resources devoted to R&D can be either increased or reduced by reputational effects.

The pressure on managers to over- or under-invest here do not come from a market concern with cash flow per se. Rather, the manager is biased in regard to early or late resolution, either of which may be associated with early or late arrival of cash flows.

Implication 2: *Disproportionately often managers or firms involved with late-resolving projects are incompetent or incompetently managed. Conventional projects are disproportionately selected by high quality managers or firms, and visionary projects are selected by low quality managers or firms.*

Because high ability managers desire early resolution, they seize upon conventional, early-resolving projects, leaving fundamental innovation for low ability managers. Therefore it is valid to be somewhat skeptical of managers who have little to show now but promise favorable resolution in the distant future. It is true that sometimes highly competent managers pursuing long-term goals will achieve late resolution. However,

Implication 2 maintains that CEO's who present themselves as visionaries leading the way to a grandiose future are often washouts who deserve the sack.[14] This sorting between managers and projects causes superb execution of minor improvements, along with monumental blunders in ambitious undertakings. Since we normally expect some complementarity between managerial ability and the project innovativeness, this outcome is from society's viewpoint perverse.

This perverse sorting may help explain why corporations that seek to generate innovative projects (in recent years, often internet-related activities) often engage in spinoffs that separate their more innovative projects from their more conventional ones, or compensate project managers with separate tracking stock. For example, in 1996, AT&T spun off Lucent Technology so that Lucent could focus on its growth opportunities. 3Com made its Palm Computing subsidiary an independent publicly traded company in March 2000 to allow Palm to focus on its promising markets. More recently, AT&T announced a plan to split into four parts. According to the company (see Yahoo!.News/Reuters, 10/25/00, having AT&T Wireless as a separate company will allow it, among other things, to better 'attract and retain employees.' Even more recently, Lucent spun off Avaya, a collection of old-line corporate assets.

Corollary to Proposition 1: *The profitability of a firm that obtains early resolution is on average higher than the profitability of a firm that obtains late resolution.*

This is because early-resolving projects are disproportionately undertaken by better managers and firms, and late-resolving projects by inferior managers and firms. This leads immediately to the following implication, which has not as yet been tested.

Implication 3: *Holding constant the quality of the ex ante pool of potential projects available to firms, projects that are completed quickly will on average be more profitable than projects that are completed late.*

Implication 3 is based upon the reasonable assumption that early completion on average is associated with early resolution. It predicts, for example, that drugs which are developed quickly and receive early FDA approval are on average more profitable than

[14] We can reinterpret the model with hidden resolution choice as one in which the choice to advance or defer is visible, but outsiders don't know which alternative is *justified* based on net discounted value (see footnote 9). If the value of the visionary project is sufficiently higher than the value to the early-resolving conventional one, even a high ability manager will defer. This possibility would allow a low ability manager to defer, pretending to be a high ability manager with a superb late-resolving project. Continuing high R&D expenditures can also be associated with an effort to defer visible resolution of failure on an innovative project. See footnote 6 in the introduction.

those that take a long time, after normalizing for other determinants of profitability.[15]

4 Visible Investment Choice

In this section we assume that a manager's attempt to advance or defer resolution of uncertainty is immediately visible to the public. There can be an up-front component of total cash flow C that arrives at date 0 and which differs for A versus D, the initial investment or disinvestment. It can be the observation of this cash flow which allows investors to infer the choice. It can also be that further stochastic arrival of cash flow components are what reveal good or bad news at dates 1 or 2. But the analysis is identical if we view investors as directly observing the investment decision A versus D, and observing further good or bad news distinct from cash flows.

At least some degree of visibility is reasonable, in that R&D expenditures may be inferred from the firm's accounting statements, and some product development activities (such as hiring a research team and buying equipment) are hard to disguise.

Proposition 2 *With visible resolution choice, if $d \neq -c(1+\delta)$ there are five possible Perfect Bayesian Equilibria:*[16]

1. *Both high and low ability managers advance resolution.*
2. *Both high and low ability managers defer resolution.*
3. *A high ability manager advances resolution and a low ability manager randomizes.*
4. *A high ability manager advances and a low ability manager defers resolution.*
5. *A high ability manager randomizes and a low ability manager defers resolution.*

Intuitively, a high ability manager has more to gain from early news arrival than a low ability manager. So in any equilibrium in which an L manager ever advances resolution, an H manager always does so. Since resolution choice is visible, a manager must either advance resolution or carry the stigma of low ability.[17] If the cost of advancing is

[15] Implication 3 should not be confused with the trivial claim that late product completion has direct time costs, such as the discounting of deferred revenues. "Profitability" should be interpreted here as average annual net revenues generated during the lifetime of the drug.

[16] If $d = -c(1+\delta)$, a non-generic special case, then a weak equilibrium also exists.

[17] In 1989, cold fusion proponents Pons and Fleischman announced remarkable results but withheld details of their experimental technique, preventing others from precisely replicating their procedures. This visible deferral of resolution was greeted with great skepticism by other scientists.

sufficiently high, a low ability manager will nevertheless sometimes defer; for even higher cost both types will defer.

Corollary to Proposition 2 *If advancing resolution is not too costly, i.e., if $c \leq 0$ or if $c > 0$ is sufficiently small, then the only equilibrium that satisfies the Universal Divinity criterion of Banks and Sobel (1987) is one in which both a high and a low ability manager advance resolution.*

Intuitively, a high ability manager gains more from early resolution and will advance unless there is a loss of discounted value ($c > 0$) from doing so; and thus, a low ability manager is forced to mimic. In the hidden resolution case, if $c = 0$ it was possible that the low ability manager deferred resolution. Thus, resolution-advancing decisions are more favored when they are visible to outsiders. This is because visibility prevents a low ability manager from hiding in the timing noise.

The Corollary to Proposition 2 implies overinvestment in resolution-advancing activities, such as accelerating the completion and introduction of a new product, and underinvestment in resolution-deferring activities. As a result, we have:

Implication 4: *From the viewpoint of maximizing shareholder wealth, new products will be introduced prematurely.*

Implication 5: *From the viewpoint of maximizing shareholder wealth, firms will invest too little in exploratory research, and too much in completion of product development.*

Implication 4 does not mean that firms will intentionally introduce a disastrously incomplete product. But they will expend excessive resources getting the product ready early, and may introduce it in a less perfected form than would be optimal from shareholders' viewpoint. This can increase the risk of disaster, as with the famous example of Apple's introduction of the first Personal Digital Assistant (PDA) in August 1993.[18] There has been much complaint over the last decade about too many bugs in newly introduced PC software and associated hardware devices. Our approach suggests that this is a real phenomenon that results from the incentive for firms to maintain a reputation for being at the cutting edge.

The prediction of the Corollary to Proposition 2 for fundamental research is the reverse of its prediction for conventional product development. The market views managers

[18]This product introduced handwriting recognition in a PDA, but was subject to wide ridicule for being highly error-prone. This feature ultimately was highly prized by consumers, as reflected years later in the popularity of the Palm Pilot PDA.

engaging in visionary projects skeptically, because these defer resolution of uncertainty. Hence firms will underinvest in exploratory research from the viewpoint of shareholders. This is consistent with the fact that most R&D expenditure and activity by large firms is for direct product development, not basic research (Griliches (1990 p. 1674)). (The problem of appropriability provides a plausible alternative explanation.)

R&D spending has been cited in public policy debates as a measure of a firm's long-term focus. If resolution is advanced through innovative expenditure, then the analysis implies that managers, whether able or incompetent, will invest excessively in R&D, in order to enhance their reputations in the short-term. A high ability manager would invest in even moderately unprofitable R&D, because the decrease in discounted value would be offset by the benefit of separation. A low ability manager, will thus also be biased in favor of investing in R&D, since not to do so would reveal him as incompetent. However, he has less to gain from early resolution, since A tends to reveal him as low ability even if he does engage in R&D. So if R&D is sufficiently expensive (c large), he may randomize between A and D, or may always select D.

Since most R&D expenditure by large firms is for direct product development rather than basic research, R&D is probably on the whole resolution-advancing. Based on this identification, R&D is predicted to be generally too high. However, reported R&D expenditures are heterogeneous; clearly Bell Labs did exploratory as well as directly applied research.

The next proposition describes the stock price reaction to a firm's visible investment decision, and biases in managers' project choices.

Proposition 3 *In any equilibrium in which a high ability manager and a low ability manager behave differently, the stock price rises on the announcement of an activity that advances resolution, and falls on the announcement of an activity that defers resolution.*

This is true even if advancing resolution reduces NPV and deferring increases NPV. Ryan (2000) examined this implication of our model empirically by examining the stock price reactions to announcements of changes in capital expenditures, using the change in analyst forecast dispersion as a measure of the amount of uncertainty resolution. Proposition 3 implies that those announcements that resolve more uncertainty will on average be associated with a larger (more positive) stock price reaction. His findings are generally consistent with this prediction. Although he applies this idea to capital expenditures, his approach to testing Proposition 3 could also be applied to other investment measures such as R&D spending.

Proposition 3 has other empirical implications as well.

Implication 6: *The stock price reaction to new product introductions will on average be positive, even if advancing the introduction reduces net discounted value.*

Woolridge and Snow (1990) report a positive average stock price reaction to new product introductions.

If A corresponds to undertaking an R&D project that reduces net discounted value ($c > 0$), then R&D spending becomes a costly indicator of high managerial or firm quality. Proposition 3 asserts that this effect outweighs the negative value of investment, so that the stock price reaction is positive.

Implication 7: *If increased R&D generally advances resolution of uncertainty, then the stock price reaction to R&D increases will on average be positive.*

Since R&D expenditures as a whole represent product development more than basic research, our model is consistent with evidence that increases in R&D expenditures lead to a positive average abnormal stock price reaction (Office of the Chief Economist, SEC (1985); Woolridge (1989)). However, it is likely that for some firms R&D is resolution advancing, and for others it is resolution deferring. According to Proposition 3, a positive (negative) stock price reaction identifies increasing R&D expenditure as a resolution advancing (deferring) action in the model. Since there is a bias in favor of A over D, we obtain the following implication.

Implication 8: *Among an ex ante indistinguishable class of firms, if the stock market reaction to increases R&D is on average positive, firm will tend to make excessive R&D expenditures. If the stock market reaction to R&D is on average negative, firms will tend to invest too little in R&D.*

The evidence of a positive average stock price reaction to increases in R&D spending is therefore consistent on the whole with *over*investment rather than underinvestment in innovation.[19] Chan *et al* (1990) have provided evidence that for one class of firms (high-tech) the average reaction to increased R&D is negative while for another (low-tech) the average reaction is positive. Implication 8 therefore suggests that in fact some firms do overinvest and others overinvest in R&D.[20]

[19]More generally, if an H manager has a higher net discounted value from investment than an L manager, then a positive reaction to advancing resolution is consistent with a positive net discounted value for a high ability manager.

[20]A possible interpretation of their evidence is that low-tech boost R&D to hasten the completion of new products, while high-tech firms do so when they plan significant strategic shifts to visionary

Proposition 3 shows that a manager concerned with his own or his firm's short-term reputation will be biased in favor of visible actions that raise the stock price. Since increases in reported R&D expenditures are on the whole associated with a positive stock price reaction, a reputational argument implies overinvestment. Althought the argument is strongest for innovative expenditures, a similar point applies to conventional investment. Greater capital expenditures may represent quicker implementation of a new strategy, or initiation of a distinct strategy. Stock prices in average react positively to increases in capital expenditures (McConnell and Muscarella (1985); oil firms were an exception).[21]

Implication 9 *Stockholders of bidding firms in takeovers will on average earn negative abnormal returns in diversifying and synergistic acquisitions involving far-reaching strategic shifts, and positive abnormal returns in 'bustup' takeovers.*

Deferral of resolution can be associated with strategic as well as technological innovations. For example, Brennan (1990, p. 725) suggested that multidivisional conglomerates may be hard to evaluate. A large acquisition (allegedly) for purposes of far-reaching globalization, diversification or synergization can make it harder to evaluate a manager's record early (the Times-Warner merger may be an example). In contrast, a bust-up takeover does not defer resolution, since the success or failure in selling off divisions at a favorable price becomes apparent early. The greater proclivity of low quality managers or firms to defer resolution of uncertainty implies that the stock price will react negatively to the announcement of such activities. This is consistent with a large body of evidence of low returns to bidders in takeover contests (for tender offers, approximately zero over several decades, and negative in the 1980's; see, e.g., Roll (1986), Bradley *et al* (1988), and Schwert (2000)). To the extent that a takeover bid signifies a large strategic shift for the firm that makes it harder to evaluate performance in the short term, the bid is bad news for the acquiror's shareholders. The prediction of positive average abnormal returns for bidders in bustup takeovers is as yet untested.

Implication 9 is consistent with the evidence of Morck *et al* (1990) that the returns to bidding shareholders are lower when their firm diversifies and when it buys a rapidly growing target. These actions are likely to be associated with momentous shifts in

projects that defer resolution.

[21]Several models derive a similar point, based on mimicry of firms with positive NPV projects, rather than on the desire of managers/firms with better prospects to advance resolution of uncertainty (e.g., Trueman (1986), Bebchuk and Stole (1993)).

the bidder's business strategy, and thus with deferral of resolution of uncertainty.[22] Consistent with the model, Comment and Jarrell (1995) and Berger and Ofek (1999) found that firms that narrowed their focus to fewer lines of business earned positive abnormal returns, and those that diversified had negative abnormal returns. Similarly, Sicherman and Pettway (1987) found that the returns to purchasers of divested assets in 1983-85 was larger for assets in related product lines than for unrelated assets. The result also implies that diversified firms will on average have lower value since there are disproportionally more low quality managers/firms among those that defer resolution. Empirical evidences show that diversified firms have lower Tobin's q and trade at a discount relative to comparable portfolios of stand-alone firms (e.g., Lang and Stulz (1994), Berger and Ofek (1995), and Servaes (1996)).

One way of deferring resolution is to add noise to the news outcome, *i.e.*, choose a project whose outcome is known to be poorly correlated with firm or managerial quality. In our model, late resolution is analogous to infinite noise; the arrival of no news at date 1 is equivalent to the arrival of a "signal" that is uninformative. In a previous version of this paper, we showed that equilibria similar to those of the visible resolution timing model apply in a "noise" model in which the manager can choose visible projects whose outcomes are correlated strongly or weakly with his ability. Another visible decision that affects noise and so resolution timing may be the choice of accounting methods, which can alter the ease of assessing performance.

5 Varying Reputational Pressure

Critics of the market for corporate control have argued that takeover threats and pressure from institutional shareholders force managers to focus excessively on short-term stock prices. This section examines the effects of varying the weight δ in (2) placed by the manager on the later relative to the earlier stock price. The parameter δ can be interpreted as an inverse measure of the threat of a hostile takeover, and of pressure from institutional investors. Regarding the latter, Lang and McNichols (1997) provide some evidence consistent with the view that institutional shareholders sell after poor stock price performance, which presumably puts pressure on corporate management.

[22] Two other studies of mergers also find that bidders in closely related acquisitions have positive abnormal returns while bidders in unrelated acquisitions have negative abnormal returns (see Eckbo (1985), and Scanlon *et al* (1989)).

5.1 Hidden Resolution Choice

In the hidden resolution model, differentiation leads to the following comparative statics.

Proposition 4 *In the hidden action setting, lower δ implies that the manager is more likely to take actions that decrease cash flow.*[23]

If A and D refers to an overall strategic decision of whether to aim for conventional execution projects, or toward visionary exploratory projects, then deferral is associated with high innovative activity.

Implication 10 *Takeover pressures and increased institutional shareholding can lead to a shift from conventional, early-resolving projects to visionary, late-resolving projects.*

This result contrasts sharply with the critiques of the hostile takeover market offered in the popular press during the 1980s, and which to some extent continue to be influential today (see, e.g., Thurow (1993), Laverty (1996)).

5.2 Visible Resolution Choice

The following proposition describes the effects of greater insulation from market pressures on resolution timing and the stock market reaction to firm decisions.

Proposition 5 *When the resolution choice is visible, a higher weight δ on the future stock price in the manager's objective function decreases the probability that projects or actions associated with positive stock price reactions will be undertaken.*

If managerial decisions are visible, and if advancing resolution is costly, then a greater takeover threat pressures a low ability manager to advance resolution.[24] As discussed in

[23]In Section 5, we exclude the unstable equilibrium in which an H manager randomizes and an L manager defers. This equilibrium is unreasonable in the sense that there is a tendency to migrate from this equilibrium to a pure strategy equilibrium. The fragility of this equilibrium is analogous to the fragility of the mixed strategy equilibrium in a traffic coordination game in which drivers randomize between driving on the left side and the right side of the road. If people believe that others will drive on the right side (say) with 50.1% instead of 50% probability, then they too will find it strongly optimal to drive on the right side. In dynamic models that describe how a game can reach a mixed strategy equilibrium from a sequence of interactions of the players, there is no convergence to unstable mixed strategy equilibria of this sort (see, for example, Binmore (1992, pp. 404 - 409)).

[24]The intuition is similar to that given in the hidden resolution choice model. This comparative statics is only relevant when the manager randomizes, which by the Corollary to Proposition 2, requires that $c > 0$. Thus, Proposition 5 implies that when δ increases, the firm adopts less A and more D.

Section 4 (see the discussion near Implications 5-7), we continue to interprete R&D expenditures that lead to positive stock price reactions as being associated with resolution-advancing activities.

Implication 11: *If the average stock price reaction to increases in R&D among a class of firms is positive, then greater insulation from takeovers and lower institutional ownership will be associated with* **lower** *R&D expenditures.*

This prediction is consistent with the evidence of Meulbroek *et al* (1990) that after adopting anti-takeover amendments ("shark repellents") firms on average decrease R&D spending. This suggests that takeover threats do not reduce this kind of investment.[25] Mahoney, Sundaramurthy, and Mahoney (1997) find that the adoption of antitakeover provisions is associated with decreases in capital expenditure intensity and especially R&D intensity. This evidence contrasts with criticisms of takeovers in the popular press, as well as models in which a slackening in short-term market pressure leads to *higher* R&D.

Inconsistent with criticisms of the effect of institutional investors, but consistent with our model, Hansen and Hill (1991) found evidence suggesting that, after controlling for other variables, higher institutional ownership is weakly associated with *greater* R&D expenditures. SEC Office of the Chief Economist (1985) reported that as institutional share ownership increased from 1980-1983, the average ratio of R&D expenditure to revenue increased. This study also found cross-sectionally that holding industry effects constant, greater institutional ownership is associated with greater R&D, and that changes in institutional ownership are weakly associated with higher R&D. Baysinger, Kosnik, and Turk (1991) found a positive correlation between institutional ownership and R&D across Fortune 500 firms in 1980. In a careful study, Wahal and McConnell (2000) document a robust positive relation between industry-adjusted R&D expenditures and the fraction of shares owned by institutional investors. (An exception to this body of findings was Graves (1988) finding of a negative relation between institutional ownerhips and R&D among computer manufacturers.)

[25]It is hard to estimate a pure effect of shark repellents, as these may be proposed in response to takeover threats. However, Pound (1987) found that firms that adopted shark repellents were indeed acquired with lower frequency than those that did not. (Furthermore, Meulbroek *et al.* perform several robustness checks to address simultaneity. First, they rerun the test discarding firms that became takeover targets. Second, they use year 0 (the year of adoption of the shark repellent) instead of year -1 as a baseline for measuring changes in R&D. The argument is that a takeover threat may suddenly appear at date 0, so there could be some difference in the extent of the simultaneity problem using the different baselines. With both checks the results are virtually identical.)

Proposition 6 *A higher weight δ on the future stock price in the manager's objective function leads to more positive stock price reactions to the decision to advance resolution.*

Proposition 5 shows that higher δ decreases the probability that an L manager advances resolution. This implies that when investors observe an action that advances resolution, it is more likely from the high ability manager, therefore the stock price reaction will be more positive.

Implication 12: *The stock price reaction to increased R&D expenditures should be more positive for firms that are better insulated from market pressures, such as firms protected by antitakeover amendments, or firms with low institutional share ownership.*

The predictions of Implication 12 have not, to our knowledge, been empirically tested.

6 Conclusion

Almost any substantive action taken by a firm is likely to affect the information possessed by outside observers. In most recent literature, the firm's action affects outsiders perceptions of the firm only because they observe either the action itself, or an immediate effect of that action on the current cash flow. However, most important firm decisions, whether directly observable or not, affect the timing of arrival of *future* news about the firm. Managers can manipulate the news arrival process in many ways, cash flow shifting being one special case. This paper offers general propositions about how managers and firms manipulate the timing of information arrival, and the inferences investors draw from the arrival or non-arrival of news.

For some actions, such as updating an existing product, the success or failure consequences of an investment choice are likely to become apparent rapidly, while for others, such as developing an innovative new product or business model, the full outcome may not become apparent for years. The intensity of investment also affects the rate of resolution of uncertainty. In either case, high quality managers (or firms) are biased toward advancing resolution of uncertainty, while low ability managers may favor either advancing or deferring resolution.

Resolution timing offers an explanation for various stylized facts, some quite puzzling, about R&D expenditures, takeovers, product introductions, spinoffs, issuance of tracking stock by firms with innovative projects, and the stock price reactions associated with these events. This approach also yields several predictions that are as yet untested.

Certain predictions of the model contrast with previous literature on managerial reputation and project choice. For example, a manager will sometimes unobservably overinvest. Hidden investment can be useful to a high quality manager or his firm because it can accelerate a likely-favorable resolution. For visible investment choices, we show that in contrast with popular accounts, greater insulation from market pressures can reduce R&D expenditures. Thus, our model provides an explanation for the evidence of Meulbroek et al (1990) and Mahoney, Sundaramurthy, and Mahoney (1997) that antitakeover amendments (which reduce takeover threats) on average decrease R&D, and that high institutional shareholding are associated with high R&D expenditures.

The analysis suggests that there are social costs of resolution timing. One such cost may be a bias toward immediate product development over basic research activity. Perhaps more importantly, resolution manipulation can lead to a perverse sorting of high quality managers and firms to conventional projects, and inefficient managers and firms to visionary projects.

The analysis therefore provides a new perspective on policy debates about whether managers are prone to underinvest and under-innovate. Our model suggests that underinvestment is most likely for exploratory projects (which defer resolution of uncertainty), and overinvestment for execution projects (which advance resolution). Furthermore, overinvestment is predicted for visible investments that accelerate the completion of product development. Thus, any attempt to motivate managers to invest more efficiently faces the task of targeting these different kinds of investment. Since induced resolution timing can lead to excessive R&D activity (either visible or hidden), in some firms it may be desirable for the board of directors to monitor innovative projects and ration capital.

It was often argued in the popular press during the 1980s that the takeover wave of that decade was causing a failure of U.S. firms to innovate, and a decline of U.S. competitiveness on world markets. Our model shows that there is no presumption on theoretical grounds that takeover threats will reduce innovative activity. In our model takeover threats can be associated with excessive rather than insufficient innovation. Takeover threats can encourage managers or firms with poor prospects to focus on more innovative, late-resolving projects (if this decision is hidden), and can encourage firms with good prospects to intensify R&D spending to accelerate product development (if this decision is visible).

The analysis tends to weaken the criticism frequently leveled by target managers against particular hostile takeovers, that poor stock price performance of the target re-

flects the stock market's failure to grasp management's vision for the long-term. Utopian futuristic "vision" is the last refuge of incompetence. (Even though some managers who invest for the long-term are highly able.) Since high ability managers are more willing to advance resolution than low ability managers, it is valid to be somewhat skeptical of managers who hold out the promise favorable resolution in the distant future.

Deferral of resolution may be associated not only with innovative expenditure, but with acquisition or other major strategic reorientation of the firm. Also, the choice of projects with noisy outcomes makes it harder to evaluate a manager, deferring resolution about his ability. The analysis suggests that able managers will tend to be too conservative, owing to their desire to obtain favorable resolution; while poor managers may also be conservative, to mimic, or may favor radical changes, to defer resolution.

An interesting direction for further research is the role of option-based compensation (see Hagerty, Ofer and Siegel (1990)). On the one hand, an option with a short term to expiration encourages a manager to advance resolution of uncertainty, to exploit the option value. However, it also encourages managers to take other risk-increasing actions, which may add noise to the resolution process. Thus, the net effect of option compensation on resolution timing is not obvious.

Resolution timing is also relevant in other labor market settings in which the employee has some discretion over tasks. Young academics are often told to do conventional research before tenure to prove they are good (obtain early resolution); after tenure, the advice goes, they can sit back, survey the big picture, and attempt major (late-resolving) projects. The introduction of noise to confuse judgement of ability is also relevant in other settings, as with obscurantism in modern music, poetry and visual arts.[26] Of course, while those with no talent should be obscure, some that are obscure are highly talented.

[26]Or in the words of W. S. Gilbert, "If this young man expresses himself in terms too deep for me, why what a very singularly deep young man this deep young man must be."

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Appendix

Some basic calculations for hidden investment case:

From equation (3),

$$\begin{aligned} E_0[V_1 + \delta V_2|\Theta] &= \theta r[\gamma_\Theta V_1(G, s=1) + (1-\gamma_\Theta)V_1(B, s=1) + \delta V_2(\Theta, s=1)] \\ &+ (1-\theta r)[V_1(s=2) + \delta V_2(\Theta, s=2)], \end{aligned} \tag{4}$$

where $\gamma_H = 1$, $\gamma_L \equiv \gamma$.

Date 1 and date 2 stock prices are defined as the expected cash flow.

$$V_t(\cdot) = E_t[C|\cdot] = E_t[dI_H(\Theta) - cI_A(\mathrm{M})|\cdot] = dPr(H|\cdot) - cPr(A|\cdot). \tag{5}$$

Therefore,

$$\begin{aligned} V_1(\mathrm{G}, s=1) &= dPr(\mathrm{H}|\mathrm{G}, s=1) - c, \\ V_1(\mathrm{B}, s=1) &= -c, \\ V_1(s=2) &= dPr(\mathrm{H}|s=2) - cPr(\mathrm{A}|s=2), \\ V_2(\Theta, s=1) &= dI_H(\Theta) - c, \\ V_2(\Theta, s=2) &= dI_H(\Theta) - cPr(\mathrm{A}|\Theta, s=2). \end{aligned} \tag{6}$$

From (4)-(6), the gain to an H manager of advancing is

$$\begin{aligned} U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) &= rd[Pr(\mathrm{H}|\mathrm{G}, s=1) - Pr(\mathrm{H}|s=2)] \\ &- rc[(1+\delta) - Pr(\mathrm{A}|s=2) - \delta Pr(\mathrm{A}|\mathrm{H}, s=2)]. \end{aligned} \tag{7}$$

Similarly, for an L manager

$$\begin{aligned} U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) &= rd[\gamma Pr(\mathrm{H}|\mathrm{G}, s=1) - Pr(\mathrm{H}|s=2)] \\ &- rc[(1+\delta) - Pr(\mathrm{A}|s=2) - \delta Pr(\mathrm{A}|\mathrm{L}, s=2)]. \end{aligned} \tag{8}$$

The conditional probabilities are given below.

$$\begin{aligned} Pr(\mathrm{H}|\mathrm{G}, s=1) &= \frac{Pr(\mathrm{G}, s=1|\mathrm{H})\lambda}{Pr(\mathrm{G}, s=1|\mathrm{H})\lambda + Pr(\mathrm{G}, s=1|\mathrm{L})(1-\lambda)} \\ &= \frac{h\lambda}{h\lambda + l\gamma(1-\lambda)}. \end{aligned} \tag{9}$$

$$\begin{aligned} Pr(\mathrm{H}|s=2) &= \frac{Pr(s=2|\mathrm{H})\lambda}{Pr(s=2|\mathrm{H})\lambda + Pr(s=2|\mathrm{L})(1-\lambda)} \\ &= \frac{(1-hr)\lambda}{(1-hr)\lambda + (1-lr)(1-\lambda)}. \end{aligned} \tag{10}$$

$$\begin{aligned} Pr(\mathrm{A}|s=2) &= \frac{Pr(s=2|\mathrm{A})Pr(\mathrm{A})}{Pr(s=2)} \\ &= \frac{(1-r)[h\lambda + l(1-\lambda)]}{(1-hr)\lambda + (1-lr)(1-\lambda)}. \end{aligned} \tag{11}$$

$$Pr(\mathrm{A}|\Theta, s=2) = \frac{(1-r)\theta}{(1-r)\theta + (1-\theta)}. \tag{12}$$

Proof of Proposition 1: In a pure strategy equilibrium, one of the following four outsider beliefs must be confirmed.

1. $h = 0$, $l = 0$, *i.e.*, an H manager defers resolution and an L manager mimics. Intuitively, this belief can be an equilibrium because for a sufficiently high c, any manager who advances cannot escape an adverse inference about incurring c.

2. $h = 1$, $l = 1$, *i.e.*, an H manager advances resolution and an L manager mimics. Intuitively, this is not an equilibrium because an L manager could defer in order to conceal his type without any adverse inference about his type (or about the failure to incur c even if $c < 0$).

3. $h = 0$, $l = 1$, *i.e.*, an H manager defers resolution and an L manager advances resolution. Intuitively, we do not expect Belief 3 to hold because an L manager prefers late resolution, and will defect if investors believe that an H manager defers resolution.

4. $h = 1$, $l = 0$, *i.e.*, an H manager advances resolution and an L manager defers resolution. Intuitively, we expect Belief 4 to hold only for some parameter values. For a sufficiently low cost of advancing resolution an L manager will also advance resolution and the equilibrium breaks down. Similarly, if the cost of advancing resolution is high, an H manager will also defer resolution and once again the equilibrium breaks down.

We now describe parameter values under which Beliefs 1 and 4 are confirmed in equilibrium, and under which a mixed strategy equilibrium applies. Beliefs 2 and 3 are inconsistent with equilibrium.

Belief 1 $h = 0$, $l = 0$. When good news (G) is observed at $t = 1$, defection to advance is attributed to high type with probability β. Equations (7) and (8) can be written as

$$\begin{aligned} U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) &= r[d(\beta - \lambda) - c(1+\delta)], \\ U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) &= r[d(\gamma\beta - \lambda) - c(1+\delta)]. \end{aligned} \tag{13}$$

Let $c^{\Theta}(h, l)$ denote the value of c for which the type Θ manager is indifferent between A and D given that investors believe H advances with probability h and L with probability l. From (13), Belief 1 is a Perfect Bayesian Equilibrium when $c > c^{\mathrm{H}}(0, 0)$.

Belief 2 $h = 1$, $l = 1$. L defects by deferring resolution since

$$\begin{aligned} U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) &= rd\left[\gamma\frac{\lambda}{\lambda + \gamma(1-\lambda)} - \lambda\right] \\ &= -\frac{rd\lambda^2(1-\gamma)}{\lambda + \gamma(1-\lambda)} < 0. \end{aligned} \tag{14}$$

So Belief 2 is not a Perfect Bayesian Equilibrium.

Belief 3 $h = 0$, $l = 1$. From the inspection of equations (7) and (8), whenever an L manager prefers advancing, an H manager also prefers advancing resolution since

$$U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) > U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) \tag{15}$$

Thus, Belief 3 is not an equilibrium.

Belief 4 $h = 1$, $l = 0$. By equation (7) an H manager advances resolution if

$$\frac{r(d-c)(1-\lambda)}{(1-r)\lambda + (1-\lambda)} > 0. \tag{16}$$

This holds as long as $c < d$.

By equation (8) an L manager defers resolution if

$$rd\left[\gamma - \frac{(1-r)\lambda}{(1-r)\lambda + (1-\lambda)}\right] - rc\left[(1+\delta) - \frac{(1-r)\lambda}{(1-r)\lambda + (1-\lambda)}\right] < 0. \tag{17}$$

(17) holds for $c > d[\gamma(1-r\lambda)-(1-r)\lambda]/[(1-\lambda)+r\delta(1-r\lambda)]$. Thus, Belief 4 is a Perfect Bayesian Equilibrium for $c \in (c^{\mathrm{L}}(1,0), c^{\mathrm{H}}(1,0)) = (d[\gamma(1-r\lambda) - (1-r)\lambda]/[(1-\lambda) + r\delta(1-r\lambda)], d)$.

Mixed Strategy Equilibria: We now consider the mixed strategy equilibrium in which an H manager advances and an L manager randomizes.

For $c \in (c^{\mathrm{L}}(1,1)(= -\infty), c^{\mathrm{L}}(1,0))$, Belief 4 ($h = 1, l = 0$) fails because when $h = 1$ and $l = 0$, an L manager prefers to advance resolution and Belief 2 ($h = 1$, $l = 1$) fails, because an L manager prefers late resolution. In other words, $U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) > 0$ when $l = 0$ and $U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) < 0$ when $l = 1$. Furthermore, direct differentiation of (8) shows that $U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D})$ is continuous and decreases monotonically in l. We shall refer to this fact as the *decreasing monotonicity condition.*

Let $l^* \in (0,1)$ be the candidate equilibrium, defined as the value of l where $U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) = 0$. A unique l^* exists by the decreasing monotonicity condition because $U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D})$ is continuous, positive for $l = 0$ and negative for $l = 1$. And (7) and (8) show that when an L manager is indifferent, an H manager strictly prefers advancing resolution. Therefore, the mixed strategy equilibrium in which an H manager advances and an L manager randomizes exists for $c \in (c^{\mathrm{L}}(1,1), c^{\mathrm{L}}(1,0))$.

There is another mixed strategy equilibrium where an H manager randomizes and an L defers. For $c \in (c^{\mathrm{H}}(0,0), c^{\mathrm{H}}(1,0))$ and $l = 0$, $U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) < 0$ when $h = 0$, and $U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) > 0$, when $h = 1$. Direct differentiation of (7) shows that $U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D})$ is continuous and monotonically increasing in h (*increasing monotonicity condition*). Following the similar logic as for the previous mixed strategy equilibrium, we can show that the mixed strategy equilibrium in which an H manager mixes and an L manager defers exists for $c \in (c^{\mathrm{H}}(0,0), c^{\mathrm{H}}(1,0))$.

Proof of Corollary to Proposition 1: Consider the hidden resolution choice equilibria where both early and late resolutions are possible: (a) H advances, L defers, (b) H advances, L randomizes, and (c) H randomizes and L defers.

Let us define $V(s=1)$ and $V(s=2)$ as expected cash-flows given early or late resolutions. Then

$$\begin{aligned} V(s=1) &= dPr(\mathrm{H}|s=1) - c, \\ V(s=2) &= dPr(\mathrm{H}|s=2) - cPr(\mathrm{A}|s=2). \end{aligned} \tag{18}$$

From (18), the difference between $V(s=1)$ and $V(s=2)$ is

$$V(s=1) - V(s=2) = d[Pr(\mathrm{H}|s=1) - Pr(\mathrm{H}|s=2)] - c[1 - Pr(\mathrm{A}|s=2)]. \tag{19}$$

We will show that (19) is greater than zero in the listed equilibria above.

For equilibrium (a) where H advances and L defers, $Pr(\mathrm{H}|s=1) = 1$ and $Pr(\mathrm{A}|s=2) = Pr(\mathrm{H}|s=2)$. Then equation (19) can be written as

$$V(s=1) - V(s=2) = (d-c)[1 - Pr(\mathrm{H}|s=2)] > 0. \tag{20}$$

The inequality is from the fact that equilibrium (a) holds for $c < d$, and $Pr(\mathrm{H}|s=2) < 1$.

Now consider equilibrium (b). Since the L manager randomizes, he must be indifferent between A and D. From (8), this implies that the following is zero.

$$d[\gamma Pr(\mathrm{H}|\mathrm{G}, s=1) - Pr(\mathrm{H}|s=2)] - c[(1+\delta) - Pr(\mathrm{A}|s=2) - \delta Pr(\mathrm{A}|\mathrm{L}, s=2)]. \tag{21}$$

Comparing (19) with (21), (19) is greater than (21) since

$$Pr(\mathrm{H}|s=1) = \frac{\lambda}{\lambda + l(1-\lambda)} > \gamma \frac{\lambda}{\lambda + l\gamma(1-\lambda)} = \gamma Pr(\mathrm{H}|\mathrm{G}, s=1). \tag{22}$$

Therefore, (19) is greater than zero.

Similarly for equilibrium (c), we can show that (19) is greater than zero since (19) is greater than (7) divided by r, which is zero since H manager is indifferent between A and D.

Since market participants are rational, these results imply that the expected profits given early resolution are larger than expected profits given late resolution.

Proof of Proposition 2: By inspection of Figure 2, (2) becomes

$$\begin{aligned} E_0[V_1 + \delta V_2|\Theta] &= \theta r[\gamma_\Theta V_1(\mathrm{G},\mathrm{A}) + (1-\gamma_\Theta)V_1(\mathrm{B},\mathrm{A}) + \delta V_2(\Theta,\mathrm{A})] \\ &+ \theta(1-r)[V_1(\mathrm{A}) + \delta V_2(\Theta,\mathrm{A})] + (1-\theta)[V_1(\mathrm{D}) + \delta V_2(\Theta,\mathrm{D})]. \end{aligned} \tag{23}$$

The stock prices are as follow.

$$V_1(\mathrm{G},\mathrm{A}) = dPr(\mathrm{H}|\mathrm{G},\mathrm{A}) - c, \tag{24}$$

$$V_1(\mathrm{B},\mathrm{A}) = -c \tag{25}$$

$$V_1(\mathrm{A}) = dPr(\mathrm{H}|\mathrm{A}) - c \tag{26}$$

$$V_1(\mathrm{D}) = dPr(\mathrm{H}|\mathrm{D}) \tag{27}$$

$$V_2(\Theta,\mathrm{M}) = dI_{\mathrm{H}}(\Theta) - cI_{\mathrm{A}}(M) \tag{28}$$

The gain to an H or L manager of advancing is then

$$U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) = d[rPr(\mathrm{H}|\mathrm{G},\mathrm{A}) + (1-r)Pr(\mathrm{H}|\mathrm{A}) - Pr(\mathrm{H}|\mathrm{D})] - c(1+\delta). \quad (29)$$

$$U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) = d[r\gamma Pr(\mathrm{H}|\mathrm{G},\mathrm{A}) + (1-r)Pr(\mathrm{H}|\mathrm{A}) - Pr(\mathrm{H}|\mathrm{D})] - c(1+\delta). \quad (30)$$

If both A and D can occur with a positive probability, the probabilities becomes

$$\begin{aligned} Pr(\mathrm{H}|\mathrm{A}) &= \frac{h\lambda}{h\lambda + l(1-\lambda)}, \\ Pr(\mathrm{H}|\mathrm{D}) &= \frac{(1-h)\lambda}{(1-h)\lambda + (1-l)(1-\lambda)}, \\ Pr(\mathrm{H}|\mathrm{G},\mathrm{A}) &= \frac{h\lambda}{h\lambda + l\gamma(1-\lambda)}. \end{aligned} \quad (31)$$

Belief 5 *$h = 0, l = 0$ and a defection to advance is attributed, with probability β to an H manager.*

(31) now becomes

$$\begin{aligned} Pr(\mathrm{H}|\mathrm{A}) &= \beta,\ Pr(\mathrm{H}|\mathrm{D}) = \lambda, \\ Pr(\mathrm{H}|\mathrm{G},\mathrm{A}) &= \frac{\beta}{\beta + \gamma(1-\beta)} \end{aligned}$$

(29) and (30) become

$$U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) = d\left[r\frac{\beta}{\beta+\gamma(1-\beta)} + (1-r)\beta - \lambda\right] - c(1+\delta). \quad (32)$$

$$U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) = d\left[r\frac{\gamma\beta}{\beta+\gamma(1-\beta)} + (1-r)\beta - \lambda\right] - c(1+\delta). \quad (33)$$

From (32) and (33), Belief 5 is Perfect Bayesian Equilibrium when $c > c^H(0,0)$.

Belief 6 *$h = 1, l = 1$ and a defection to defer is attributed, with probability β to an H manager.*

(31) now becomes

$$\begin{aligned} Pr(\mathrm{H}|\mathrm{A}) &= \lambda,\ Pr(\mathrm{H}|\mathrm{D}) = \beta, \\ Pr(\mathrm{H}|\mathrm{G},\mathrm{A}) &= \frac{\lambda}{\lambda + \gamma(1-\lambda)}. \end{aligned}$$

(29) and (30) become

$$U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) = d\left[r\frac{\lambda}{\lambda+\gamma(1-\lambda)} + (1-r)\lambda - \beta\right] - c(1+\delta). \quad (34)$$

$$U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) = d\left[r\gamma\frac{\lambda}{\lambda+\gamma(1-\lambda)} + (1-r)\lambda - \beta\right] - c(1+\delta). \quad (35)$$

From (34) and (35), the conjectured equilibrium holds for $c < c^L(1,1)$.

Belief 7 $h = 0, l = 1$

(29) and (30) now become

$$U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) = U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) = -d - c(1+\delta). \tag{36}$$

H and L types will either both advance or both defer. Thus, the conjectured equilibrium does not hold (unless $c = -d/(1+\delta)$, in which case it holds weakly).

Belief 8 $h = 1, l = 0$

(29) and (30) now become

$$U^{\mathrm{H}}(\mathrm{A}) - U^{\mathrm{H}}(\mathrm{D}) = d - c(1+\delta). \tag{37}$$

$$U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) = d[r\gamma + (1-r)] - c(1+\delta). \tag{38}$$

For $c \in (d[r\gamma + (1-r)]/(1+\delta), d/(1+\delta)) = (c^{\mathrm{L}}(1,0), c^{\mathrm{H}}(1,0))$ an H manager advances and an L manager defers.

Mixed Strategy Equilibria: We now consider the mixed strategy equilibria. Following same procedures as proof for Proposition 1, we can show that the mixed strategy equilibrium in which an H manager advances and an L manager randomizes exists for $c \in (c^{\mathrm{L}}(1,1), c^{\mathrm{L}}(1,0))$ and the mixed strategy equilibrium in which an H manager randomizes and an L defers exists for $c \in (c^{\mathrm{H}}(0,0), c^{\mathrm{H}}(1,0))$.

Proof of Corollary to Proposition 2: To satisfy the Universal Divinity criteria of Bank and Sobel (1987), we assign $\beta = 1$ in Belief 5 ($h = l = 0$) since an H manager has more incentive to deviate by advancing, and $\beta = 0$ in Belief 6 ($h = l = 1$) since an L manager is more likely to defer. Then

$$c^{\mathrm{H}}(0,0) = d\left(\frac{1-\lambda}{1+\delta}\right) > 0. \tag{39}$$

$$c^{L}(1,1) = \frac{d\lambda}{1+\delta}\left[\frac{r\gamma}{\lambda + \gamma(1-\lambda)} + (1-r)\right] > 0. \tag{40}$$

For $c < min(c^{\mathrm{H}}(0,0), c^{\mathrm{L}}(1,1))$, there is only one equilibrium in which both H and L manager advances.

Proof of Proposition 3: Consider the equilibria where both advancing and deferring decision can be observed: (a) H advances, L defers, (b) H advances, L randomizes, and (c) H randomizes and L defers.

The stock price just before the manager's decision to advance or defer (V_0^-) is the expected value of the stock price after the decision (V_0^+).

$$V_0^- = [h\lambda + l(1-\lambda)]V_0^+(\mathrm{A}) + [1 - (h\lambda + l(1-\lambda))]V_0^+(\mathrm{D}), \tag{41}$$

where

$$V_0^+(\mathrm{A}) = dPr(\mathrm{H}|\mathrm{A}) - c \tag{42}$$
$$V_0^+(\mathrm{D}) = dPr(\mathrm{H}|\mathrm{D}). \tag{43}$$

The difference of stock prices is

$$V_0^+(\mathrm{A}) - V_0^+(\mathrm{D}) = d[Pr(\mathrm{H}|\mathrm{A}) - Pr(\mathrm{H}|\mathrm{D})] - c. \tag{44}$$

We will show that $V_0^+(\mathrm{A}) > V_0^+(\mathrm{D})$ in all three equilibria listed above. First consider the equilibrium (a) where an H manager advances and an L manager defers. Then (44) becomes

$$V_0^+(\mathrm{A}) - V_0^+(\mathrm{D}) = d - c. \tag{45}$$

This equilibrium holds only if $c < d/(1+\delta)$. Therefore, $V_0^+(\mathrm{A}) > V_0^+(\mathrm{D})$ in equilibrium (a). Next, consider the equilibrium (b) where an H manager advances and an L manager randomizes. Then (44) becomes

$$V_0^+(\mathrm{A}) - V_0^+(\mathrm{D}) = dPr(\mathrm{H}|\mathrm{A}) - c. \tag{46}$$

It can be shown that (46) is greater than (30) since

$$Pr(\mathrm{H}|\mathrm{A}) = \frac{\lambda}{\lambda + \mathrm{l}(1-\lambda)} > \gamma \mathrm{Pr}(\mathrm{H}|\mathrm{G},\mathrm{A}) = \gamma \frac{\lambda}{\lambda + \mathrm{l}\gamma(1-\lambda)}. \tag{47}$$

and (30) is zero because L manager is indifferent between advancing and deferring. Therefore, $V_0^+(\mathrm{A}) > V_0^+(\mathrm{D})$.

Now, consider the equilibrium (c) where an H manager randomizes and an L manager defers. In this case, $Pr(\mathrm{H}|\mathrm{G},\mathrm{A}) = Pr(\mathrm{H}|\mathrm{A}) = 1$. (44) becomes

$$V_0^+(\mathrm{A}) - V_0^+(\mathrm{D}) = d[1 - Pr(\mathrm{H}|\mathrm{D})] - c. \tag{48}$$

We can easily show that (48) is greater than (29) which is zero since H manager is indifferent between advancing and deferring. Therefore, $V_0^+(\mathrm{A}) > V_0^+(\mathrm{D})$.

Proof of Proposition 4: We need to consider mixed strategy equilibrium where an H manager advances and an L manager mixes ($h = 1$, $l = l^*$). Let the gain to an L manager of advancing given (8) be:

$$\begin{aligned} F(l) &\equiv U^{\mathrm{L}}(\mathrm{A}) - U^{\mathrm{L}}(\mathrm{D}) \\ &= rd[\gamma Pr(\mathrm{H}|\mathrm{G},\mathrm{s}=1) - \mathrm{Pr}(\mathrm{H}|\mathrm{s}=2)] \\ &- rc[(1+\delta) - Pr(\mathrm{A}|s=2) - \delta Pr(\mathrm{A}|L, s=2)] \end{aligned} \tag{49}$$

Since L manager is indifferent between advancing and deferring, $F(l^*) = 0$. Taking total differentiation with respect to l and δ on both sides of (49) at $l = l^*$, we get

$$\frac{\partial F}{\partial l^*} dl^* + \frac{\partial F}{\partial \delta} d\delta = 0 \tag{50}$$

$$\Rightarrow \frac{dl^*}{d\delta} = -\left(\frac{\partial F}{\partial \delta}\right) / \left(\frac{\partial F}{\partial l^*}\right). \tag{51}$$

$\partial F/\partial l^* < 0$ from the decreasing monotonicity condition, and from (49), $sign(\partial F/\partial \delta) = -sign(c)$. Therefore,

$$sign\left(\frac{dl^*}{d\delta}\right) = -sign(c). \tag{52}$$

If $c > 0$, $dl^*/d\delta < 0$, and if $c < 0$, $dl^*/d\delta > 0$. So, lower δ implies that an L manager is more likely to take costly action.

Proof of Proposition 5: Consider the mixed strategy equilibrium where an H manager advances and an L manager randomizes ($h = 1$, $l = l^*$) that satisfies the Universal Divinity criteria of Bank and Sobel (1987).

Similar to the proof of Proposition 4, it can be shown that

$$sign\left(\frac{dl^*}{d\delta}\right) = -sign(c). \tag{53}$$

Since this equilibrium holds for only $c > 0$, $dl^*/d\delta < 0$. Therefore, higher δ decreases the probability that an L manager advances resolution.

Proof of Proposition 6: Consider the mixed strategy equilibrium where an H manager advances and an L manager randomizes. The stock price reaction to advancing decision is

$$\Delta V \equiv V_0^+(A) - V_0^- = [1 - \lambda - l^*(1-\lambda)]V_0^+(A), \tag{54}$$

where $V_0^+(A)$ and V_0^- are as defined in the proof of Proposition 3, and the last equality is from the fact that $V_0^+(D) = 0$ in this equilibrium.

Differentiating ΔV with respect to δ,

$$\frac{\partial(\Delta V)}{\partial \delta} = -(1-\lambda)V_0^+(A)\frac{\partial l^*}{\partial \delta} + [1 - \lambda - l^*(1-\lambda)]\frac{\partial V_0^+(A)}{\partial l^*}\frac{\partial l^*}{\partial \delta} \tag{55}$$

In the proof for Proposition 3, we showed that $\partial l^*/\partial \delta < 0$ and that $V_0^+(A) > V_0^+(D) = 0$. Furthermore, $\partial V_0^+(A)/\partial l^* < 0$ since

$$V_0^+(A) = dPr(\mathrm{H|A}) - c = \frac{d\lambda}{\lambda + l^*(1-\lambda)} - c \tag{56}$$

Therefore,

$$\frac{\partial(\Delta V)}{\partial \delta} > 0. \tag{57}$$

So, higher δ leads to more positive stock reaction to the decision to advance resolution.

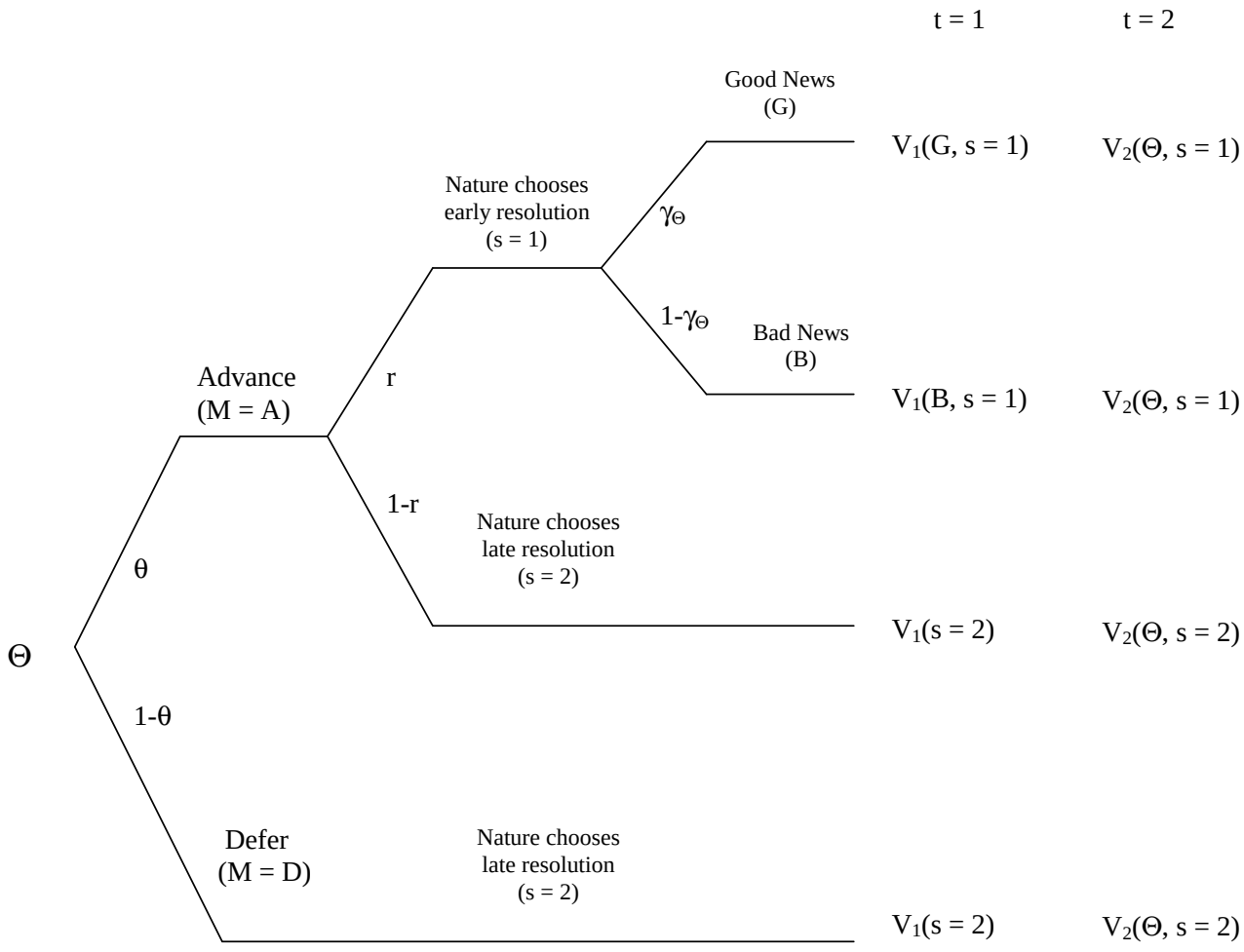

Figure 1: Event tree of type Θ manager (Θ = H or L) in hidden investment choice

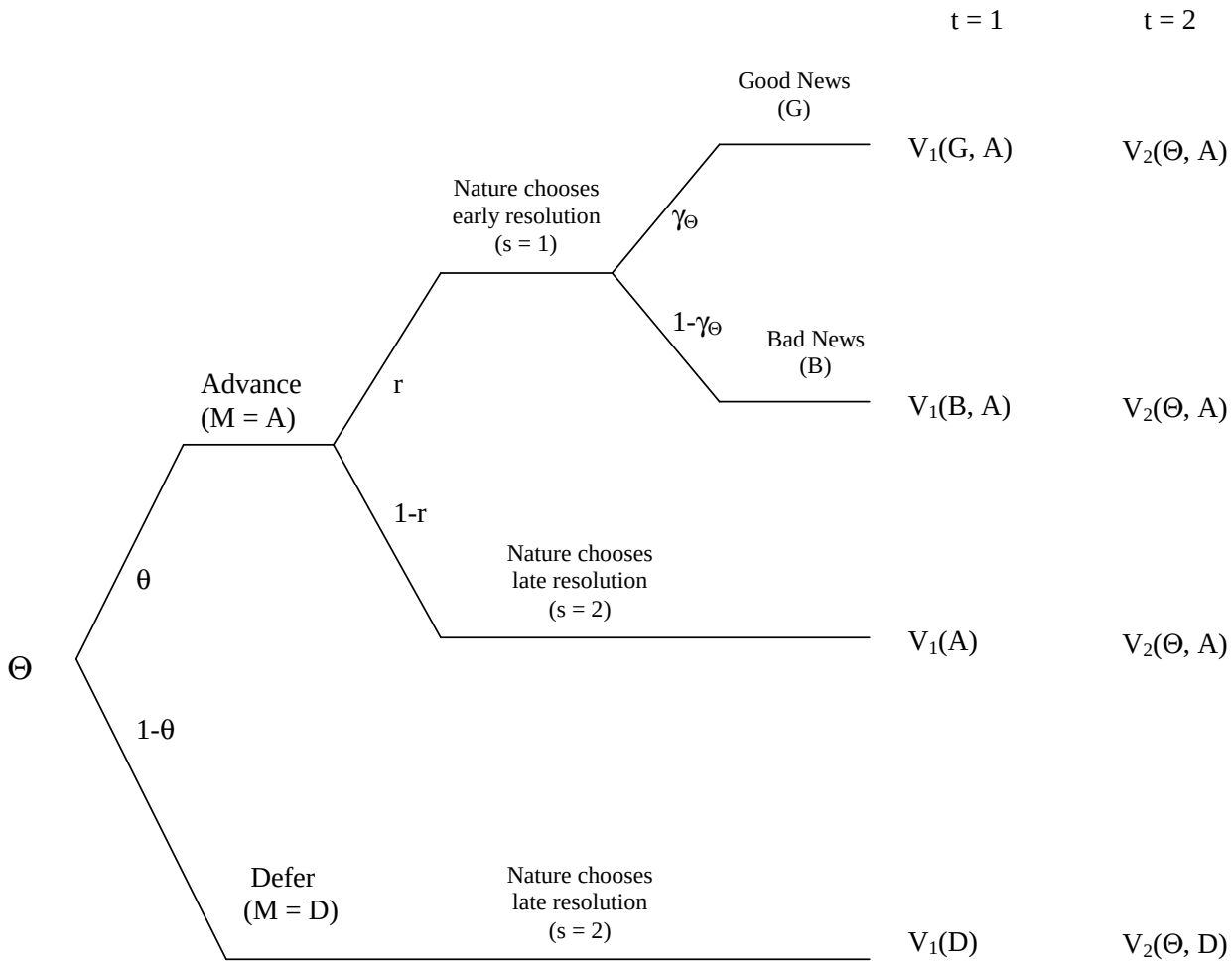

Figure 2: Event tree of type Θ manager (Θ = H or L) in visible investment choice