

How Frequent Financial Reporting Causes Managerial Short-Termism:
An Analysis of the Costs and Benefits of Reporting Frequency

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1. Introduction

How frequently should publicly traded firms be required to report the results of their operations to the capital market? This is an important policy question of concern to accounting regulators. In the United States the frequency of mandatory reporting has risen from annual reporting to semi-annual reporting to quarterly reporting. With increasing demands for greater accountability and transparency of financial information, it is likely there will be pressure on regulators to call for even more frequent reporting. In the absence of a clear sense of the potential costs and benefits associated with the frequency of financial reporting, the knee jerk reaction that more information is preferred to less will undoubtedly prevail. Such a conclusion is derived from studies of disclosure in pure exchange settings where the only effect of information is to reduce the risk premium in stock prices or to reduce informational differences across traders. However, in this paper we demonstrate that when the “real” effect of frequent disclosures on firms’ project selection policies are taken into account, more frequent disclosure could actually be worse, because it could induce managerial short-termism (myopia). We develop both the cost side and the benefit side of reporting frequency and study their tradeoff.

More frequent reporting enhances the information that is impounded in stock prices by providing more timely and more disaggregate information on a firm’s performance. In turn, more informed prices provide better market discipline in the sense of discouraging investment in negative net present value projects. There could be additional potential benefits that we do not explicitly consider. Perhaps, more frequent reports would decrease informational differences across traders in the capital market thus increasing market liquidity. Perhaps more frequent reports would facilitate corporate governance. While the benefits are not difficult to imagine, the *costs* associated with increased reporting frequency (apart from increased compliance costs) are more subtle and less apparent. In the voluntary disclosure literature, proprietary costs arising from information leakage to competing firms is commonly believed to be a potent force that

limits disclosure.¹ However such proprietary costs while damaging the cash flows of the disclosing firm, would enhance the cash flows of competing firms, so the *social* costs to such disclosure could be small or even non-existent. Therefore, proprietary cost arguments are unlikely to sway regulators who mandate disclosure frequency. Gigler and Hemmer [1998] identify one potential cost due to increased reporting frequency. They argue that moral hazard problems arising from the unobservable effort of a firm's manager become more severe if reporting frequency is increased.

Neither proprietary costs nor moral hazard costs arise *directly* from disclosure to the capital market. They arise because disclosure to capital markets is equated with disclosure to other parties. One plausible cost that could arise directly from capital market pricing comes from the fact that accounting measurement errors would become more severe if the measurement window is shortened due to more frequent disclosure requirements. Kanodia and Mukherji [1996], and Kanodia, Sapra and Venugopalan [2004] show how such measurement errors distort market pricing and create price pressure to forego or decrease desirable investments that are not directly observable.

But there could be another potentially more serious cost associated with the frequency of financial reporting that is suggested by the recent debate surrounding the proposal to mandate quarterly reporting in Europe, Singapore and Australia. Bhojraj and Libby [2005] report the following excerpts from the popular press:

“Some of Europe’s most powerful investors are calling on the European Commission to drop plans to introduce mandatory quarterly reporting for companies....it (quarterly reporting) has not helped prevent corporate scandals in the U.S., and there is risk that it will encourage short-termism.” (*Financial Times*, January 27, 2003)

¹ For examples, see Dye [1986], Darrough and Stoughton [1990], and Gigler [1994].

“Hong Kong says no to quarterly reportingCritics say an unintended consequence will be short-termism in the market, with investors focused on seasonal profits rather than long-term earnings growth.” (*Investor Relations Magazine*, November 15, 2002)

Rahman, Tay, Ong and Cai [2007] summarize the European debate as follows:

“In the debate over quarterly reporting, those in favor believe that the more frequent reporting of earnings increases analyst following of firms, improves timeliness of earnings, and improves stock trading. Those in opposition argue that it encourages short-termism, which can lead to earnings management and stock price volatility.” They also report that: “In the United Kingdom, Chartered Institute of Management Accountants (CIMA) warned that without the conclusion of enough management commentary on business outlook in quarterly reports, companies ran the risk of making short-term decisions to make the bottom-line numbers attractive to investors.”

In lieu of these concerns, in 2004, the European Union Parliament rejected the proposal to mandate quarterly reporting, and in Singapore, the Council on Corporate Disclosure and Governance recommended that companies with a market capitalization of less than \$75 million should be exempt from quarterly reporting. A similar example in the U.S. received much publicity. During Google’s IPO offering in 2004, the management of Google explicitly declined to provide frequent earnings guidance to analysts, saying that it did not want to lose focus on its long-term goals.

The above excerpts from the popular press suggest that a broad spectrum of practitioners intuitively feel that if firms are required to report, or forecast, the results of their operations too frequently, managers would become overly focused on short-term goals that are not in the best interests of the firm. Importantly, the intuition is that this short-termism is caused by *price pressure* from the capital market, rather than an outcome of managerial career concerns or the

result of poorly designed performance measures. If the short-termism hypothesis is true, the costs of requiring ever more frequent disclosure could become formidable. In this paper, we flesh out this managerial short-termism /myopia hypothesis, and develop plausible conditions under which an increase in the frequency of financial reporting would precipitate managerial short-termism as an equilibrium response solely due to price pressure from the capital market.

Thus, as analyzed in this paper, there is clear tradeoff between the costs and benefits of increasing the frequency of mandatory financial reporting. The benefit from increasing the frequency of financial reporting is that it provides better *ex ante* incentives for investment. The cost of increased frequency is that it increases the probability of inducing managerial short-termism. We tradeoff these costs and benefits and develop conditions under which greater reporting frequency is desirable and conditions under which it is not.

The layman's intuition is that corporate myopia is caused by impatient traders in the capital market who hold the firm only for short-term capital gains and consequently demand quick returns to managerial actions. We show that this popular intuition is incomplete. Impatience in the capital market, while necessary, is insufficient to create the kind of price pressure that would sustain managerial myopia. Since markets are forward looking, any actions that favor the short-term at the expense of greater long-term value creation would be effectively punished by lower capital market prices. Managerial myopia is sustainable only if there are informational gaps between the capital market and corporate managers, leading to market inferences from noisy summary statistics of the sort typically reported by periodic accounting statements. Given such informational differences, we study equilibrium pricing and corporate investment strategies in two accounting regimes that differ only in the frequency with which firms are required to report the results of operations. In each regime, capital markets are "efficient" in the sense that market participants make rational Bayesian inferences from accounting reports regarding variables that affect the future profitability of the firm, their

inferences are consistent with the optimizing strategy of the firm, and market prices fully reflect these rational inferences.

We show that frequent reporting results in price pressures that are analogous to the pressure caused by the premature evaluation of any action whose value is probabilistically manifested only over the long run. These premature evaluations are tempered by subsequent evaluations, but the damage caused by early evaluations cannot be overcome when shareholders are sufficiently impatient. Thus, frequent reports magnify the attraction of managerial actions that are more likely to produce quick bottom line results. Such pressures disappear when the reporting frequency is decreased. Thus, infrequent reports could provide better incentives for project selection decisions even though they provide less information to the capital market.

Managerial myopia has been studied in other contexts. Stein [1988] found that corporate takeover threats induce managers to signal the hidden true value of their firms by prematurely selling off assets at prices lower than the benefits they would yield to the firm over the long-term. Bebchuk and Stole [1993] develop informational conditions under which managers would over-invest and conditions under which they would under-invest in long-term projects relative to short-term projects. Narayanan [1985] shows that labor market concerns could induce decisions that yield short-term personal gains to the manager at the expense of the long-term interests of shareholders. Stein [1989] showed that capital market pressure could induce firms to borrow earnings from the future at unfavorable terms in order to boost their current market price. None of these studies are concerned with the frequency of financial reporting, which is the main object of study in the present paper. However, all share the feature that managerial myopia is caused by inferences that outsiders are forced to make when they know less than the firm's manager. In a different kind of model, Dye [2008] showed that managers who gradually divest their shares over time would prefer rules that allow bunching of disclosures at a single point in time, rather than rules that require continuous dissemination of information over the disclosure horizon.

Besides anecdotal evidence there is formal empirical evidence that is consistent with our theory. Bhojraj and Libby [2005] manipulated reporting frequency and price pressure in a laboratory experiment, with experienced financial managers from publicly traded corporations. They found that corporate managers become myopic when faced with intense price pressure and high reporting frequency. These results were obtained in the absence of any agency frictions and even when managers have the opportunity to make voluntary disclosures. Ernstberger, Link and Vogler (2011) empirically investigated the “real” effects of reporting frequency in the European Union where less than half of the countries adopted mandatory quarterly reporting while others did not. They found that, relative to semi-annual reporters, quarterly reporters generally exhibit higher levels of “real activities management,” in the form of myopic decisions that increase short-term cash flows at the expense of long-term value. They also found that this real effect is strongest when shareholders have short investment horizons and the level of monitoring by analysts is low.

2. The Model

Consider a setting where the real cash flow returns to investment by a publicly traded firm depend stochastically upon one of two possible states of nature, state G (good) or state B (bad). Investment is desirable in state G but not in state B , in a sense to be described below. The state itself is not observable to any agent in the economy, but can be probabilistically inferred from observable outcomes and signals. The firm’s manager observes a noisy signal \tilde{S} that is informative about the state, before she makes the investment decision. We refer to the state generically as σ , so $\sigma \in \{G, B\}$ and λ as the prior probability that $\sigma = G$. The signal \tilde{S} has fixed support on the interval $[\underline{S}, \bar{S}]$ and the stochastic relationship between signals and states are described by the conditional density functions $\xi(S | G)$ and $\xi(S | B)$. We assume these conditional densities satisfy the strict monotone likelihood ratio property (MLRP), so that higher

values of S represent good news. We further assume that the signal becomes perfectly informative in the limit. More explicitly, we assume that:

$$\frac{\xi(S|G)}{\xi(S|B)} \text{ is strictly increasing in } S \quad (1)$$

Also, $\frac{\xi(S|G)}{\xi(S|B)} \rightarrow \infty$ as $S \rightarrow \bar{S}$ and $\rightarrow 0$ as $S \rightarrow \underline{S}$. These assumptions imply that $\text{Prob}(G|S)$

is strictly increasing in S , that $\lim_{S \rightarrow \bar{S}} \text{Prob}(G|S) = 1$ and $\lim_{S \rightarrow \underline{S}} \text{Prob}(G|S) = 0$.

The manager chooses whether or not to invest after observing the signal S and, if she chooses to invest, she chooses between a short-term project and a long-term project (projects M and L respectively). The investment choice is therefore $I \in \{\emptyset, M, L\}$, where the choice of \emptyset indicates the manager does not invest. Cash flows are normalized such that if no investment is made, all period cash flows are identically zero. For reasons that will become apparent later, we assume that projects M and L require the same initial investment of K . Investment outlays occur at date zero, and the chosen project, either M or L , yields stochastic cash inflows in periods 1 through N , with $N > 2$. Let:

$\tilde{x}_t =$ the stochastic cash inflow at date t from the chosen project, $t = 1, 2, \dots, N$, and

$\tilde{y}_t \equiv \sum_{\tau=1}^t \tilde{x}_\tau =$ the stochastic cumulative cash inflow through period t , $t = 1, 2, \dots, N$.

Since cash flows are jointly affected by the project choice and the underlying state of nature, we represent the probability density of the period t cash flow conditional on each state ($\sigma = G$ or B) and each project ($I = L$ or M) as $f_t(x_t | \sigma, I)$. We assume for simplicity that, conditional on the state and the project, cash flows are inter-temporally independent. Every period's cash inflow from each of the two projects is stochastically smaller in state B than in state G , and each period's cash inflow satisfies strict monotone likelihood ordering:

$$\frac{f_t(x_t | G, I)}{f_t(x_t | B, I)} \text{ is strictly increasing in } x_t \text{ for all } t \text{ and for each } I \in \{M, L\}. \quad (2)$$

Thus, observed cash flows are informative about the state with $\text{Prob}(G | x_t, I)$ strictly increasing in x_t , regardless of which of the two projects has been chosen. These likelihood ratios are

assumed to satisfy boundary conditions similar to those of the signal S in that $\frac{f_t(x_t | G, I)}{f_t(x_t | B, I)} \rightarrow \infty$

as $x_t \rightarrow \infty$ and $\rightarrow 0$ as $x_t \rightarrow -\infty$ for all t and for each $I \in \{M, L\}$.

For each $t = 0, 1, \dots, N-1$, let $V_t(\sigma, I)$ denote the expectation of the sum of future cash flows from date t onwards, conditional on the project and the state, i.e.,²

$$V_t(\sigma, I) = E_t(\tilde{x}_{t+1} + \tilde{x}_{t+2} + \dots + \tilde{x}_N | \sigma, I), \quad \sigma \in \{G, B\}, \quad I \in \{M, L\}.^3$$

Our previous assumptions regarding the nature of good and bad states imply that

$$V_t(G, I) > V_t(B, I), \quad \forall t, \quad \forall I \in \{M, L\}. \quad (3)$$

The key differences between the short and the long-term projects are as follows. Looking forward from any date, the long term project has a higher present value of expected future cash flows than the short-term project in each of the two states. More precisely,

$$V_t(\sigma, L) > V_t(\sigma, M), \quad t = 0, 1, \dots, N-1, \quad \sigma \in \{G, B\} \quad (4)$$

² We ignore discounting of future cash flows and assume risk-neutral pricing, as discounting and risk aversion are immaterial to our arguments.

³ The notation E_t means the expectation conditional on the information at period t .

Thus the long-term project is superior to the short-term project in a very strong sense. The only attraction of the short-term project is that, in *early* periods, the short-term project produces stochastically bigger cash flows than the long-term project, in each of the two states. Consistent with this idea, we assume there exists a date $t^* < N$ such that, in each state, project M produces stochastically bigger cumulative cash flows \tilde{y}_t at each $t < t^*$, but stochastically smaller cumulative cash flows at each $t \geq t^*$. Throughout our analysis we assume that $t^* = 2$, so that the tradeoff between short-term and long-term returns can be captured in a relatively simple two period setting. This simplification gives us the following representation of short v. long-term projects: For each $\sigma \in \{G, B\}$,

$$\tilde{x}_1 | \sigma, M \text{ is stochastically bigger than } \tilde{x}_1 | \sigma, L, \quad (5)$$

$$\tilde{x}_2 | \sigma, M \text{ is stochastically smaller than } \tilde{x}_2 | \sigma, L \quad (6)$$

$$\tilde{x}_1 + \tilde{x}_2 | \sigma, M \text{ is stochastically smaller than } \tilde{x}_1 + \tilde{x}_2 | \sigma, L \quad (7)$$

Consistent with the idea that investment is desirable in the good state, but undesirable in the bad state, we assume:

$$V_0(G, L) > V_0(G, M) > K, \text{ and} \quad (8)$$

$$V_0(B, M) < V_0(B, L) < K. \quad (9)$$

We assume that the prior probability of the good state is sufficiently small so that in the absence of sufficiently good news it is undesirable to invest, i.e.,

$$\lambda V_0(G, L) + (1 - \lambda) V_0(B, L) - K < 0. \quad (10)$$

However, because $\Pr ob(G | S)$ is strictly increasing in S and has the limiting properties

described in (1), there exists a unique interior threshold $S_L^* \in (\underline{S}, \bar{S})$ satisfying:

$$\Pr ob(G | S_L^*) V_0(G, L) + \Pr ob(B | S_L^*) V_0(B, L) - K = 0,$$

so that the long-term project has positive net present value when $S > S_L^*$. Similarly, there exists

a unique interior threshold $S_M^* \in (\underline{S}, \bar{S})$ satisfying:

$$\Pr ob(G | S_M^*) V_0(G, M) + \Pr ob(B | S_M^*) V_0(B, M) - K = 0,$$

so that the short-term project has positive net present value when $S > S_M^*$. Obviously,

$$S_L^* < S_M^*.$$

The firm outlives its current shareholders, and all cash inflows are retained in the firm until the terminal date. Thus, current shareholders derive their returns entirely through the pricing of the firm in the capital market. This last assumption is essential to the existence of “price pressure.” If current shareholders hold the firm until the terminal date and obtain their returns entirely from a liquidating dividend, market pricing becomes irrelevant and there is no scope for price pressure.⁵ In our two-period representation, we assume that current shareholders (i.e., date 0 shareholders) are initially identical but later may turn out to be one of two types: long-term investors who sell at date 2 or short-term investors who sell at date 1. The probability of being a short-term investor is common knowledge and exogenous, and is parameterized by $\alpha \in (0, 1)$.

⁴ This assumption is without loss of generality. The tradeoffs we wish to capture are essentially unaffected if the inequality in (10) is reversed.

⁵ Realistically, publicly traded firms do not have well defined terminal dates and do not pay liquidating dividends unless they go into bankruptcy. Also the composition of its shareholders is continuously changing, as witnessed by the enormous volume of trading in the capital market. So the assumption that shareholders obtain their returns through market pricing is much more realistic than the more commonly made assumption that shareholders obtain their returns from terminal dividends.

Thus, ex ante, before a shareholder knows his type, he would like the firm to choose its investment strategy to maximize:

$$\max_I [\alpha E_0(\tilde{P}_1 | S, I) + (1 - \alpha) E_0(\tilde{P}_2 | S, I)], \quad (11)$$

where \tilde{P}_1 and \tilde{P}_2 are equilibrium capital market prices of the firm at dates 1 and 2, respectively.

In order to focus the analysis solely on price pressure, we assume the manager is benevolent and imbibes the preferences of the current shareholders, i.e, the manager chooses investment to maximize (11). Thus, in our model, there are no conflicts of interest between corporate managers and their shareholders, no managerial career concerns, and therefore no incentive issues that would generate a demand for compensation contracts⁶.

By assuming that the firm's objective function incorporates capital market valuations only at dates 1 and 2 even though the cash flows from investment occur over $N > 2$ periods, we have parsimoniously operationalized the layman's sense of impatience in the capital market. Higher values of the parameter α represent higher impatience in the capital market. While we have exogenously assumed impatience in the capital market, such impatience does not automatically result in myopic decisions by management. We will show that impatience in the capital market, no matter how extreme, cannot by itself produce the kind of price pressure that would induce managerial myopia. Informational imperfections in the capital market and the frequency of financial reporting are essential to managerial myopia.

⁶ In the concluding section we additionally comment on the possibility of using contracts to alleviate managerial short-termism.

3. Equilibrium with fully informed Capital Markets: The First Best Benchmark

We define a first best world as one where the capital market observes everything the manager observes. Specifically, the capital market observes all realizations of periodic cash flows, observes the manager's signal S about the state, observes whether or not the manager has invested and, if she has, whether she has chosen the short-term or the long-term project. Assuming risk neutrality and no discounting of future cash flows, equilibrium date 1 and date 2 prices in this first best world, for each $I \in \{M, L\}$, are:

$$P_1(S, I, x_1) = x_1 + \text{Prob}(G | S, I, x_1)V_1(G, I) + \text{Prob}(B | S, I, x_1)V_1(B, I) - K \quad (12)$$

and

$$\begin{aligned} P_2(S, I, x_1, x_2) = & x_1 + x_2 + \text{Prob}(G | S, I, x_1, x_2)V_2(G, I) \\ & + \text{Prob}(B | S, I, x_1, x_2)V_2(B, I) - K \end{aligned} \quad (13)$$

And clearly $P_1(S, \emptyset) = P_2(S, \emptyset) \equiv 0$, given that zero investment generates zero cash flow.

Let $I(S, \alpha)$ denote the firm's equilibrium investment strategy. We now examine how impatience in the capital market affects the firm's equilibrium investment strategy when markets are fully informed.

Proposition 1:

When markets are fully informed, the firm's equilibrium investment strategy for every value of $\alpha \in (0, 1)$, is:

$$I(S, \alpha) = L \text{ when } S \geq S_L^* \text{ and } I(S, \alpha) = \emptyset \text{ when } S < S_L^*.$$

Proof: Given the price functions in (12) and (13):

$$E_0[P_1 | S, I] = E_0(x_1 | S, I) + E_0[\text{Prob}(G | S, I, x_1) | S, I]V_1(G, I) + E_0[\text{Prob}(B | S, I, x_1) | S, I]V_1(B, I) - K$$

and,

$$E_0[P_2 | S, I] = E_0(x_1 + x_2 | S, I) + E_0[\text{Prob}(G | S, I, x_1, x_2) | S, I]V_2(G, I) + E_0[\text{Prob}(B | S, I, x_1, x_2) | S, I]V_2(B, I) - K,$$

Now,

$$E_0(x_1 | S, I) = \text{Prob}(G | S)E_0(x_1 | G, I) + \text{Prob}(B | S)E_0(x_1 | B, I) \text{ and}$$

$$E_0(x_1 + x_2 | S, I) = \text{Prob}(G | S)E_0(x_1 + x_2 | G, I) + \text{Prob}(B | S)E_0(x_1 + x_2 | B, I)$$

Additionally, by the law of iterated expectations,

$$E_0[\text{Prob}(G | S, I, x_1) | S, I] = E_0[\text{Prob}(G | S, I, x_1, x_2) | S, I] = \text{Prob}(G | S).$$

Therefore,

$$\begin{aligned} E_0[P_1 | S, I] &= \text{Prob}(G | S)[E_0(x_1 | G, I) + V_1(G, I)] + \text{Prob}(B | S)[E_0(x_1 | B, I) + V_1(B, I)] - K \\ &= \text{Prob}(G | S)V_0(G, I) + \text{Prob}(B | S)V_0(B, I) - K. \end{aligned}$$

Similarly,

$$\begin{aligned} E_0[P_2 | S, I] &= \text{Prob}(G | S)[E_0(x_1 + x_2 | G, I) + V_2(G, I)] + \text{Prob}(B | S)[E_0(x_1 + x_2 | B, I) + V_2(B, I)] - K \\ &= \text{Prob}(G | S)V_0(G, I) + \text{Prob}(B | S)V_0(B, I) - K. \end{aligned}$$

Since the date zero expectation of the date 1 and date 2 prices are exactly the same, the relative weight on these prices becomes irrelevant, and the firm's project selection choice collapses to:

$$\max_I \text{Prob}(G | S)V_0(G, I) + \text{Prob}(B | S)V_0(B, I) - K$$

for every value of $\alpha \in (0, 1)$. By (8) and (9) project L is preferred to M for all S , and \emptyset is

preferred to L when project L has negative net present value, i.e. when $S < S_L^*$.

Q.E.D.

The above result establishes that if all knowable information is impounded in capital market valuations, managerial short-termism cannot be caused by price pressure, no matter how impatient the firm's current shareholders are. The manager invests in the long-term project whenever the expected NPV of the long-term project is positive and chooses not to invest when the expected NPV of the long-term project is negative. This important result is due to the fact that capital market prices anticipate all future cash flows, so when the market is fully informed, the cost of any myopic behavior is fully internalized by the firm's current shareholders. They cannot possibly gain by producing attractive short-term cash flows at the expense of higher long-term cash flows.

4. Information Asymmetry between the Firm and the Market: The Importance of Performance Reporting

The assumption that the outside world has the same information as the firm's manager, at every point of time, is implausible. Managers make choices based on large amounts of detailed information collected at considerable expense, which is either unavailable to outsiders or difficult to interpret by outsiders. Furthermore, this information is usually soft, sensitive and unverifiable. This kind of detailed information cannot and is not disclosed in mandatory financial statements (or in voluntary disclosures) that are disseminated to the world at large. What *is* disclosed is aggregate information on managerial choices and verifiable information on the periodic results of operations. Consistent with these observations, we make the following informational assumptions in the remainder of the paper. (i) We assume the capital market cannot observe the manager's information, S , in the light of which she makes her choice. (ii) We assume that, while the market can observe whether the firm invested in a new project, or not, and the amount of such investment, it cannot directly observe whether the project chosen was the short-term project or the long-term project. (iii) We assume that accounting reports regarding the results of operations consist of reporting the periodic cash inflows, x_1, x_2, x_3, \dots , or the cumulative cash flows $y_1, y_2,$

y_3, \dots . In our simple setting with inter-temporal independence of cash flows and perfect measurement of investment outlays, there is no scope for informative accounting accruals. Such accruals arise in more complex settings and cause measurement difficulties and measurement errors of the kind studied in Kanodia and Mukherji [1996] and Kanodia, Sapra and Venugopalan [2004].

When managers make decisions in the light of information that is not available to the capital market, periodic performance reports play a *vital* role in disciplining those decisions, as shown in Kanodia and Lee [1998]. In order to establish this beneficial role of performance reporting in the present context, we will show that if there are no performance reports at all, the firm would be trapped in a very bad equilibrium where no investment occurs no matter how favorable the signal that the manager privately observes. This result establishes that the benefits to performance reporting are so large that such reports are indispensable, but it doesn't answer the main issue to be examined in this paper: How *frequently* should the firm be required to release performance reports to the capital market? This latter issue will be examined in the next three sections.

If there are no performance reports, the date 2 price in the capital market must equal the date 1 price since no new information arrives at date 2. Both prices must depend only upon the observation that the firm has invested or has not invested. If the firm has not invested, both prices are zero. If the firm has invested, both prices must depend upon a *belief* of whether the manager chose project M or project L and an inference about the signal S that the manager must have observed, an inference that is based solely on the observation that the manager has invested.

Suppose that, upon observing that the firm has invested, the market makes the inference that $S \geq S^0$ for some threshold signal $S^0 > \underline{S}$. If S^0 is such that $\text{Prob}(G | S \geq S^0) > \text{Prob}(G | S_L^*)$ and if the market believes that any investing type invests in the long-term project, L , then both date 1 and date 2 prices will be strictly greater than zero. This being the case, *all*

firm types, including types $S < S^0$ will also invest, thus disconfirming the market's inference. On the other hand, if S^0 is such that $\text{Prob}(G | S \geq S^0) < \text{Prob}(G | S_L^*)$, then no firm type would invest since investment would result in negative date 1 and date 2 prices. Lastly, if $\text{Prob}(G | S \geq S^0) = \text{Prob}(G | S_L^*)$, then investment would result in prices of zero, making the firm indifferent between investing and not investing. In this case either all types invest or no type invests, so once again the market's inference cannot be sustained. These arguments do not depend upon whether the market believes that an investing type invests in project L or invests in project M . In either case the market's inferred threshold will unravel. The only sustainable inference, upon seeing investment, is that $S \geq \underline{S}$. But, since $\text{Prob}(G | S \geq \underline{S}) = \lambda$, investment will be priced using this prior probability of λ and therefore the equilibrium date 1 and date 2 prices resulting from investment must both be negative. Thus, in equilibrium, the manager will prefer not to invest rather than investing in either the long-term or the short-term project. We have established the following proposition, albeit informally.⁷

Proposition 2:

The equilibrium investment strategy in the absence of periodic performance reporting is

$$I(S, \alpha) = \emptyset, \forall S, \forall \alpha.$$

Proposition 2 illustrates the importance of performance reporting. Without performance reporting there is nothing to discipline the firm's investment and, therefore, no way to credibly communicate any information about the probability of state G . Consequently, a manager concerned with the stock price response to her decisions is unable to make use of her private information and simply makes the investment choice that maximizes the *ex ante* value of the

⁷ A formal proof involving specification of off-equilibrium beliefs is available, upon request, from the authors.

firm.⁸ This results in underinvestment relative to first best whenever $S > S_L^*$. (Notice that if we had assumed the reverse inequality in (10), the manager would always invest in L , leading to overinvestment when $S < S_L^*$.)

Next, we illustrate how a policy of reporting the results of operations mitigates this underinvestment problem and study regimes with more frequent vs. less frequent performance reporting. In the frequent reporting regime, operating results are disclosed at both dates 1 and 2, while in the infrequent reporting regime there is no report at date 1 and the date 2 report discloses the cumulative result of operations up to date 2. In both regimes, at date zero, the market observes only whether the firm has invested or not invested. More precisely:

Frequent Reporting: date 1 report is $\{x_1\}$, date 2 report is $\{y_2 = x_1 + x_2\}$,

Infrequent Reporting: no report at date 1, date 2 report is $\{y_2 = x_1 + x_2\}$.

Note that while frequent reporting obviously provides more information at date 1, in principle it could also provide more information at date 2 relative to infrequent reporting. In the frequent reporting regime the market can calculate x_2 from the date 2 and the date 1 reports, so that the information in the market at date 2 is $\{x_1, x_2\}$. However, in the infrequent reporting regime, information about x_1 is lost because of the failure to measure it at date 1, so that at date 2 the market learns only the *aggregate* two-period cash flow, $y_2 = x_1 + x_2$. Thus, in principle, frequent reporting could provide more timely and less aggregated information than infrequent reporting. However, in order to simplify the analysis, we make the following assumption:

$$y_2 \equiv x_1 + x_2 \text{ is a sufficient statistic for } \{x_1, x_2\},$$

⁸ See Brandenburger and Polak [1996] for a generalization of such phenomena.

so that the aggregation inherent in infrequent reporting is not an issue. Given our earlier assumption that each period's cash flow satisfies MLRP and given the sufficient statistic assumption, y_2 inherits the joint likelihood properties of $\{x_1, x_2\}$. Thus, using $h(\cdot)$ as the density function of y_2 :

$$\frac{h(y_2 | G, I)}{h(y_2 | B, I)} \text{ is strictly increasing in } y_2 \text{ for each } I \in \{M, L\}.$$

5. Equilibrium with Infrequent Reporting

Recall that at date 0, the capital market learns only whether or not the manager has invested. If the market observes that the firm has not invested, period 1 and the period 2 prices are identically zero. If the market observes that the firm has invested, it still does not know whether the firm has invested in project L or project M . Since the choice of project is endogenous, performance reports cannot signal which project the manager has invested in. Both date 1 and date 2 prices must incorporate an *anticipation* of which project the firm has chosen. Additionally, since there is no performance report at date 1, the date 1 price must reflect an inference about S based solely on the fact that the firm has invested. At date 2, however, the realized cumulative cash inflow, y_2 , is reported, so the date 2 price must additionally reflect the information contained in y_2 . In contrast to the lack of investment incentives in the scenario with no performance reporting, we will show that the *anticipation* of the date 2 performance report provides strong incentives to invest and disciplines the manager so that investment occurs only when the manager's private signal is sufficiently favorable. Additionally, we show that the manager invests in project L rather than project M whenever she chooses to invest.

We first examine the manager's preference for the short-term versus the long-term project. Next, we characterize the set of signal values at which the manager will choose to invest

and the set of signal values at which the manager will forego investment. Let $\Omega(\alpha) \subset [\underline{S}, \bar{S}]$ be the set of signal values at which the market believes the firm will invest, given the degree of impatience in the capital market. Then investment in either L or M conveys the information $S \in \Omega(\alpha)$. If, now, the market believes that the manager chose project $\hat{I} \in \{L, M\}$ the date 1 price is⁹:

$$\varphi_1(\Omega, \hat{I}) = \text{Prob}(G | S \in \Omega(\alpha))V_0(G, \hat{I}) + \text{Prob}(B | S \in \Omega(\alpha))V_0(B, \hat{I}) - K, \quad (14)$$

and the date 2 price, given observation of y_2 is:

$$\varphi_2(\Omega, y_2, \hat{I}) = y_2 + \text{Prob}(G | S \in \Omega(\alpha), y_2, \hat{I})V_2(G, \hat{I}) + \text{Prob}(B | S \in \Omega(\alpha), y_2, \hat{I})V_2(B, \hat{I}) - K. \quad (15)$$

As assessed by the manager who has privately observed some signal value S , the distribution of y_2 conditional on her observation and conditional on her choice of project $I \in \{L, M\}$ is characterized by the following mixture of distributions:

$$h(y_2 | S, I) \equiv \text{Prob}(G | S)h(y_2 | G, I) + \text{Prob}(B | S)h(y_2 | B, I). \quad (16)$$

Because $\text{Prob}(G | S)$ is strictly increasing in S , and because y_2 is stochastically bigger in state G than in state B , higher values of S cause the distribution of y_2 conditional on (S, I) to shift to the right, in the sense of first order stochastic dominance. Also, because y_2 is stochastically bigger in

⁹ In order to distinguish equilibrium prices in this setting from prices in other settings we use the notation φ to represent prices in the infrequent reporting regime. Also, we use \hat{I} to denote the market's anticipation of the firm's project choice and I to denote its actual project choice.

each state under project L than under project M , $h(y_2 | S, L)$ first order dominates $h(y_2 | S, M)$ at each fixed S .

Now, consider the manager's choice between projects L and M given observation of some signal value S . In making this choice the manager takes the market's pricing rules, described in (14) and (15) as given and beyond her control. Specifically, the set $\Omega(\alpha)$ and the market's belief \hat{I} regarding which project has been chosen are taken as givens. Given this price taking behavior, the manager's choice between projects L and M has no effect on how each realization of y_2 is priced; project choice influences only the *ex ante* distribution from which y_2 is drawn. Also, the date 1 price, $\phi_1(\Omega, \hat{I})$, as described in (14) is a constant, in the sense that it depends only upon the project anticipated by the market and not upon the project that is *actually* chosen by the manager. Therefore, for every α , the manager's objective function:

$$\max_{I \in \{L, M\}} [\alpha E_0(\phi_1 | S, I) + (1 - \alpha) E_0(\phi_2 | S, I)]$$

is equivalent to

$$\max_{I \in \{L, M\}} [E_0(\phi_2 | S, I)].$$

Proposition 3:

In the infrequent reporting regime, given any market beliefs $\{\Omega(\alpha), \hat{I}\}$ that are incorporated in stock prices, the manager strictly prefers project L to project M at every signal S that she may observe and at every value of α .

Proof

The date 2 price, as specified in (15) is strictly increasing in y_2 because

$\Pr ob(G | S \in \Omega(\alpha), y_2, \hat{I})$ is strictly increasing in y_2 for every set $\Omega(\alpha)$ and for each anticipated

project $\hat{I} \in \{L, M\}$. Then since y_2 is stochastically bigger under project L than under project M , it follows that:

$$\int \varphi_2(\Omega, y_2, \hat{I}) h(y_2 | S, L) dy_2 > \int \varphi_2(\Omega, y_2, \hat{I}) h(y_2 | S, M) dy_2, \forall \hat{I} \in \{L, M\}, \forall S.$$

Q.E.D.

Proposition 3 implies that managerial short-termism cannot occur in the infrequent reporting regime, no matter how impatient the firm's current shareholders are. The only reason why the short-term project could be attractive is that it could boost the date 1 price. But, since there is no performance report at date 1, the date 1 price becomes an exogenous constant. It cannot be boosted by producing attractive short-term cash flows via the choice of the short-term project.

Proposition 3 also implies that the only sustainable belief for the capital market is that whenever the firm chooses to invest, it invests in project L rather than project M . The equilibrium pricing rules in the capital market must reflect this fact, and therefore in equations (14) and (15) the undefined project \hat{I} must be replaced by the known project L . We use this fact in the remainder of the analysis.

We now establish that the set of S -types that invest is a strict upper interval of the support $[\underline{S}, \bar{S}]$ and establish the properties of this interval. Consider the firm's choice between not investing and investing in project L , in response to variations in the signal S that it observes. If the firm does not invest its expected payoff is zero, regardless of the value of the signal S that it has observed. If it invests in project L , the firm's expected payoff is $\alpha \varphi_1(\Omega, L) + (1 - \alpha) E_0[\varphi_2(\Omega, y_2, L) | S, L]$. Now, $\varphi_1(\alpha, L)$ does not vary with S , and $E_0[\varphi_2(\alpha, y_2, L) | S, L]$ is strictly increasing in S because the conditional distribution of y_2 moves to the right as S becomes

larger. Consequently the firm's expected payoff from investing in project L is strictly increasing in S . Therefore, if any type S' prefers investing in L to not investing, then all types $S'' > S'$ will also prefer to invest in L . Thus, the set of types who invest in L must be an upper interval of $[\underline{S}, \bar{S}]$, i.e. there exists some threshold $T_I(\alpha, L) \geq \underline{S}$ such that $\Omega(\alpha) = [T_I(\alpha, L), \bar{S}]$. The marginal type $T_I(\alpha, L)$ must be indifferent between investing in project L and not investing. This implies that $T_I(\alpha, L)$ must satisfy:

$$\alpha \varphi_1(T_I(\alpha, L), L) + (1 - \alpha) E_0[\varphi_2(T_I(\alpha, L), y_2, L) | T_I(\alpha, L), L] = 0 \quad (20)$$

Although variations in the degree of capital market impatience α , have no effect on the firm's preferences between projects L and M , the degree of impatience does affect the firm's preferences between investing in project L and not investing at all. This is because, unlike the first best economy, in the present setting the disciplining effect of the performance report implies that the date 1 price does not equal the expectation of the date 2 price. In fact, we show:

Lemma 1:

$$\varphi_1(T_I, L) > E_0[\varphi_2(T_I, y_2, L) | T_I, L], \forall T_I.$$

i.e., in the infrequent reporting regime the equilibrium date 1 price is strictly bigger than the expectation of the equilibrium date 2 price, conditional on the marginal type T_I that invests.

Proof: See the Appendix.

Lemma 1 implies that the incentive to invest is stronger when there is more impatience in the capital market, i.e. when the weight on the date 1 price is larger.

We now establish the properties of the equilibrium threshold above which the firm invests in project L and below which the firm does not invest.

Proposition 4:

In the infrequent reporting regime, the set of signal values at which the firm invests is characterized by:

- i. $\Omega(\alpha) = [T_I(\alpha, L), \bar{S}]$
- ii. $\underline{S} < T_I(\alpha, L) < S_L^*, \forall \alpha$
- iii. $T_I(\alpha, L)$ is strictly decreasing in α .

Proof: See the Appendix.

Part (ii) of Proposition 4 indicates that there is a non-empty interval of low S -values such that the manager finds investment to be unattractive when her signal lies in this interval. This is due to the discipline provided by the date 2 performance report. To see this disciplining effect more clearly, suppose the market believes that the set of types who invest are types contained in some interval $[\hat{S}, \bar{S}]$, where $\hat{S} > \underline{S}$. Then the very act of investment conveys the information that $S \geq \hat{S}$, which results in a revision of the prior probability of state G from λ to the higher number $\text{Prob}(G | S \geq \hat{S})$. This new prior is additionally updated into a posterior probability upon observation of the performance report y_2 . Because $\text{Prob}(G | S)$ is strictly increasing in S and approaches the upper bound of 1 as $S \rightarrow \bar{S}$, there exists $S^0 < \bar{S}$, $S^0 > \hat{S}$ such that $\text{Prob}(G | S \geq \hat{S}) = \text{Prob}(G | S^0)$. Then at any $S < S^0$,

$$\begin{aligned} E_0[\text{Prob}(G | S \geq \hat{S}, y_2, L) | S, L] &< E_0[\text{Prob}(G | S \geq \hat{S}, y_2, L) | S^0, L] \\ &= E_0[\text{Prob}(G | S^0, y_2, L) | S^0, L] = \text{Prob}(G | S^0) \end{aligned}$$

Thus at every $S < S^0$, $E_0[\text{Prob}(G | S \geq \hat{S}, y_2, L) | S, L] < \text{Prob}(G | S \geq \hat{S})$ implying that if such a type chooses to invest that type *expects* that the revised prior $\text{Prob}(G | S \geq \hat{S})$ generated by the act

of investment will be downgraded upon observation of the performance report, thus disciplining the desire to invest. Because $\text{Prob}(G | S \geq \hat{S}, y_2, L)$ is strictly increasing in y_2 and lower types expect lower values of y_2 , lower types expect greater degrees of downgrading. This discipline was missing in the previous setting where there are no performance reports.

The result $T_I(\alpha) < S_L^*, \forall \alpha$, implies that, in equilibrium, there are some low S -types that invest even though the manager *privately* believes that the project has negative net present value. This is because the market cannot distinguish between such low types and higher types that have strictly positive net present value projects, resulting in a pooled average market valuation which is greater than zero. In fact, in this imperfectly informed setting, type S_L^* *strictly* prefers investment to no investment rather than being indifferent. This claim is due to the following observation:

$$E_0[\text{Prob}(G | S \geq S_L^*, y_2, L) | S_L^*, L] > E_0[\text{Prob}(G | S_L^*, y_2, L) | S_L^*, L] = \text{Prob}(G | S_L^*)$$

Thus, while performance reports discipline managers, the discipline provided by infrequent reports is less than perfect, resulting in over-investment (in the sense of investing even when the project has negative net present value). Proposition 4 also indicates that the region of over-investment is larger when there is greater impatience in the capital market (α is larger). Figure 1 below is a pictorial representation of the firm's equilibrium investment strategy in the infrequent reporting regime.

INSERT FIGURE 1 HERE

6. Equilibrium with Frequent Reporting

The only difference between the frequent and infrequent reporting regimes is that in the frequent reporting regime there is a performance report at date 1 that reveals the first period cash inflow x_1 , in addition to the date 2 performance report that reveals the cumulative two period cash flow y_2 . As in the infrequent reporting regime, the performance reports in the frequent reporting regime discipline the firm's investment so that investment occurs only when the signal S is above some critical threshold, which we denote T_F . In general, the threshold T_F will depend upon the weight on the first period price α and the anticipated project \hat{I} that is built into market pricing. We suppress this dependence until later in the analysis. Thus, the observation of investment at date 0 communicates that $S \geq T_F$. But, since the market cannot observe which project the manager has chosen, market prices must incorporate some anticipated project, as in the infrequent reporting regime. In equilibrium, the market's anticipation must coincide with the actual project chosen by the firm, but off-equilibrium possibilities must be considered in order to characterize the equilibrium. Given some anticipated investment $\hat{I} \in \{L, M\}$ and given some threshold T_F , the date 1 price on observation of the date 1 performance report is:

$$P_1(T_F, x_1, \hat{I}) = x_1 + \text{Prob}(G | S \geq T_F, x_1, \hat{I}) V_1(G, \hat{I}) + \text{Prob}(B | S \geq T_F, x_1, \hat{I}) V_1(B, \hat{I}) - K \quad (21)$$

and the date 2 price is,

$$P_2(T_F, y_2, \hat{I}) = y_2 + \text{Prob}(G | S \geq T_F, y_2, \hat{I}) V_2(G, \hat{I}) + \text{Prob}(B | S \geq T_F, y_2, \hat{I}) V_2(B, \hat{I}) - K \quad (22)$$

Given that x_1 and y_2 satisfy MLRP, P_1 is strictly increasing in x_1 and P_2 is strictly increasing in y_2 . Also, P_1 and P_2 are strictly increasing in T_F since $\text{Prob}(G|S \geq T_F, \cdot, \cdot)$ is strictly increasing in T_F .

Lemma 2

In the frequent reporting regime, for any given $S_F \in [\underline{S}, \bar{S})$ and any given $\hat{I} \in \{L, M\}$,

$$E_{x_1}[P_1(T_F, \hat{I}, x_1)|T_F, \hat{I}] > E_{y_2}[P_2(T_F, \hat{I}, y_2)|T_F, \hat{I}]$$

Proof: See the Appendix.

Lemma 2 says that, conditional on the marginal type that invests, the expectation of the first period price is strictly larger than the expectation of the second period price. The intuition for this fact is somewhat similar to the analogous result in the infrequent reporting regime. There is more discipline built into the second period price than the first period price because the second period price is disciplined by both the first and second period performance reports, while the first period price is disciplined by only the first period performance report.

We now establish some key properties of the equilibrium thresholds in the frequent reporting regime. For each $\hat{I} \in \{L, M\}$ and for each $\alpha \in (0, 1)$, the equilibrium thresholds $T_F(\alpha, \hat{I})$ must be such that when the market anticipates that the firm has invested in project \hat{I} the firm with signal value T_F is indifferent between investing in \hat{I} and not investing. Therefore the threshold $T_F(\alpha, L)$ is defined by the values of T_F that satisfy:

$$\alpha E_0[P_1(T_F, x_1, L)|T_F, L] + (1 - \alpha) E_0[P_2(T_F, y_2, L)|T_F, L] = 0 \quad (23)$$

And the threshold $T_F(\alpha, M)$ is defined by the values of T_F that satisfy:

$$\alpha E_0[P_1(T_F, x_1, M) | T_F, M] + (1 - \alpha) E_0[P_2(T_F, y_2, M) | T_F, M] = 0 \quad (24)$$

These thresholds share some of their features with the threshold $T_I(\alpha, L)$ that holds in the infrequent reporting regime (the key difference between the thresholds in the infrequent and frequent reporting regimes will be developed later). The following is the counterpart to Proposition 4.

Proposition 5:

In the frequent reporting regime, the set of signal values at which the firm invests is characterized by:

- i. $\Omega_F(\alpha, \hat{I}) = [T_F(\alpha, \hat{I}), \bar{S}]$
- ii. $\underline{S} < T_F(\alpha, L) < S_L^*, \forall \alpha$
- iii. $\underline{S} < T_F(\alpha, M) < S_M^*, \forall \alpha$
- iv. $\frac{\partial}{\partial \alpha} T_F(\alpha, \hat{I}) < 0, \forall \hat{I} \in \{L, M\}.$

Proof: See the Appendix.

We now examine the manager's preference ordering between the short and long-term projects, given the pricing rules specified in (21) and (22). Since the date 1 price is strictly increasing in x_1 regardless of which project the market anticipates the firm to take, and since the short-term project produces stochastically bigger cash flows at date 1 than the long-term project,

$$E_0[P_1(T_F, x_1, \hat{I}) | S, M] > E_0[P_1(T_F, x_1, \hat{I}) | S, L], \quad \forall \{S, T_F, \hat{I}\}$$

However, the ordering is reversed for the expectation of the date 2 price since the cumulative cash flow over two periods is stochastically smaller under the short-term project than under the long-term project:

$$E_0[P_2(T_F, y_2, \hat{I}) | S, M] < E_0[P_2(T_F, y_2, \hat{I}) | S, L], \quad \forall \{S, T_F, \hat{I}\}$$

Thus, in the frequent reporting regime, the manager faces a non-trivial tradeoff when choosing between the short and long-term projects. The first period price pressures the manager to choose the short-term project, while the second period price pressures the manager to choose the long-term project.

Given $\{\hat{I}, T_F(\alpha, \hat{I})\}$, i.e. given the parameters that are built into the market's pricing rules, the manager prefers project L to project M at $\{\alpha, S\}$ if:

$$\begin{aligned} & \alpha E_0[P_1(T_F(\alpha, \hat{I}), x_1, \hat{I}) | S, L] + (1 - \alpha) E_0[P_2(T_F(\alpha, \hat{I}), y_2, \hat{I}) | S, L] \geq \\ & \alpha E_0[P_1(T_F(\alpha, \hat{I}), x_1, \hat{I}) | S, M] + (1 - \alpha) E_0[P_2(T_F(\alpha, \hat{I}), y_2, \hat{I}) | S, M] \end{aligned} \quad (24)$$

The manager prefers project M to project L if the inequality in (24) is reversed. (When the manager is indifferent between projects L and M , we assume the manager chooses L).

Equivalently, defining,

$$\Delta_1(T_F(\alpha, \hat{I}), \hat{I}, S) \equiv E_0[P_1(T_F(\alpha, \hat{I}), x_1, \hat{I}) | S, M] - E_0[P_1(T_F(\alpha, \hat{I}), x_1, \hat{I}) | S, L] \quad (25)$$

and,

$$\Delta_2(T_F(\alpha, \hat{I}), \hat{I}, S) \equiv E_0[P_2(T_F(\alpha, \hat{I}), y_2, \hat{I}) | S, L] - E_0[P_2(T_F(\alpha, \hat{I}), y_2, \hat{I}) | S, M], \quad (26)$$

the manager prefers L to M if and only if :

$$\alpha \Delta_1(T_F(\alpha, \hat{I}), \hat{I}, S) \leq (1 - \alpha) \Delta_2(T_F(\alpha, \hat{I}), \hat{I}, S) \quad (27)$$

Obviously, the preferences of the manager depend crucially upon the values of α , S and \hat{I}

Below, we investigate how each of these key determinants affects the manager's choice.

We begin by examining variations in the manager's private signal S . In general the effect of S on the manager's choice of project could be quite erratic. Even though the expectation of each price is strictly increasing in S , nothing is known about how the *differences* in expected prices, as specified in (25) and (26), vary with S . Below, we make an assumption that guarantees that if the manager prefers one project over the other at any particular value of S , that preference is preserved at all values of S .

For each $\sigma \in \{G, B\}$, $I \in \{L, M\}$, let $F_t(x_t | \sigma, I)$ be the cumulative distribution function of period t cash flows, and let $H(y_2 | \sigma, I)$ be the corresponding cumulative distribution function of y_2 .

Assumption: Stochastically Equal Damage

$$F_t(x_t | G, L) - F_t(x_t | B, L) = F_t(x_t | G, M) - F_t(x_t | B, M), \forall t \quad (28)$$

Because the distribution of y_2 is a convolution of the distributions of x_1 and x_2 , (28) implies:¹⁰

$$H(y_2 | G, L) - H(y_2 | B, L) = H(y_2 | G, M) - H(y_2 | B, M), \quad (29)$$

Assumption (28) also implies:

$$E(x_t | G, L) - E(x_t | B, L) = E(x_t | G, M) - E(x_t | B, M), \forall t, \quad (30)$$

and therefore:

$$V_t(G, L) - V_t(B, L) = V_t(G, M) - V_t(B, M), \forall t, \quad (31)$$

¹⁰ See Shaked and Shantikumar [2007], Theorem 6.B.16.

We had earlier assumed that relative to state G , state B stochastically damages each project's cash flow each period. Assumption (28) additionally says that, in a probabilistic sense, the damage caused by the bad state to the long term project is equal to the damage caused to the short-term project.

Lemma 3:

Given the assumption of stochastically equal damage:

$$\frac{\partial}{\partial S} \{\Delta_1(S_F(\alpha, \hat{I}), \hat{I}, S)\} = \frac{\partial}{\partial S} \{\Delta_2(S_F(\alpha, \hat{I}), \hat{I}, S)\} = 0, \forall \alpha, \hat{I}, S \quad (32)$$

Proof: See the Appendix.

Lemma 3 implies that when the bad state equally damages the short and long-term projects, the tradeoff between the short-term and the long-term project depends only upon α and does not depend on S . In other words, if for a given value of α , the manager prefers the long-term (short-term project) at a particular value of S , then he would have the same preference for all values of S .

Next, we examine how variations in α affect the manager's choice of project. The effect of α is two fold. Higher values of α increase the weight on the first period price and decrease the weight on the second period price, thus tilting the manager's preference towards the short-term project. But also higher values of α decrease the thresholds T_F that are incorporated into the first and second period prices, as shown in Proposition 5. In general, a lower threshold makes investment in *each* of the two projects less attractive, but the *relative* effect of the threshold on the long-term and short-term projects is unknown. The overall effect of variations in α depends upon the marginal rates of substitution between α and T_F , conditional on each project choice and conditional on each anticipated project that is built into market pricing. Below, we make an

ordering assumption on these marginal rates of substitution that permits a clean characterization of how the manager's preferences vary with α . For each pair $\hat{I}, I \in \{L, M\}$ define:

$$U(\alpha, T_F, \hat{I} | I) \equiv \alpha E(P_1(T_F, x_1, \hat{I}) | T_F, I) + (1 - \alpha) E(P_2(T_F, y_2, \hat{I}) | T_F, I), \quad (33)$$

where P_1 and P_2 are as specified in (21) and (22) and the expectations are with respect to the random variables x_1 and y_2 respectively. For a firm that chooses project I when the market's anticipation is \hat{I} , the marginal rate of substitution at any point in the $\{\alpha, T_F\}$ space is:

$$\frac{\partial T_F(\alpha, \hat{I} | I)}{\partial \alpha} = - \frac{U_\alpha(\alpha, T_F, \hat{I} | I)}{U_{T_F}(\alpha, T_F, \hat{I} | I)}.$$

Now,

$$U_\alpha(\alpha, T_F, \hat{I} | L) = E(P_1(T_F, x_1, \hat{I}) | T_F, L) - E(P_2(T_F, y_2, \hat{I}) | T_F, L)$$

and,

$$U_\alpha(\alpha, T_F, \hat{I} | M) = E(P_1(T_F, x_1, \hat{I}) | T_F, M) - E(P_2(T_F, y_2, \hat{I}) | T_F, M)$$

Stochastic dominance arguments imply that the expectation of the first period price is strictly greater under project M than under project L , at every $\{T_F, \hat{I}\}$, and the expectation of the second period price is strictly smaller. Therefore:

$$-U_\alpha(\alpha, T_F, \hat{I} | M) < -U_\alpha(\alpha, T_F, \hat{I} | L), \forall \{\alpha, T_F, \hat{I}\} \quad (34)$$

Also $U_{T_F} > 0, \forall \{\alpha, T_F, \hat{I}\}$. Unfortunately, $U_{T_F}(\alpha, T_F, \hat{I} | M) - U_{T_F}(\alpha, T_F, \hat{I} | L)$ cannot be signed with generality, hence the need for an assumption. We assume:

The Single Crossing Property

$$\frac{\partial T_F(\alpha, \hat{I} | M)}{\partial \alpha} < \frac{\partial T_F(\alpha, \hat{I} | L)}{\partial \alpha}, \forall \{\alpha, \hat{I}\} \quad (35)$$

or, equivalently,

$$U_{\alpha}(\alpha, T_F, \hat{I} | M) U_{T_F}(\alpha, T_F, \hat{I} | L) > U_{\alpha}(\alpha, T_F, \hat{I} | L) U_{T_F}(\alpha, T_F, \hat{I} | M), \forall \{\alpha, T_F, \hat{I}\}$$

We now, characterize the equilibrium for the frequent reporting regime using the assumptions in (28) and (35). The equilibrium is fully described in Proposition 6 below. Since the proof of Proposition 6 is lengthy and tedious, we provide a loose intuitive argument here. As $\alpha \rightarrow 0$, i.e. when almost all of the weight is on the date 2 price, the manager's project selection decision is analogous to that in the infrequent reporting regime. So the manager strictly prefers the long-term project to the short-term project, regardless of which project \hat{I} and what threshold T_F the market anticipates and incorporates into prices. This preference is solely due to the fact that the cumulative two period cash inflow y_2 is stochastically bigger if the manager chooses project L than if she chooses project M . But, as more and more weight is shifted onto the first period price the manager's preference begins to tilt towards the short-term project. When almost all of the weight is on the first period price, i.e. $\alpha \rightarrow 1$, the manager strictly prefers the short-term project to the long-term project solely due to the fact that the first period cash inflow is stochastically bigger under the short-term project. Thus when α exceeds some interior threshold, the manager's preference must switch from the long-term project to the short-term project.

An essential feature of the equilibrium is that $\hat{I} = I$. Thus project L is sustained in equilibrium only when L is preferred to M conditional on the market pricing the firm as if it has

chosen project L , and project M is sustained in equilibrium only when M is preferred to L conditional on the market pricing the firm as if it has chosen M . The critical threshold value of α at which the firm's preferences switch from one project to the other depends upon which project \hat{I} the market has anticipated and built into the date 1 and date 2 price. Let α^* be this threshold value when $\hat{I} = L$, and let α^{**} be the threshold when $\hat{I} = M$. The single crossing property, that we have assumed, guarantees that α^* and α^{**} are unique, i.e. once the manager begins to prefer the short-term project over the long-term project this preference will continue to hold for all bigger values of α . This implies that in the interval $\alpha > \alpha^*$, the long-term project cannot be sustained in equilibrium because when the market anticipates and prices the firm as if it has chosen project L the firm deceives the market and chooses project M . However, project M is sustainable in equilibrium only when $\alpha > \alpha^{**}$.

In general $\alpha^* \neq \alpha^{**}$, and the ordering of these thresholds is indeterminate. If $\alpha^{**} > \alpha^*$ then project L is sustained in equilibrium at all values of $\alpha \leq \alpha^*$, $S \geq T_F(\alpha, L)$, and project M is sustained in equilibrium at all values of $\alpha \geq \alpha^{**}$, $S \geq T_F(\alpha, M)$. In the interval (α^*, α^{**}) there is no pure strategy equilibrium because project L is not sustainable at any $\alpha > \alpha^*$, and project M is not sustainable at any $\alpha < \alpha^{**}$. In this case, the only possible equilibrium is a mixed strategy equilibrium. If $\alpha^{**} < \alpha^*$ then project L is sustained as the unique equilibrium at all values of $\alpha \leq \alpha^{**}$, $S \geq T_F(\alpha, L)$ and project M is sustained in equilibrium at all values $\alpha \geq \alpha^*$, $S \geq T_F(\alpha, M)$. In the interval (α^{**}, α^*) there are multiple pure strategy equilibria since both project L and project M are sustainable depending on which project the market anticipates the manager to choose.

Proposition 6:

Given the assumptions of stochastically equal damage and the single crossing property,

if $\alpha^{**} \geq \alpha^*$, then:

- i. $I(S, \alpha) = L, \forall \alpha \leq \alpha^*, S \geq T_F(\alpha, L)$
- ii. $I(S, \alpha) = M, \forall \alpha \geq \alpha^{**}, S \geq T_F(\alpha, M)$
- iii. $I(S, \alpha) = \emptyset, \forall \alpha \leq \alpha^*, S < T_F(\alpha, L)$ and $\forall \alpha > \alpha^{**}, S < T_F(\alpha, M)$
- iv. At each $\alpha \leq \alpha^*$:

$$P_1 = x_1 + \text{Prob}(G | S \geq T_F(\alpha, L), x_1, L) V_1(G, L) +$$

$$\text{Prob}(B | S \geq T_F(\alpha, L), x_1, L) V_1(B, L) - K$$

$$P_2 = y_2 + \text{Prob}(G | S \geq T_F(\alpha, L), y_2, L) V_2(G, L)$$

$$+ \text{Prob}(B | S \geq T_F(\alpha, L), y_2, L) V_2(B, L) - K$$

At each $\alpha \geq \alpha^{**}$

$$P_1 = x_1 + \text{Prob}(G | S \geq T_F(\alpha, M), x_1, M) V_1(G, M)$$

$$+ \text{Prob}(B | S \geq T_F(\alpha, M), x_1, M) V_1(B, M) - K$$

$$P_2 = y_2 + \text{Prob}(G | S \geq T_F(\alpha, M), y_2, M) V_2(G, M)$$

$$+ \text{Prob}(B | S \geq T_F(\alpha, M), y_2, M) V_2(B, M) - K$$

If $\alpha^{**} < \alpha^*$, then:

- v. $I(S, \alpha) = L, \forall \alpha \leq \alpha^{**}, S \geq T_F(\alpha, L)$
- vi. $I(S, \alpha) = M, \forall \alpha \geq \alpha^*, S \geq T_F(\alpha, M)$
- vii. $I(S, \alpha) = \emptyset, \forall \alpha \leq \alpha^{**}, S < T_F(\alpha, L)$ and $\forall \alpha > \alpha^*, S < T_F(\alpha, M)$
- viii. At each $\alpha \leq \alpha^{**}$:

$$P_1 = x_1 + \text{Prob}(G | S \geq T_F(\alpha, L), x_1, L) V_1(G, L) +$$

$$\text{Prob}(B | S \geq T_F(\alpha, L), x_1, L) V_1(B, L) - K$$

$$P_2 = y_2 + \text{Prob}(G | S \geq T_F(\alpha, L), y_2, L) V_2(G, L)$$

$$+ \text{Prob}(B | S \geq T_F(\alpha, L), y_2, L) V_2(B, L) - K$$

At each $\alpha \geq \alpha^*$

$$P_1 = x_1 + \text{Prob}(G | S \geq T_F(\alpha, M), x_1, M) V_1(G, M)$$

$$+ \text{Prob}(B | S \geq T_F(\alpha, M), x_1, M) V_1(B, M) - K$$

$$P_2 = y_2 + \text{Prob}(G | S \geq T_F(\alpha, M), y_2, M) V_2(G, M)$$

$$+ \text{Prob}(B | S \geq T_F(\alpha, M), y_2, M) V_2(B, M) - K$$

Proof: See the Appendix.

Proposition 6 says that frequent reporting will induce managerial short-termism, with probability one, if the degree of impatience in the capital market is sufficiently high. This result is consistent with the intuition expressed in the European debate, described earlier. Since managerial short-termism never occurs in the infrequent reporting regime, but does occur in the frequent reporting regime, Proposition 6 identifies a potentially large endogenous cost that could be precipitated by increasing the frequency of financial reporting.

7. Is Frequent Reporting Socially Desirable?

We measure social welfare as the *ex ante* expected surplus (before S is privately observed by managers) over the entire investment horizon, (N periods), without regard to how that surplus is divided between individual shareholders (current and future). We have in mind a regulator who is concerned solely with economic efficiency. The regulator is empowered to choose the reporting frequency and implement it by fiat.

Welfare comparisons depend upon whether the firm's shareholders are sufficiently patient so that the long-term project is sustained in the equilibrium of the frequent reporting regime, or sufficiently impatient so that the short-term project is sustained in the equilibrium of the frequent reporting regime. First, consider the case where the long-term project is sustained in the equilibrium of the frequent reporting regime. The relevant thresholds above which the firm invests in the long-term project are $T_I(\alpha, L)$ and $T_F(\alpha, L)$, in the infrequent and frequent reporting regimes, respectively. Since both thresholds lie below the first best threshold S_L^* , in both regimes the firm sometimes invests in negative net present value projects. We show, below, that the frequent reporting regime imposes greater discipline on the firm's investment so that the probability of investing in negative net present value projects is strictly smaller in the frequent reporting regime than in the infrequent reporting regime.

Proposition 7: $T_I(\alpha, L) < T_F(\alpha, L)$, $\forall \alpha \in (0, 1)$, and $T_I(\alpha, L) = T_F(\alpha, L)$ as $\alpha \rightarrow 0$.

Proof: See the Appendix.

We have shown that when the firm's shareholders are sufficiently patient, there are strict benefits to increasing the reporting frequency and there are no costs since greater reporting frequency does not result in managerial short-termism. The benefits are due to the greater discipline imposed by more frequent reporting on the firm's incentive to invest in negative net present value projects. This implies:

Proposition 8: *If the firm's current shareholders are sufficiently patient so that the long-term project is sustained in the equilibrium of the frequent reporting regime then frequent reporting of the results of operations dominates infrequent reporting.*

Now consider the case where the firm's shareholders are sufficiently impatient so that frequent reporting triggers investment in the short-term project. Since the short-term project has lower net present value than the long-term project, this induced myopia significantly lowers social welfare. But, because frequent reporting provides greater discipline it could decrease the probability of undertaking negative net present value projects. So, potentially, there are also benefits to frequent reporting. We explore this tradeoff below.

Given that in the infrequent reporting regime the firm always invests in project L , but in the frequent reporting regime the firm invests in project M , the relevant thresholds above which the firm invests are $T_I(\alpha, L)$ in the infrequent reporting regime and $T_F(\alpha, M)$ in the frequent reporting regime. While it is true that $T_I(\alpha, M) < T_F(\alpha, M)$, the thresholds $T_I(\alpha, L)$ and $T_F(\alpha, M)$ cannot generally be ordered. Therefore we consider each possibility. If $T_I(\alpha, L) \geq T_F(\alpha, M)$ at some value of α where frequent reporting triggers managerial short-termism, then there are no benefits from frequent reporting while the cost remains, so that infrequent reporting unambiguously dominates frequent reporting. However, if $T_I(\alpha, L) < T_F(\alpha, M)$ there are both costs and benefits to frequent reporting, so there is a non-trivial tradeoff.

Let $\Pi_I(\alpha)$ and $\Pi_F(\alpha)$ be the *ex ante* expected surplus from investment in the infrequent and frequent reporting regimes, respectively. Let $\xi(S) \equiv \lambda \xi(S | G) + (1 - \lambda) \xi(S | B)$ be the unconditional density of the manager's private signal. Then, for values of α at which frequent reporting induces managerial short-termism:

$$\Pi_I(\alpha) = \int_{T_I(\alpha, L)}^{\bar{S}} \{ \text{Prob}(G | S) V_0(G, L) + \text{Prob}(B | S) V_0(B, L) - K \} \xi(S) dS ,$$

and

$$\Pi_F(\alpha) = \int_{T_F(\alpha, M)}^{\bar{S}} \{ \text{Prob}(G | S)V_0(G, M) + \text{Prob}(B | S)V_0(B, M) - K \} \xi(S) dS$$

Therefore, if $T_I(\alpha, L) < T_F(\alpha, M)$,

$$\begin{aligned} \Pi_I(\alpha) - \Pi_F(\alpha) = & \int_{T_I(\alpha, L)}^{T_F(\alpha, M)} \{ \text{Prob}(G | S)V_0(G, L) + \text{Prob}(B | S)V_0(B, L) - K \} \xi(S) dS + \\ & \int_{T_F(\alpha, M)}^{\bar{S}} \{ \text{Prob}(G | S)[V_0(G, L) - V_0(G, M)] + \text{Prob}(B | S)[V_0(B, L) - V_0(B, M)] \} \xi(S) dS \end{aligned} \quad (37)$$

The second term in (37) is unambiguously positive since the long-term project has a higher net present value than the short-term project in both states of Nature. The first term in (37) is negative if $S_L^* > T_F(\alpha, M)$, but could be either negative or positive if $S_L^* < T_F(\alpha, M)$ because the long-term project has positive net present value at each $S > S_L^*$. The second term describes the benefit of infrequent reporting arising from the result that infrequent reporting sustains the long-term project while frequent reporting causes managerial short-termism. The first term describes the potential cost associated with infrequent reporting arising from the lower discipline imposed by infrequent reporting relative to frequent reporting. If the sum of these two terms is positive then infrequent reporting dominates frequent reporting given that the degree of impatience in the capital market is large enough to trigger managerial short-termism.

The tradeoff specified in (37) is specific to the degree of impatience in the capital market, and it also depends upon the endogenous thresholds $T_I(\alpha, L)$ and $T_F(\alpha, M)$. An unconditional result that applies to all degrees of impatience that cause managerial short-termism can be obtained by calculating a lower bound to the benefits and an upper bound to the costs of infrequent reporting relative to frequent reporting. These bounds can be calculated by replacing $T_F(\alpha, M)$ by S_M^* , and replacing $T_I(\alpha, L)$ by \underline{S} in (37). This yields:

Proposition 9:

Infrequent reporting dominates frequent reporting for all levels of impatience exceeding the threshold that triggers managerial short-termism if:

$$\begin{aligned} & \int_{S_M^*}^{\bar{S}} \{ \text{Prob}(G | S)[V_0(G, L) - V_0(G, M)] + \text{Prob}(B | S)[V_0(B, L) - V_0(B, M)] \} \xi(S) dS + \\ & \int_{S_L^*}^{S_M^*} \{ [\text{Prob}(G | S)V_0(G, L) + \text{Prob}(B | S)V_0(B, L)] - K \} \xi(S) dS > \\ & \int_{\underline{S}}^{S_L^*} \{ K - [\text{Prob}(G | S)V_0(G, L) + \text{Prob}(B | S)V_0(B, L)] \} \xi(S) dS \end{aligned}$$

7. Discussion and Conclusion

In research organizations, it is common wisdom that premature evaluations of research based solely on immediately observable outcomes are dysfunctional. We have shown that the same wisdom applies when uninformed capital markets price the firm solely in the light of observed cash flows from investment projects. When the results of operations are reported too frequently, capital market pricing becomes equivalent to premature evaluation of managerial actions whose benefits arrive mostly in later periods. Consequently, actions that produce large short-term benefits become more attractive and actions that do not immediately produce such benefits but would *ultimately* create more value for the firm become less attractive. Thus, frequent reporting becomes dysfunctional even though such reporting provides more information to the capital market.

The policy implications we have derived from a study of the *real* effects of disclosure stand in strong contrast to the policy implications implied by the study of pure exchange economies. In pure exchange economies, the firm's business decisions are held fixed, so the only effect of disclosure is to decrease the residual uncertainty of a fixed exogenous distribution of

liquidating dividends. In a risk averse economy, such reductions in residual uncertainty decrease the risk premium incorporated in equilibrium capital market prices.¹¹ Thus, one would mistakenly conclude that greater frequency of disclosure is *always* desirable, and the only cost that would prevent disclosure frequency from degenerating into weekly or even daily reports is the legal and book-keeping costs of compliance. Our study also illustrates the importance of distinguishing “price efficiency” from “economic efficiency.” It may seem that any new disclosure mandate that adds information to the capital market and thus makes prices “more efficient” must promote social welfare. Such a result always holds in a first best world or when enhanced disclosure is so rich that it moves the economy to a first best world. However, when a first best world is unattainable, the provision of new information to the capital market could motivate firms to change their business decisions in such a way that economic efficiency suffers even though price efficiency is enhanced. By explicitly analyzing such *real* effects, we have shown that infrequent reporting could provide better incentives for investment by *destroying* information. This result may seem counterintuitive in the light of Blackwell’s theorem, but begins to make sense when we take into account that that information has strategic consequences, i.e., it changes the world that is being assessed.

We have chosen to model the benefits to periodic performance reporting in terms of the discipline they impose on managerial decisions that are made *prior* to the release of the report, as first described in Kanodia and Lee [1998]. An alternative, and more popular, view is that such reports guide *subsequent* investment decisions that new investors may intend to make after buying into the firm. Our view is that such a situation is analogous to the raising of new capital through an IPO or a seasoned equity offering. Not only are such offerings rare, but they are always accompanied by a detailed prospectus and forecasts by underwriters and analysts that contain much more information than is typically contained in periodic accounting reports. We

¹¹ See Verrecchia [2001]

have tried to capture the benefits of performance reports that are *routinely* disseminated to the capital market at fixed pre-specified intervals, regardless of whether the firm intends to raise new capital. We think the debate on disclosure frequency is more concerned with such routine periodic reports.

It may seem that the inefficiency caused by frequent disclosure could easily be mitigated by appropriately designed managerial compensation contracts. Surely, any compensation contract that rewards the manager solely on the basis of cumulative long-term cash flows would induce her to choose the long-term project, rather than the short-term project. It may seem that such a contract would also benefit the firm's current shareholders, since capital market valuations would improve. However, the benefit to current shareholders, from such a contract, comes not from aligning the incentives of the manager with that of current shareholders – by assumption, their incentives are already perfectly aligned. The benefits come from signaling *future* shareholders that the manager will not behave opportunistically. But having so convinced future shareholders, current shareholders would *want* the manager to behave in an opportunistic way, so any such contract would quickly unravel.¹² The problem lies not in the short-termism of the manager but in the short-termism of current shareholders. So, what would be needed is a contract between *current* and *future shareholders* which alleviates the short-termism of current shareholders. Such a contract is problematic because future shareholders constitute an unidentifiable faceless crowd in the capital market. We think that regulators, such as the SEC, are mindful of such difficulties associated with contracting, and have chosen mandatory corporate disclosure as the principal mechanism for mediating the tension between current and future shareholders. In previous work, we have demonstrated repeatedly that the effectiveness of such

¹² See Persons [1994] for a rigorous articulation of such an argument.

disclosure requirements depends critically on the choice of accounting measurement rules.¹³ In the present paper, we have shown that the frequency of disclosure is also a critical policy choice available to regulators and we have demonstrated that a judicious choice of disclosure frequency could help in curbing managerial opportunism.

¹³ See Kanodia [2006] for a survey of research that documents the effect of accounting measurement rules on corporate decisions through the interaction of those decisions with market pricing.

Appendix

Proof of Lemma1:

The date 1 price $\varphi_1(T_I, L)$, as described in (14), can be expressed as:

$$\begin{aligned}\varphi_1(T_I, L) = & \text{Prob}(G | S \geq T_I)[E(y_2 | G, L) + V_2(G, L)] \\ & + \text{Prob}(B | S \geq T_I)[E(y_2 | B, L) + V_2(B, L)] - K\end{aligned}$$

and from (15),

$$\begin{aligned}E_0[\varphi_2(T_I, y_2, L | T_I, L)] = & \text{Prob}(G | T_I)E(y_2 | G, L) + \text{Prob}(B | T_I)E(y_2 | B, L) \\ & + E_0[\text{Prob}(G | S \geq T_I, y_2, L) | T_I, L]V_2(G, L) \\ & + E_0[\text{Prob}(B | S \geq T_I, y_2, L) | T_I, L]V_2(B, L) - K\end{aligned} \tag{A1}$$

Because $\text{Prob}(G | S \geq T_I) > \text{Prob}(G | T_I)$ and because $E(y_2 | G, L) > E(y_2 | B, L)$,

$$\begin{aligned}& \text{Prob}(G | S \geq T_I)E(y_2 | G, L) + \text{Prob}(B | S \geq T_I)E(y_2 | B, L) \\ & > \text{Prob}(G | T_I)E(y_2 | G, L) + \text{Prob}(B | T_I)E(y_2 | B, L)\end{aligned}$$

Additionally,

$$\begin{aligned}\text{Prob}(G | S \geq T_I) = & E_0[\text{Prob}(G | S \geq T_I, \tilde{y}_2, L) | S \geq T_I, L] \\ & > E_0[\text{Prob}(G | S \geq T_I, \tilde{y}_2, L) | T_I, L]\end{aligned}$$

where, the equality is due to the law of iterated expectations and the inequality is due to the fact

that $S \geq T_I$ is a more favorable event than $S = T_I$. Thus, since $V_2(G, L) > V_2(B, L)$,

$$\text{Prob}(G | S \geq T_I)V_2(G, L) + \text{Prob}(B | S \geq T_I)V_2(B, L) >$$

$$E_0[\text{Prob}(G | S \geq T_I, y_2, L) | T_I, L]V_2(G, L) + E_0[\text{Prob}(B | S \geq T_I, y_2, L) | T_I, L]V_2(B, L)$$

Q.E.D.

Proof of Proposition 4:

Part (i) of the proposition has already been established in the body of the paper. We now establish that $T_I(\alpha, L)$ is strictly decreasing in α . Since $T_I(\alpha, L)$ must satisfy (20) at every α ,

$$\frac{\partial}{\partial \alpha} \{ \alpha \varphi_1(T_I(\alpha, L), L) + (1 - \alpha) E_0[\varphi_2(T_I(\alpha, L), y_2, L) | T_I(\alpha, L), L] \} = 0$$

Carrying out the differentiation yields,

$$\varphi_1 - E_0[\varphi_2 | T_I(\alpha, L), L] + \frac{dT_I}{d\alpha} \left[\alpha \frac{\partial \varphi_1}{\partial T_I} + (1 - \alpha) \frac{\partial E_0(\varphi_2)}{\partial T_I} \right] = 0 \quad (A2)$$

Now, from Lemma 1, $\varphi_1 - E_0[\varphi_2 | T_I(\alpha, L), L] > 0, \forall \alpha$. Also, since $\text{Prob}(G | S \geq T_I)$ is strictly increasing in T_I , $\frac{\partial \varphi_1}{\partial T_I} > 0$. Additionally, note that in equation (A1) T_I appears only as a

conditioning argument in probability calculations. Since both $\text{Prob}(G | S \geq T_I, y_2, L)$ and the expectation of this probability conditional on T_I are strictly increasing in T_I , it follows that

$$\frac{\partial E_0(\varphi_2)}{\partial T_I} > 0. \text{ Therefore, (A2) implies } \frac{dT_I}{d\alpha} < 0.$$

Now, we establish part (ii) of the proposition. Since $T_I(\alpha, L)$ is strictly decreasing in α , we need only establish that $T_I < S_L^*$ at $\alpha = 0$, and $T_I > \underline{S}$ at $\alpha = 1$. First, consider $\alpha = 0$. At $\alpha = 0$ all of the weight is on the date 2 price. Therefore $T_I(0, L)$ must satisfy:

$$\begin{aligned} E_0(y_2 | S_I(0, L), L) + E_0[\text{Prob}(G | S \geq S_I(0, L), y_2, L) | S_I(0, L), L] V_2(G, L) + \\ E_0[\text{Prob}(B | S \geq S_I(0), y_2, L) | S_I(0), L] V_2(B, L) - K = 0 \end{aligned} \quad (A3)$$

And, by definition of S_L^* ,

$$\text{Prob}(G | S_L^*) V_0(G, L) + \text{Prob}(B | S_L^*) V_0(B, L) - K = 0, \text{ implying that}$$

$$\text{Prob}(G | S_L^*) [E(y_2 | G, L) + V_2(G, L)] + \text{Prob}(B | S_L^*) [E(y_2 | B, L) + V_2(B, L)] - K = 0 \quad (A4)$$

At $T_I(0, L) = S_L^*$, $E(y_2 | T_I(0, L), L) = \text{Prob}(G | S_L^*)E(y_2 | G, L) + \text{Prob}(B | S_L^*)E(y_2 | B, L)$

But, $E_0[\text{Prob}(G | S \geq S_L^*, y_2, L) | S_L^*, L] > E_0[\text{Prob}(G | S_L^*, y_2, L) | S_L^*, L] = \text{Prob}(G | S_L^*)$

Therefore at $T_I(0, L) = S_L^*$ the left hand side of (A3) is greater than the left hand side of (A4),

from which it follows that the satisfaction of (A3) requires $T_I(0, L) < S_L^*$. Now, consider $\alpha = 1$.

In this case since all the weight is on the first period price, (14) and (A4) imply that $T_I(1, L)$ must satisfy:

$$\begin{aligned} & \text{Prob}(G | S \geq T_I(1, L))V_0(G, L) + \text{Prob}(B | S \geq T_I(1, L))V_0(B, L) \\ &= \text{Prob}(G | S_L^*)V_0(G, L) + \text{Prob}(B | S_L^*)V_0(B, L) . \end{aligned}$$

But this equality can only hold if $\text{Prob}(G | S \geq T_I(1, L)) = \text{Prob}(G | S_L^*)$ which, in turn, implies

that $T_I(1, L) > \underline{S}$ because $\text{Prob}(G | S \geq \underline{S}) = \lambda < \text{Prob}(G | S_L^*)$.

Q.E.D.

The proof of Lemma 2 uses Lemma 2(a) below:

Lemma 2(a)

In the frequent reporting regime, given any $T_F \in [\underline{S}, \bar{S})$ and any $\hat{I} \in \{L, M\}$,

$$E_{x_1}[\text{Prob}(G | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}] > E_{y_2}[\text{Prob}(G | S \geq T_F, y_2, \hat{I}) | T_F, \hat{I}]$$

Proof:

By the law of iterated expectations,

$$\begin{aligned} \text{Prob}(G | S \geq T_F, x_1, \hat{I}) &= E_{x_2}[\text{Prob}(G | S \geq T_F, x_1, x_2, \hat{I}) | S \geq T_F, x_1, \hat{I}] \\ &> E_{x_2}[\text{Prob}(G | S \geq T_F, x_1, x_2, \hat{I}) | T_F, x_1, \hat{I}], \forall \{x_1, T_F\} \end{aligned}$$

where, the last inequality is due to the fact that $S \geq T_F$ is a more favorable event than $S = T_F$.

Therefore,

$$E_{x_1}[\text{Prob}(G | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}] > E_{x_1}[E_{x_2}[\text{Prob}(G | S \geq T_F, x_1, x_2, \hat{I}) | T_F, x_1, \hat{I}] | T_F, \hat{I}]$$

$$\begin{aligned}
&= E_{x_1, x_2} [\text{Prob}(G | S \geq T_F, x_1, x_2, \hat{I}) | T_F, \hat{I}] \\
&= E_{y_2} [\text{Prob}(G | S \geq T_F, y_2, \hat{I}) | T_F, \hat{I}]
\end{aligned}$$

where, the last equality is due to the assumption that y_2 is sufficient for $\{x_1, x_2\}$.

Proof of Lemma 2

The proof here uses Lemma 2(a) stated above. The expectation of the date 1 price can be expressed as:

$$\begin{aligned}
E_{x_1} [P_1(T_F, x_1, \hat{I}) | T_F, \hat{I}] &= E(x_1 | T_F, \hat{I}) + \\
E_{x_1} [\text{Prob}(G | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}] [E(x_2 | G, \hat{I}) + V_2(G, \hat{I})] &+ \\
E_{x_1} [\text{Prob}(B | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}] [E(x_2 | B, \hat{I}) + V_2(B, \hat{I}) - K]
\end{aligned}$$

The expectation of the date 2 price is:

$$\begin{aligned}
E_{y_2} [P_2(T_F, \hat{I}, y_2) | T_F, \hat{I}] &= E(x_1 | T_F, \hat{I}) + E(x_2 | T_F, \hat{I}) + \\
E_{y_2} [\text{Prob}(G | S \geq T_F, y_2, \hat{I}) | T_F, \hat{I}] V_2(G, \hat{I}) &+ \\
E_{y_2} [\text{Prob}(B | S \geq T_F, y_2, \hat{I}) | T_F, \hat{I}] V_2(B, \hat{I}) - K
\end{aligned}$$

But,

$$E(x_2 | T_F, \hat{I}) = \text{Prob}(G | T_F) E(x_2 | G, \hat{I}) + \text{Prob}(B | T_F) E(x_2 | B, \hat{I})$$

And, by the law of iterated expectations,

$$\text{Prob}(G | T_F) = E_{x_1} [\text{Prob}(G | T_F, x_1, \hat{I}) | T_F, \hat{I}] < E_{x_1} [\text{Prob}(G | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}]$$

Therefore,

$$\begin{aligned}
E(x_2 | T_F, \hat{I}) &< E_{x_1} [\text{Prob}(G | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}] E(x_2 | G, \hat{I}) + \\
&E_{x_1} [\text{Prob}(B | S \geq T_F, x_1, \hat{I}) | T_F, \hat{I}] E(x_2 | B, \hat{I})
\end{aligned}$$

Also, by Lemma 2(a),

$$\begin{aligned}
& E_{y_2} [\text{Prob}(G | S \geq T_F, y_2, \hat{I} | T_F, \hat{I}) V_2(G, \hat{I}) + E_{y_2} [\text{Prob}(B | S \geq T_F, y_2, \hat{I} | T_F, \hat{I}) V_2(B, \hat{I}) \\
& < E_{x_1} [\text{Prob}(G | S \geq T_F, x_1, \hat{I} | T_F, \hat{I}) V_2(G, \hat{I})] + E_{x_1} [\text{Prob}(B | S \geq T_F, x_1, \hat{I} | T_F, \hat{I}) V_2(B, \hat{I})
\end{aligned}$$

Q.E.D.

Proof of Proposition 5

We first show that $T_F(\alpha, \hat{I})$ as defined in (23) and (24) are strictly decreasing in α .

Differentiating (23) or (24) with respect to α gives:

$$\begin{aligned}
& E_0[P_1(T_F, x_1, \hat{I}) | T_F, \hat{I}] - E_0[P_2(T_F, y_2, \hat{I}) | T_F, \hat{I}] + \\
& \frac{\partial T_F}{\partial \alpha} \left\{ \alpha \frac{\partial}{\partial T_F} E_0[P_1(T_F, x_1, \hat{I}) | T_F, \hat{I}] + (1 - \alpha) \frac{\partial}{\partial T_F} E_0[P_2(T_F, y_2, \hat{I}) | T_F, \hat{I}] \right\} = 0 \quad (\text{A5})
\end{aligned}$$

The first term in (A5) is the expected difference in the first and second period prices which is strictly positive as proved in Lemma 2, and:

$$\begin{aligned}
& \frac{\partial}{\partial T_F} \left\{ E_0[P_1(T_F, x_1, \hat{I}) | T_F, \hat{I}] \right\} = \\
& \int \frac{\partial P_1}{\partial T_F} f_1(x_1 | T_F, \hat{I}) dx_1 + \int P_1 \frac{\partial}{\partial T_F} f_1(x_1 | T_F, \hat{I}) dx_1 \quad (\text{A6})
\end{aligned}$$

The second term in (A6) is strictly positive because P_1 is strictly increasing in x_1 and the distribution of x_1 moves to the right as T_F increases. The first term in (A6) =

$$[V_1(G, \hat{I}) - V_1(B, \hat{I})] \int \frac{\partial}{\partial T_F} \left\{ \text{Prob}(G | S \geq T_F, x_1, \hat{I}) \right\} f_1(x_1 | T_F, \hat{I}) dx_1, \text{ which is also strictly}$$

positive since $V_1(G, \hat{I}) - V_1(B, \hat{I}) > 0$ and $\text{Prob}(G | S \geq T_F, x_1, \hat{I})$ is strictly increasing in T_F . The

expression for $\frac{\partial}{\partial T_F} \left\{ E_0[P_2(T_F, y_2, \hat{I}) | T_F, \hat{I}] \right\}$ has a form similar to that in (A6) with y_2

replacing x_1 and V_2 replacing V_1 , and is therefore also strictly positive. These facts imply that

both of the factors multiplying $\frac{\partial T_F}{\partial \alpha}$ in (A5) are strictly positive. Therefore, the satisfaction of

(A5) requires $\frac{\partial T_F}{\partial \alpha} < 0$.

The claim that $T_F(0, L) < S_L^*$ follows from the fact that $T_F(0, L) = T_I(0, L)$ and $T_I(0, L) < S_L^*$. We later show, in Proposition 7, that $T_F(\alpha, L) > T_I(\alpha, L)$, at $\alpha = 1$, hence the proof that $T_F(1, L) > \underline{S}$ being subsumed by this result, is not presented here. Similar arguments apply to the claims regarding $T_F(\alpha, M)$.

Q.E.D.

Proof of Lemma 3:

$$\frac{\partial}{\partial S} \{\Delta_1(T_F(\alpha, \hat{I}), \hat{I}, S)\} = \int \left(P_1(T_F(\alpha, \hat{I}), x_1, \hat{I}) \frac{\partial}{\partial S} [f_1(x_1 | S, M) - f_1(x_1 | S, L)] \right) dx_1$$

But,

$$\begin{aligned} \frac{\partial}{\partial S} f_1(x_1 | S, M) &= \frac{\partial}{\partial S} (\text{Prob}(G | S) f_1(x_1 | G, M) + \text{Prob}(B | S) f_1(x_1 | B, M)) \\ &= \left(\frac{\partial}{\partial S} \text{Prob}(G | S) \right) [f_1(x_1 | G, M) - f_1(x_1 | B, M)]. \end{aligned}$$

Similarly,

$$\frac{\partial}{\partial S} f_1(x_1 | S, L) = \left(\frac{\partial}{\partial S} \text{Prob}(G | S) \right) [f_1(x_1 | G, L) - f_1(x_1 | B, L)].$$

Therefore,

$$\begin{aligned} \frac{\partial}{\partial S} \{\Delta_1(T_F(\alpha, \hat{I}), \hat{I}, S)\} &= \\ &= \left(\frac{\partial}{\partial S} \text{Prob}(G | S) \right) \left(\int P_1(T_F, x_1, \hat{I}) \{ [f_1(x_1 | G, M) - f_1(x_1 | B, M)] - [f_1(x_1 | G, L) - f_1(x_1 | B, L)] \} dx_1 \right) \end{aligned}$$

Evaluating the integral by parts gives,

$$\frac{\partial}{\partial S} \{\Delta_1(T_F(\alpha, \hat{I}), \hat{I}, S)\} =$$

$$- \left(\frac{\partial}{\partial S} \text{Prob}(G | S) \right) \left(\int \frac{\partial P_1}{\partial x_1} \{ [F_1(x_1 | G, M) - F_1(x_1 | B, M)] - [F_1(x_1 | G, L) - F_1(x_1 | B, L)] \} \right) dx_1.$$

Clearly, (28) implies that $\frac{\partial}{\partial S} \{\Delta_1(S_F(\alpha, \hat{I}), \hat{I}, S)\} = 0$

Using exactly the same analysis as above, it can be shown that,

$$\frac{\partial}{\partial S} \{\Delta_2(S_F(\alpha, \hat{I}), \hat{I}, S)\} =$$

$$\left(\frac{\partial}{\partial S} \text{Prob}(G | S) \right) \int \left(\frac{\partial P_2}{\partial y_2} \{ [H(y_2 | B, L) - H(y_2 | G, L)] - [H(y_2 | B, M) + H(y_2 | G, M)] \} \right) dy_2.$$

Therefore (29) implies $\frac{\partial}{\partial S} \{\Delta_2(S_F(\alpha, \hat{I}), \hat{I}, S)\} = 0$

Q.E.D

Proof of Proposition 6

Suppose that $\hat{I} = L$, and consider the firm's preferences between projects L and M . At each α , define a new threshold $T_F(\alpha, \hat{I} = L | I = M)$ by the value of T_F that satisfies:

$$U(\alpha, T_F, \hat{I} = L | I = M) \equiv \alpha E[P_1(T_F, x_1, \hat{L}) | T_F, M] + (1 - \alpha) E[P_2(T_F, y_2, \hat{L}) | T_F, M] = 0$$

$T_F(\alpha, \hat{I} = L | I = M)$ is an off-equilibrium schedule. It defines the threshold that makes the firm indifferent between M and \emptyset when the market prices the firm as if it has chosen project L and the firm's private signal equals the threshold. Recall that the threshold $T_F(\alpha, L)$ characterizes the firm's indifference between L and \emptyset when the market prices the firm as if it has chosen

project L and the firm's private signal equals the threshold. These two thresholds are graphed in Figure 2 below. The salient properties of the threshold $T_F(\alpha, L)$ were derived in Proposition 5.

We now derive the properties of the off-equilibrium threshold $T_F(\alpha, \hat{I} = L | I = M)$ as graphed in Figure 2 below.

INSERT FIGURE 2 HERE

First, we show that the schedule $T_F(\alpha, \hat{I} = L | I = M)$ is strictly decreasing in α .

$$\frac{\partial T_F(\alpha, \hat{I} = L | I = M)}{\partial \alpha} = - \frac{U_\alpha(\alpha, T_F, \hat{I} = L | I = M)}{U_{T_F}(\alpha, T_F, \hat{I} = L | I = M)}. \text{ It is easy to see that}$$

$U_{T_F}(\alpha, T_F, \hat{I} = L | I = M) > 0$. Also, by (34) and Lemma 2,

$$U_\alpha(\alpha, T_F, \hat{I} = L | I = M) > U_\alpha(\alpha, T_F, \hat{I} = L | I = L) > 0. \text{ Therefore } \frac{\partial T_F(\alpha, \hat{I} = L | I = M)}{\partial \alpha} < 0.$$

Next, we show that $T_F(\alpha, \hat{I} = L | I = M) > T_F(\alpha, L)$ at $\alpha = 0$. At $\alpha = 0$, all of the weight is on the date 2 price, so $T_F(0, L)$ must satisfy $E[P_2(T_F(0, L), y_2, L) | T_F(0, L), L] = 0$. Then, since

$$E[P_2(T_F, y_2, L) | T_F, M] < E[P_2(T_F, y_2, L) | T_F, L], \forall T_F, E[P_2(T_F(0, L), y_2, L) | T_F(0, L), M] <$$

0. Therefore the satisfaction of $E[P_2(T_F(0, \hat{I} = L | I = M), y_2, L) | T_F(0, \hat{I} = L | I = M), M] = 0$

must require $T_F(0, \hat{I} = L | I = M) > T_F(0, L)$. Next, we show that $T_F(\alpha, \hat{I} = L | I = M) < T_F(\alpha, L)$

at $\alpha = 1$. At $\alpha = 1$, all of the weight is on the date 1 price, so $T_F(1, L)$ must satisfy

$$E[P_1(T_F(1, L), x_1, L) | T_F(1, L), L] = 0. \text{ Then, since } E[P_1(T_F, x_1, L) | T_F, M] >$$

$$E[P_1(T_F, x_1, L) | T_F, L], \forall T_F, E[P_1(T_F(1, L), x_1, L) | T_F(1, L), M] > 0. \text{ Therefore the satisfaction}$$

of $E[P_1(T_F(1, \hat{I} = L | I = M), x_1, L) | T_F(1, \hat{I} = L | I = M), M] = 0$ must require

$T_F(1, \hat{I} = L | I = M) < T_F(1, L)$. Since both schedules are continuous in α , there exists at least one value of $\alpha \in (0, 1)$ at which $T_F(\alpha, \hat{I} = L | I = M) = T_F(\alpha, L)$. The single crossing property implies that this value of α , call it α^* , is unique, as pictured in Figure 2.

Now, in Figure 2, consider any $\alpha < \alpha^*$, where $T_F(\alpha, \hat{I} = L | I = M) > T_F(\alpha, L)$. By construction, $U(\alpha, T_F(\alpha, \hat{I} = L | I = M), \hat{I} = L | I = M) = 0$. Then, since $T_F(\alpha, L) < T_F(\alpha, \hat{I} = L | I = M)$, $U(\alpha, T_F(\alpha, L), \hat{I} = L | I = M) < 0$. Also, by construction $U(\alpha, T_F(\alpha, L), \hat{I} = L | I = L) = 0$. These facts imply that at any $\alpha < \alpha^*$ and $S = T_F(\alpha, L)$, the firm is indifferent between projects L and \emptyset but strictly prefers \emptyset to M and thus strictly prefers L to M, when market prices incorporate the belief that the firm invests in project L. Lemma 3 guarantees that this strict preference for L over M continues to hold for all other values of S. Therefore, the equilibrium at every $\alpha < \alpha^*$ entails the firm choosing L when it privately observes $S \geq T_F(\alpha, L)$ and choosing \emptyset when $S < T_F(\alpha, L)$. Now, consider any $\alpha' > \alpha^*$, where $T_F(\alpha', \hat{I} = L | I = M) < T_F(\alpha', L)$. Here $U(\alpha', S_F(\alpha', L), \hat{I} = L | I = M) > 0$ and $U(\alpha', T_F(\alpha', L), \hat{I} = L | I = L) = 0$. This implies that when the market prices the firm under the assumption that project L has been chosen, the firm would actually choose project M rather than L at every value of $S \geq T_F(\alpha', L)$. Thus, project L is sustained in equilibrium only when $\alpha \leq \alpha^*$ and cannot be sustained in equilibrium at any value of $\alpha > \alpha^*$.

Now suppose that $\hat{I} = M$, i.e., the market prices the firm as if the firm has chosen project M whenever investment is observed. This situation is described in Figure 3 below.

INSERT FIGURE 3 HERE

The threshold incorporated into market prices is now $T_F(\alpha, M)$. Note that this threshold is also declining in α as proved in Proposition 5. In order to characterize the firm's preferences between projects L and M when $\hat{I} = M$, consider the off-equilibrium threshold $T_F(\alpha, \hat{I} = M | I = L)$ which makes the firm indifferent between projects L and \emptyset when the market prices the firm as if has invested in project M and the firm's private signal equals this threshold. The two thresholds, $T_F(\alpha, M)$ and $T_F(\alpha, \hat{I} = M | I = L)$ are described in Figure 3. At each α , $T_F(\alpha, \hat{I} = M | I = L)$ is defined by the value of T_F that satisfies:

$$U(\alpha, T_F, \hat{I} = M | I = L) \equiv \alpha E[P_1(T_F, x_1, M) | T_F, L] + (1 - \alpha) E[P_2(T_F, y_2, M) | T_F, L] = 0$$

This schedule, $T_F(\alpha, \hat{I} = M | I = L)$, could be decreasing or increasing in α since

$$U_\alpha(\alpha, T_F, \hat{I} = M | I = L) = E[P_1(T_F, x_1, M) | T_F, L] - E[P_2(T_F, y_2, M) | T_F, L]$$

is ambiguous in sign. But, we know, unambiguously, that at $\alpha = 0$, $T_F(\alpha, \hat{I} = M | I = L) <$

$T_F(\alpha, M)$ because $E[P_2(T_F(0, M), y_2, M) | S_F, L] > E[P_2(T_F(0, M), y_2, M) | T_F, M] = 0$.

At $\alpha = 1$, $T_F(\alpha, \hat{I} = M | I = L) < T_F(\alpha, M)$ because $E[P_1(T_F(1, M), x_1, M) | T_F, L] <$

$E[P_1(T_F(1, M), x_1, M) | T_F, M] = 0$. Then the single crossing property implies that, regardless of

whether $T_F(\alpha, \hat{I} = M | I = L)$ is decreasing or increasing in α , there exists a unique $\alpha^{**} \in (0, 1)$

such that $T_F(\alpha^{**}, M) = T_F(\alpha^{**}, \hat{I} = M | I = L)$. At each $\alpha < \alpha^{**}$, $T_F(\alpha, \hat{I} = M | I = L) <$

$T_F(\alpha, M)$ implying that the firm strictly prefers project L to M when the market prices the firm

as if it has invested in project M and the firm's private signal equals the threshold $T_F(\alpha, M)$.

Lemma 3 then implies that this strict preference for L over M continues to hold at every value of

S . At each $\alpha > \alpha^{**}$, the opposite is true and the firm strictly prefers project M to L at every value

of S . Thus project M is sustained in equilibrium only in the interval $\alpha > \alpha^{**}$, but cannot be sustained when $\alpha < \alpha^{**}$.

Q.E.D.

Proof of Proposition 7

$T_I(\alpha, L)$ and $T_F(\alpha, L)$ satisfy:

$$\begin{aligned} \alpha \varphi_1(T_I(\alpha, L), L) + (1 - \alpha) E_0[\varphi_2(T_I(\alpha, L), y_2, L) | T_I(\alpha, L), L] = \\ \alpha E_0[P_1(T_F(\alpha, L), x_1, L) | T_F(\alpha, L), L] + (1 - \alpha) E_0[P_2(T_F(\alpha, L), y_2, L) | T_F(\alpha, L), L] = 0 \end{aligned} \quad (36)$$

First, consider the hypothesis that $T_I(\alpha, L) = T_F(\alpha, L)$ at some $\alpha > 0$. Given that the threshold for investment is exactly the same and the firm invests in L in both regimes, the expectation of the date 2 price must be exactly the same in both regimes. But, the date 1 price in the infrequent reporting regime is strictly bigger than the expectation of the date 1 price in frequent reporting regime, as shown below.

$$\varphi_1(T_I(\alpha, L), L) = \text{Prob}(G | S \geq T_I(\alpha, L)) [E(x_1 | G, L) + V_1(G, L)] +$$

$$\text{Prob}(B | S \geq T_I(\alpha, L)) [E(x_1 | B, L) + V_1(B, L)] - K$$

and,

$$E_0[P_1(T_F(\alpha, L), x_1, L) | T_F(\alpha, L), L] = \text{Prob}(G | T_F(\alpha, L)) E(x_1 | G, L) + \text{Prob}(B | T_F(\alpha, L)) E(x_1 | B, L) +$$

$$E_0[\text{Prob}(G | S \geq T_F(\alpha, L), x_1, L) | T_F(\alpha, L), L] V_1(G, L) +$$

$$E_0[\text{Prob}(B | S \geq T_F(\alpha, L), x_1, L) | T_F(\alpha, L), L] V_1(B, L) - K$$

Now under the hypothesis that $T_F(\alpha, L) = T_I(\alpha, L)$, $\text{Prob}(G | S \geq T_I(\alpha, L)) > \text{Prob}(G | T_F(\alpha, L))$

and,

$$\text{Prob}(G | S \geq T_I(\alpha, L)) = E_0[\text{Prob}(G | S \geq T_F(\alpha, L), x_1, L) | S \geq T_F(\alpha, L), L]$$

$$> E_0[\text{Prob}(G | S \geq T_F(\alpha, L), x_1, L) | T_F(\alpha, L), L].$$

Therefore $\varphi_1(T_I(\alpha, L), L) > E_0[R_1(T_F(\alpha, L), x_1, L) | T_F(\alpha, L), L]$. So, if $T_I(\alpha, L) = T_F(\alpha, L)$ and $\alpha > 0$, the left hand side of (36) is strictly greater than the right hand side of (36). Such inequality continues to be true if $T_I(\alpha, L) > T_F(\alpha, L)$. The satisfaction of (36) requires $T_I(\alpha, L) < T_F(\alpha, L)$ at $\forall \alpha > 0$. When $\alpha = 0$, there is no weight on the date 1 price, so equality of the date 2 expected prices requires $T_I(\alpha, L) = T_F(\alpha, L)$.

Q.E.D.

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