# Information Disclosure, Real Investment, and Shareholder Welfare

Sunil Dutta*
Haas School of Business,
University of California, Berkeley
dutta@haas.berkeley.edu

Alexander Nezlobin
Haas School of Business
University of California, Berkeley
nezlobin@haas.berkeley.edu

May 15, 2017

**Abstract**

This paper investigates the preferences of a firm's current and future shareholders for the quality of mandated public disclosures. In contrast to earlier studies, our analysis takes into account the effect of the quality of public information on the firm's internal investment decisions. We show that while the firm's investment is monotonically increasing in the quality of public information, the welfare of the firm's current shareholders can be maximized by an imperfect disclosure regime. In particular, the current shareholders prefer an intermediate level of public disclosures if (i) the firm's current assets in place are small relative to its future growth opportunities, and either (ii) the firm's investment is observable by the stock market and sufficiently elastic with respect to the cost of capital, or (iii) the firm's investment is not directly observable by the stock market and is sufficiently inelastic with respect to the cost of capital. The welfare of the firm's future shareholders is increasing in the quality of public disclosures if the growth rate in the firm's operations during their period of ownership is sufficiently high.

JEL Codes: D53, E22, G12, M41.
Keywords: Investment, Cost of Capital, Information Disclosure, Welfare.

*We thank Tim Baldenius, Xu Jiang, Yufei Lin, Dmitry Livdan, Igor Vaysman, seminar participants at Duke University, and the participants of the 2016 Burton Conference at Columbia University for their comments and suggestions.

# 1 Introduction

How does the quality of mandated public disclosures affect the welfare of a firm's shareholders? This question is of central importance for both academics and financial regulators. Conventional wisdom from models with a single round of trading is that more precise public information leads to investors demanding a lower risk premium for holding the firm's stock (see, for instance, Easley and O'Hara, 2004, and Lambert et al., 2007). In a dynamic setting with overlapping generations of investors, Dutta and Nezlobin (2017b) show that the firm's current and future shareholders can have divergent preferences over mandated disclosure regimes. While the welfare of the firm's current shareholders is maximized under the full disclosure regime, the welfare of future shareholders increases in the precision of public disclosures only if the expected growth rate in the firm's operations during their period of ownership is above a certain threshold. All of these results are, however, obtained under the assumption of exogenous cash flows.

In this paper, we study the relation between disclosure quality and investor welfare in a dynamic production economy, i.e., taking into account the effect of disclosure quality on the firm's internal investment decisions. We characterize this relation in two alternative settings studied in the earlier literature: when the firm's internal investment choices are directly observed by the market (henceforth, the *observable* investment model) and when they are not (henceforth, the *unobservable* investment model). While the observable investment setting is descriptive of investments in physical assets such as property, plant, and equipment, the assumption of unobservable investments is more reasonable for certain "soft" and fungible investments that cannot be credibly separated from the firm's regular operating costs.

The main findings of our paper are as follows. First, we show that the relation between the precision of public disclosures and the firm's internal investment is unambiguous: the firm invests more when public disclosures are more precise. This result obtains with both observable and unobservable investment. However, unlike in Dutta and Nezlobin (2017b), the welfare of the firm's current shareholders is not necessarily maximized under the full disclosure regime. If investment is observable and sufficiently sensitive to the cost of equity capital, the firm's current shareholders prefer a disclosure regime with imperfect precision. In contrast, in the scenario with unobservable investment, the firm's current shareholders prefer a regime with imperfect disclosures if investment is sufficiently inelastic to the cost of capital. The disclosure preferences of future shareholders are qualitatively similar in the observable and unobservable investment settings. Specifically, we show that their welfare is increasing in the quality of public information for a broader range of parameters than in the pure exchange model studied in Dutta and Nezlobin (2017b). Lastly, holding the quality of accounting disclosures fixed, we directly compare welfare of the firm's future shareholders in observable and unobservable investment regimes. It turns out that future shareholders prefer the regime with unobservable investments if the firm's investment is sufficiently elastic with respect to the cost of capital.

Our model considers a firm whose stock is traded by overlapping generations of investors. Each generation holds the firm's stock for one period of time, during which the firm makes one dividend payment and invests in a new project. At the end of each period, the firm releases a public report that informs investors about the next period's cash flow. Once the report is released, the firm's stock is sold in a competitive market to the next generation of investors. Therefore, each generation of shareholders is exposed to risk associated with the forthcoming dividend, which we label *dividend risk*, and risk associated with the future resale price of the stock, which we call *price risk*. A higher quality reporting environment results in a lower dividend risk but also a higher price risk since each generation of investors anticipates that the resale price will be formed based on a more informative public report.

We first focus on the model with observable investment and study the relation between the firm's investment choices and disclosure quality. For any given long-term project, when public disclosures are more precise, the resolution of risk shifts to earlier periods. As a consequence, such risk is borne by generations of investors that are further away from consuming the cash flows generated by the long-term project. We show that due to discounting, an earlier generation demands a lower premium for risk associated with a given cash flow than a later generation. Therefore, the total risk premium associated with a given project is unambiguously decreasing in the precision of public disclosures. This implies that the firm's current shareholders prefer the firm to invest more when the required public disclosures are more precise.

While the directional relation between the firm's investments and disclosure quality is the same in the model with unobservable investment (i.e., better disclosure quality leads to higher investments), two additional economic forces are at play to determine the magnitude of equilibrium investment. First, since the investment made by the selling generation of shareholders is no longer directly observable by the buying generation, the resale price of the firm's stock is partly based on the buying generation's *conjecture* about the firm's investment level and therefore is less sensitive to its *actual* value. This "expected value" effect leads to weaker investment incentives, and has been widely documented in the literature on real effects of accounting disclosure.[1] Second, when investments are unobservable, the buying generation's assessment of the firm's dividend risk is also based on its conjecture about the relevant investment level rather than its actual value. As a consequence, the total risk premium associated with each individual investment becomes less sensitive to the actual investment amount than in the setting with observable investments. We show that this "risk premium" effect of unobservability induces the selling generation to invest at higher levels.

To summarize, the firm's investments are increasing in the precision of public disclosures in both observable and unobservable investment settings. However, it is not a priori clear that, holding the quality of disclosures fixed, the firm invests less when its investments are unobservable. In fact, we show that if the firm's investments are sufficiently elastic with respect to the cost of capital, then the risk premium effect described above dominates the expected value effect, and the firm's investment levels in the setting with unobservable investments exceed those in the setting with observable investments. This finding stands in contrast to a standard result in the real effects literature that

[1] See, for instance, Fishman and Hagerty (1989) and Kanodia and Mukherji (1996). Kanodia and Sapra (2016) provide a survey of the related literature.

the firm invests less when its investment choice is unobservable than when it is observable. The reason is that this prediction of a negative effect of unobservability on investment level is obtained in risk-neutral settings in which the risk premium effect is absent.

We next turn to characterizing how the quality of public information affects welfare of investors holding the firm's equity over a particular period of time. To address this question, we need to account for several effects: the quality of public information affects the purchase price of the stock, the resale price of the stock, the uncertainty about the forthcoming dividend payment, and the firm's past and future investment levels, i.e., the firm size. The overall effect of these forces will be summarized by the risk premium charged by investors for holding the stock over a given period of time and will determine their expected welfare over that period. Consistent with the earlier literature (e.g., Dye 1990 and Kurlat and Veldkamp 2015), we note that potential future shareholders prefer to have access to *riskier* investments, i.e., the welfare of the investors increases in the expected risk premium during their period of ownership.[2]

In a model with exogenous cash flows and observable investments, Dutta and Nezlobin (2017b) show that the expected welfare of future shareholders increases in the quality of public disclosures if the firm's growth rate is above a certain threshold and decreases otherwise. The key to this result is that higher quality public disclosures reduce the firm's dividend risk but simultaneously increase the resale price risk in every period. For fast-growing firms, resale price risk is relatively more important than dividend risk, and therefore the periodic risk premium for such firms increases in the quality of public information. In our model, there is an additional effect of public information on the firm's risk premium: the firm invests more when public disclosures are more precise, which translates into a higher price *and* dividend risk in every period.

We show that the threshold growth rate of the firm above which future investors' welfare monotonically increases in the quality of public information is lower when one takes into account the effect of public information on the firm's internal investment. For firms growing just below the threshold rate, the expected welfare of their future shareholders in increasing in the quality of public information when that quality is sufficiently low and decreasing afterwards. Lastly, for very slow-growing (or declining) firms, the periodic risk premia and the welfare of future investors monotonically decline in the quality of public information. Overall, in our production economy, the welfare of potential future shareholders is increasing in the quality of public information for a wider set of parameters than in a comparable pure exchange setting. The relation between the welfare of future shareholders and disclosure quality turns out to be qualitatively similar in the observable and unobservable investment models.

Holding the quality of disclosure fixed, are future shareholders better off in the regime with observable or unobservable investments? In models where all investors are assumed to be risk-neutral, future shareholders are indifferent between the two regimes (e.g., Dutta and Nezlobin 2017a). To answer this question in the context of our model, recall that i) the welfare of future

[2]As a special case of this observation, note that if investors only had access to the risk-free asset their expected utility would be less than if they also had access to a risky security.

shareholders increases in the risk premium during their period of ownership, and ii) investment unobservability has a positive effect on investment levels (and thus risk premia) only if the firm's investment is sufficiently elastic with respect to the cost of capital. It follows that when the firm's investment is sufficiently elastic with respect to the cost of capital, future shareholders prefer the regime with unobservable investments.

We next study the relation between the quality of public information disclosures and the welfare of the firm's *current* shareholders. Financial reporting preferences of current shareholders are generally different from those of the potential future shareholders since the purchase price of the stock is a sunk cost for the former group yet a relevant cost for the latter group. We identify two effects of the quality of public information on the welfare of the current owners. First, holding the firm's future investment levels fixed, current shareholders prefer more informative disclosure regimes, since such regimes minimize the total risk premium associated with the firm's future projects, and thus maximize the expected resale price of the stock for the current owners. Second, we show that when future generations of shareholders take control of the firm, they will make the firm invest at higher levels than what would be preferred by the current owners, i.e., the actual future investment levels will be higher than those that maximize the resale price of the stock for the current generation. As a consequence, the current owners can be better off under a less informative disclosure regime, since it leads to less overinvestment by future generations.

In the setting with observable investment, we show that the current owners will indeed prefer an imperfect disclosure regime if the firm's investment is sufficiently sensitive to the cost of capital and the firm's future investment opportunities are large relative to its assets in place. In contrast, in the setting with unobservable investment, the current owners will prefer an intermediate disclosure regime if the firm's investment is relatively *inelastic* with respect to the cost of capital. In this latter case, the expected value effect of unobservability (which lowers the current owners' investment incentives) dominates the risk premium effect (which induces higher investment levels), and thus helps mitigate the problem of overinvestment by future shareholders.

Comparing our results to those in Dutta and Nezlobin (2017b), we find that when one endogenizes the firm's internal investment decisions, the preferences of the firm's current shareholders for public information get weaker while the preferences of future shareholders get stronger relative to a model with exogenous cash flows. These results might explain why the current shareholders do not always lobby for the most informative public disclosure regime, and, in fact, often oppose increasing the transparency of mandatory financial disclosures. Our model allows us to make predictions about which shareholders are more likely to prefer imperfect disclosure regimes – those are the current shareholders of firms whose investment is more (less) sensitive to the cost of capital if investment is observable (unobservable) and whose future investment opportunities outweigh their assets in place. In contrast, the welfare of the potential future shareholders decreases in disclosure quality only if the firm's growth rate during their period of ownership is sufficiently low. Since one of the stated objectives of the Financial Accounting Standards Board is to provide information "useful to existing and potential investors, lenders, and creditors," it is important to shed additional light on the difference in disclosure preferences between the current and potential future shareholders of the firm.

From the regulatory perspective, the need for increasing the informativeness of mandated public disclosures is often justified by their effect on the economy-wide cost of capital.[3] Our paper shows that in analyzing the effects of public information in a dynamic setting, it is important to distinguish between two different concepts of the cost of capital: the cost of financing new long-term projects and the equity risk premium that investors demand for holding the firm's stock for a period of time.[4] The periodic equity risk premium reflects part of the risk associated with assets in place at the purchase date as well as part of the risk associated with the new projects undertaken since then. This measure determines investor welfare over the given period, which, according to our results, is not necessarily monotonic in the precision of public disclosures. In contrast, the cost of financing new projects is indeed monotonically decreasing in the precision of public information. Though this cost is not directly observable in the stock returns, it is reflected in the investment levels undertaken by the firm.

The modeling framework used in our paper is most closely related to the asset pricing literature based on infinite horizon overlapping generations models with the CARA-Normal structure (e.g., Dutta and Nezlobin 2017b, Spiegel 1998, Suijs 2008, and Watanabe 2008). Christensen et al. (2010), Easley and O'Hara (2004), and Hughes et al. (2007) also investigate the link between disclosure quality and the cost of capital. These studies show that higher quality disclosures reduce the *ex post* cost of capital. Unlike our production setting, however, these studies consider pure exchange economies with exogenously specified distributions of future cash flows. Lambert et al. (2007) and Gao (2010) investigate production economies in static settings with observable investments. However, these papers assume that public disclosure improves information available not only to the market but also to the decision-makers inside the firm. In contrast, our analysis focuses on a setting in which public disclosures do not alter the amount of information available to the firm when it makes its investment choices. Consequently, our analysis isolates the effect of information available to the stock market from the effect of the information available to the firm on its investment choices.

The unobservable investment part of our analysis is closely related to the real effects literature in accounting (see, e.g., Kanodia 1980, Kanodia and Mukherji 1996, Kanodia and Sapra 2016, and Stein 1989). Similar to our paper, this literature investigates the equilibrium relationship between firms' disclosure environments and their internal investment choices when these choices are not directly observed by the market. Unlike our paper, however, much of the work in the real effects literature is based on the assumption of risk-neutral investors. Hence, these real effects studies do not investigate the links among disclosure quality, equilibrium risk premium, and investor welfare.

[3]For instance, Statement of Financial Accounting Concepts #8 (FASB 2010) states: "Reporting financial information that is relevant and faithfully represents what it purports to represent helps users to make decisions with more confidence. This results in more efficient functioning of capital markets and a lower cost of capital for the economy as a whole."

[4]Our analysis focuses on the risk premium as measured in absolute dollar terms. Though one could scale this measure by the beginning-of-the-period price to convert it into the familiar rate of return form, we focus on the unscaled risk premium measure because it is directly related to shareholder welfare in our CARA-Normal framework.

In fact, an immediate consequence of risk neutrality is that the potential future investors break even in equilibrium, and hence are indifferent to alternative disclosure policies. In contrast, our analysis demonstrates that risk-averse investors' welfare crucially depends on disclosure quality, since public disclosure standards affect firms' future investment choices, which, in turn, affect investors' access to risk bearing opportunities.

The rest of the paper is organized as follows. Section 2 describes the model setup. Section 3 characterizes the equilibrium relationship between information disclosure, real investments, and shareholder welfare in the setting with observable investments. Section 4 presents the results with unobservable investments. Section 5 concludes the paper.

## 2 Model Setup

Much of the earlier work on information disclosure, stock returns, and investor welfare has focused on pure exchange settings with exogenously specified cash flows (see, e.g., Christensen et al., 2010; Dutta and Nezlobin, 2017b; Easley and O'Hara, 2004; Hughes et al., 2007; Lambert et. al., 2007; Suijs 2008). In contrast, we study a production setting in which the firm's investment levels are endogenously determined.

Specifically, consider an infinitely lived firm that undertakes a sequence of overlapping investment projects. Each project has a useful life of two periods, and the scale of each project is chosen irreversibly at its inception. Let $k_{t-2}$ denote the scale of the project started at date $t-2$, and let $v(k_{t-2})$ be the associated cost of investment. We assume that the cost of investment function, $v(\cdot)$, is increasing and convex in the project's scale.

The project started at date $t-2$ generates a payoff of $c_t$ dollars at date $t$:

$$c_t \equiv x_t k_{t-2}, \tag{1}$$

where the random variable $x_t$ models uncertain investment productivity in period $t$. The productivity parameters, $\{x_t\}$, are drawn from independent normal distributions with means $\{m_t\}$ and variance $\sigma^2$. We initially assume that the firm's investment choices and realized cash flows are directly observed by all shareholders; the assumption of observable investments is relaxed in Section 4.

The firm's stock is traded in a perfectly competitive market by overlapping generations of identical short-horizon shareholders with symmetric information. Specifically, the shareholders of generation $t$ buy all the firm's shares from the previous generation at date $t-1$ and sell all the shares to the next generation at date $t$. In addition to the firm's shares, investors can trade a risk-free asset that yields a rate of return of $r > 0$. Consistent with much of the earlier work in this literature (e.g., Easley and O'Hara 2004 and Suijs 2008), we assume that the risk-free asset is in unlimited supply. It will be convenient to let $\gamma \equiv \frac{1}{1+r}$ denote the corresponding risk-free discount factor.

Since all shareholders of a given generation are identical and have the same information, we can, without loss of generality, model each generation as a single representative investor. The representative investor of generation $t$ chooses his portfolio at date $t-1$ so as to maximize the expected utility of consumption at date $t$. Let $\omega_t$ denote the investor's terminal wealth (and also consumption) at date $t$. We assume that the preferences of the representative investor of generation $t$ are summarized by the following utility function:

$$U(\omega_t) = -exp(-\rho\omega_t), \tag{2}$$

where $\rho$ is the coefficient of constant absolute risk aversion (CARA). It is well known that under CARA preferences, there is no loss of generality in normalizing the initial wealth of the generation-$t$ investor to zero.

We now turn to describing the firm's mandated public disclosures. Prior to trading at date $t$, the firm must publish a financial report, $S_t$, that provides information about the next period's operating cash flow, $c_{t+1}$. Recall that the cash flow $c_{t+1}$ will be generated by the project commenced at date $t-1$. Accordingly, we will sometimes refer to this project as the firm's assets-in-place at date $t$. The report $S_t$ takes the following form:

$$S_t = k_{t-1}s_t,$$

where $s_t$ is a noisy measure of asset productivity in period $t+1$. Specifically,

$$s_t = x_{t+1} + \varepsilon_t, \tag{3}$$

where the error terms $\{\varepsilon_t\}$ are drawn from serially independent normal distributions with mean zero and variance $\sigma_\varepsilon^2$. We additionally assume that $\{\varepsilon_t\}$ are independent of $\{x_t\}$; i.e., the measurement error terms in the firm's financial reports are independent of past, current, or future productivity parameters.

To measure the quality of the financial reporting system, we employ the following signal-to-noise ratio:

$$h \equiv \frac{\sigma^2}{\sigma^2 + \sigma_\varepsilon^2}.$$

A higher quality financial reporting system corresponds to a higher value of $h$. In particular, when $h$ is zero, $\sigma_\varepsilon^2 = \infty$, and public financial reports provide no useful information about one-period-ahead cash flows. In contrast, when $h = 1$, each report $S_t$ perfectly reveals the forthcoming values of the productivity parameter, $x_{t+1}$, and operating cash flow, $c_{t+1}$.

For future reference, it is useful to note that conditional on the public signal $s_t$, the one-period ahead asset productivity parameter, $x_{t+1}$, will be distributed normally with mean $hs_t + (1-h)m_{t+1}$ and variance $(1-h)\sigma^2$. As one would expect, the firm's shareholders will put more weight on the realized value of $s_t$ in updating their expectation of $x_{t+1}$ if the public reporting system is more precise. Also as expected, the conditional variance of the productivity parameter decreases in $h$. From the perspective of date $t-1$, the date-$t$ conditional expectation of $x_{t+1}$, $E_t(x_{t+1})$, is also a normally distributed random variable with mean $m_{t+1}$ and variance $h\sigma^2$. The variance of the conditional expectation of $x_{t+1}$ is increasing in the precision of the public signals.

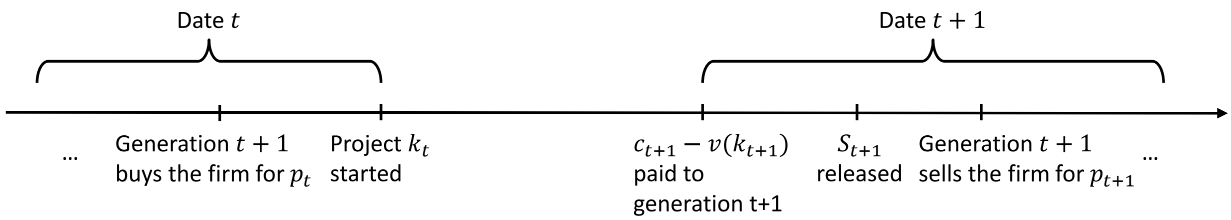


**Figure 1:** Sequence of events in period $t+1$

The timeline of events during the ownership of generation-$t+1$ shareholders is depicted in Figure 1 above. After the firm's financial report, $S_t$, is released, the market for the firm's shares opens and generation-$t+1$ shareholders acquire the firm. Then, the firm's new investment project, $k_t$, is commenced. We assume that at each point in time, the firm chooses the scale of its new project in the best interest of its *current* shareholders. Thus, $k_t$ is chosen so as to maximize the expected utility of the representative investor of generation $t+1$.

In our setting with symmetric information, it is without loss of generality to assume that the firm retains only as much cash as necessary to fund the next investment project. Therefore, at the end of each period $t$, the firm retains enough cash, $v(k_t)$, to finance the investment level $k_t$ that would be chosen by the next generation of shareholders. Thus, the net dividend distributed to generation $t+1$ shareholders at date $t+1$ is equal to $c_{t+1} - v(k_{t+1})$. We note that our results would remain unchanged under an alternative financing structure in which the firm does not retain any cash (i.e., the current shareholders receive the entire amount of current cash , $c_t$, as dividends) and funds for the new investment project are instead directly provided by the next generations of shareholders.

After paying dividends to its current shareholders, the firm releases a new financial report $S_{t+1}$, based on which the resale price of the stock, $p_{t+1}$, will be formed in a perfectly competitive market. Note that the public signal released at date $t$, $S_t$, does not provide any information about the payoff of the next project to be undertaken by the firm ($k_t$), which will be ultimately determined by $x_{t+3}$. Furthermore, the scale of the project to which this signal relates ($k_{t-1}$) cannot be changed at date $t$. A useful feature of this setup is that the quality of the financial reporting system, $h$, is not directly linked to the inherent riskiness of the firm's operations. In other words, the uncertainty that the firm faces in making its investment decisions is the same regardless of the quality of the public reporting system. Therefore, the effect of information quality on the firm's investment that we identify in this paper can indeed be attributed to the quality of information *disclosed* to the stock market at each trading date rather than the quality of information *available* to the firm at each decision-making time.

# 3 Observable Investments

Our primary objective is to examine how public information affects the firm's internal investment decisions and investor welfare. We will show that the firm's growth trajectory plays a critical role in defining the nature of both these relations. Before considering the firm's choice of optimal investments, we derive an expression for the equilibrium market price and risk premium for an exogenously given set of investment choices $(k_1, k_2, \dots)$. The following result is due to Dutta and Nezlobin (2017b):

**Lemma 1.** *For any given sequence of investments $(k_1, k_2, \dots)$, the equilibrium market price at date $t$ is given by*

$$p_t = \sum_{\tau=1}^{\infty} \gamma^{\tau} \left[ E_t(c_{t+\tau}) - v(k_{t+\tau}) - RP_{t+\tau} \right], \tag{4}$$

*where*

$$RP_{t+\tau} = \rho\sigma^2 \left[ (1-h)k_{t+\tau-2}^2 + \gamma^2 h k_{t+\tau-1}^2 \right] \tag{5}$$

*is the risk premium in period $t+\tau$.*

**Proof.** All proofs are in the Appendix.

Equation (4) shows that the equilibrium market price at each date can be expressed as the sum of expected future cash flows net of periodic risk premia discounted at the risk-free interest rate $r$. Notice that in the special case of a steady state firm (i.e., $k_t = k$ and $m_t = m$) and no information disclosure (i.e., $h = 0$), the expression for the price simplifies to $\frac{1}{r}[mk - v(k) - \rho k^2 \sigma^2]$, which is consistent with the findings of DeLong et al. (1990).

To understand the expression for the equilibrium risk premium in equation (5), consider the portfolio choice problem of generation $t+1$ investors. These investors' gross payoffs from buying the firm consists of the dividends that they receive during their period of ownership, $c_{t+1} - v(k_{t+1})$, and the resale price at which they sell their shares to the next generation, $p_{t+1}$. In our CARA-normal framework, the expected excess return (i.e., the equilibrium risk premium) is given by[5]

$$RP_{t+1} = \rho Var_t(c_{t+1} - v(k_{t+1}) + p_{t+1}).$$

Note that $v(k_{t+1})$ is deterministic. Furthermore, since project cash flows are serially uncorrelated, equation (4) implies that price $p_{t+1}$ and cash flow $c_{t+1}$ are independently distributed. Then, the equilibrium risk premium in period $t+1$ can be expressed as the sum of two components: one reflecting the dividend risk borne by investors, as measured by $Var_t(c_{t+1})$, and another reflecting the resale price risk, measured by $Var_t(p_{t+1})$. Specifically,

$$RP_{t+1} = \rho Var_t(c_{t+1}) + \rho Var_t(p_{t+1}). \tag{6}$$

[5]In our single risky asset setting, any risk is systematic and priced fully by the stock market. Our results can be extended to multi-firm economies in a fashion similar to Hughes et al. (2007) and Dutta and Nezlobin (2017b).

Equation (4) implies that $Var_t(p_{t+1}) = \gamma^2 Var_t\left(E_{t+1}(c_{t+2})\right) = \gamma^2 h\sigma^2 k_t^2$. On the other hand, dividend risk $Var_t(c_{t+1})$ is equal to $\sigma^2(1-h)k_{t-1}^2$. We note that while the dividend risk declines in the quality of public information $h$, the price risk increases in the precision of public disclosures because more precise disclosures make the resale price more volatile. As Dutta and Nezlobin (2017b) shows, the relation between the overall risk premium $RP_{t+1}$ and the precision of public information depends on the firm's growth rate as measured by $\mu \equiv \frac{k_t}{k_{t-1}} - 1$. Specifically, the risk premium decreases (increases) in the precision of public information if the growth rate $\mu$ is less (more) than $r$.

We now proceed to characterize the firm's endogenous investment choices. Suppose the firm has retained $v(k_t^*)$ cash for the investment at date $t$. The firm chooses its investment level at date $t$ so as to maximize the expected utility of its current (generation $t+1$) shareholders. Given the CARA-Normal framework, the firm would choose investment level $k_t$ so as to maximize the certainty equivalent of its current shareholders' date $t+1$ consumption

$$p_{t+1} - (1+r)v(k_t) + \Gamma,$$

where $\Gamma \equiv c_{t+1} + (1+r)(v(k_t^*) - p_t)$ does not depend on the firm's actual choice of $k_t$. The proof of Proposition 1 shows that after dropping the terms unrelated to $k_t$, the firm's optimization problem can be expressed as follows:[6]

$$\max_{k_t} \; V(k_t, h) \equiv \gamma m_{t+2} k_t - (1+r)v(k_t) - \gamma\rho(1-h)\sigma^2 k_t^2 - \frac{\gamma^2}{2}\rho h \sigma^2 k_t^2. \tag{7}$$

The first term of objective function $V(k_t, h)$ reflects the present value of expected gross payoffs from the current investment. The second term in (7) captures the direct cost of investment $v(k_t)$. The third term in (7) reflects that a higher level of investment in the current period makes future cash flows riskier, which lowers the *expected* value of the selling price at date $t+1$. Lastly, a higher level of investment also makes $p_{t+1}$ more volatile lowering the current owners' certainty equivalent by the amount of $\frac{\rho}{2} Var_t(p_{t+1})$. This risk cost is captured by the last term of (7). We obtain the following result:

**Proposition 1.** *The optimal investment level $k_t^*$ increases in the precision of public disclosure and is given by the following first-order condition:*

$$\gamma m_{t+2} = (1+r)v'(k_t^*) + \gamma\rho\sigma^2 k_t^* \left[2(1-h) + \gamma h\right] \tag{8}$$

Proposition 1 shows that the optimal investment level $k_t^*$ increases in disclosure quality (i.e., $\frac{\partial k_t^*}{\partial h} > 0$). Intuitively, a more precise public disclosure lowers the risk-related marginal cost of investments as represented by the last two terms of the objective function in (7). Consistent with

[6]To ensure a finite market price for the firm, we assume that $\sum_{\tau=1}^{\infty} \gamma^\tau m_{t+\tau+2}^2 < \infty$ for each $t$. This condition will be satisfied, for example, when the asymptotic growth rate of the investment productivity parameters $\{m_t\}$ does not exceed $\sqrt{1+r}$.

the standard intuition, it can be checked that the optimal investment level is more sensitive to the precision of public disclosure when $v''(\cdot)$ is small, or the expected marginal benefit $m_{t+2}$ is large.

For the remaining analysis, we assume that the cost of investment is quadratic; i.e..,

$$v(k_t) = bk_t^2$$

for all $t$. This assumption allows us to derive a closed form expression for the optimal investment level $k_t^*$. Specifically, the first-order condition in (8) yields

$$k_t^* = \frac{\gamma^2 m_{t+2}}{2b + \rho\gamma^2\sigma^2[2(1-h) + \gamma h]} \tag{9}$$

Note that when the parameter $b$ is low, the firm's investment is sensitive to the risk-related component of the marginal investment cost, that is, $k_t^*$ is sensitive to $\rho\sigma^2$. Accordingly, we will say that the firm's investments are sensitive to (elastic with respect to) the cost of capital when the value of $b$ is low relative to $\rho\sigma^2$ and inelastic with respect to the cost of capital when the value of $b$ is large.

We now seek to characterize the impact of public information on investors' welfare and risk premium. Proposition 2 below characterizes how the quality of public information affects the welfare of the firm's *future* prospective shareholders and the periodic risk premium they will demand for holding the stock. We investigate the effect of a change in disclosure quality on the firm's *current* shareholders in Proposition 3. The distinction between existing and future shareholders is important for welfare analysis since the purchase price of the stock a sunk cost for the current shareholders. Hence, they are primarily concerned with how the quality of public information affects the resale price of the stock. In contrast, any change to the disclosure regime affects the welfare of future shareholders through its effect on both the purchase and resale stock prices.

**Proposition 2.** *The risk premium in period $t+\tau$ and the welfare of future investors of generation $t+\tau$ increases in the informativeness of public disclosure if*

$$\frac{m_{t+\tau+1}^2}{m_{t+\tau}^2} \geq (1+r)^2 - l(h), \tag{10}$$

*where $l(h)$ is decreasing and positive for all $h$. The risk premium in period $t+\tau$ and the welfare of generation $t+\tau$ investors decreases in the informativeness of public disclosure if the opposite inequality holds.*

The proof of Proposition 2 shows that the expected utility of *future* potential investors is positively related to the risk premium in the period during which they plan to hold the firm. Specifically, we find that $CE_{t+\tau} = \frac{1}{2}RP_{t+\tau}$. The intuition for this result is that while higher risk premium means greater risk exposure, it also implies a lower asset price and hence higher expected return. We find that the expected return effect always dominates in our CARA-Normal setting.

Since the optimal investment level $k_{t+\tau-1}^*$ is proportional to the productivity parameter $m_{t+\tau}$, the inequality in the above result can be equivalently expressed in terms of the *endogenous* growth rate $\mu_{t+\tau}$, where $\mu_{t+\tau}$ is defined by $k^*_{t+\tau} = (1+\mu_{t+\tau})k^*_{t+\tau-1}$. Analogous to the finding in the exogenous investment setting of Dutta and Nezlobin (2017b), this result shows that the equilibrium relationship between risk premium and quality of public disclosure depends on the firm's growth trajectory. For instance, it shows that the risk premium in period $t+1$ increases in the informativeness of public information if the endogenous growth rate $\mu_t$ exceeds a certain threshold. However, since $l > 0$, the threshold growth rate is lower than $r$, the threshold for the exogenous investment setting. More generally, since $l(h)$ is a decreasing function, Proposition 2 implies that the risk premium (and hence investor welfare) (i) monotonically increases in the quality of public information for relatively fast growing firms, (ii) first increases and then decreases in disclosure quality for medium growth firms, and (iii) monotonically decreases in the quality of public information for relatively slow or negative growth firms.

Note that the risk premium in period $t+1$ is given by:

$$RP_{t+1} = \rho\sigma^2 \left[(1-h)(k^*_{t-1})^2 + \gamma^2 h (k^*_t)^2\right],$$

where the optimal investment levels $k^*_{t-1}$ and $k^*_t$ are as defined in (9). The above expression shows that the risk premium varies with the precision of public disclosure for two reasons. First, holding the investment levels *fixed*, Dutta and Nezlobin (2017b) show that the risk premium would decrease (increase) in the informativeness of public disclosure when the investment growth rate is lower (higher) than $r$. With endogenous investments, however, a more precise public disclosure also results in higher optimal investment levels $k^*_{t-1}$ and $k^*_t$, which leads to higher risk premium. It is because of this real effect of public disclosure that the threshold growth rate is lower in the endogenous investment setting.

Comparing our results in Propositions 1 and 2 reveals that two different notions of the cost of capital arise in our model. First, one can calculate the total risk premium associated with a given long-term project, i.e., the cost of raising equity capital for that particular project. Since in our model each project lasts for two periods, this risk premium will consist of two components charged by two different generations of investors. Our result in Proposition 1 shows that this "per project" cost of capital monotonically decreases in the quality of public information, and, as a consequence, the firm invests more when public disclosures are more precise. This result is largely consistent with the conventional wisdom that better disclosure regimes lead to a lower cost of capital.

In contrast, Proposition 2 speaks about a different notion of the cost of capital – the risk premium that investors of a given generation demand for holding the firm's stock for one period of time. This periodic risk premium originates, in our model, from two projects: the firm's assets-in-place at the beginning of the period and the new project that was started during the period. Our result in Proposition 2 shows that the periodic risk premium can be increasing or decreasing in the quality of public information depending on the firm's growth trajectory. It is important to note that it is this "periodic" cost of capital that determines the welfare of investors holding the stock over a given period and gets directly reflected in the firm's stock returns. In contrast, the "per project" cost of capital partially affects the firm's stock returns in two different periods of time and, similarly, enters the utility function of two different generations of shareholders.

It might appear from our result in Proposition 1 that the total risk premium charged by all future shareholders for holding all of the future projects is decreasing in the quality of public information. Indeed, holding the firm's future investment levels fixed, the risk premium per each project decreases in $h$, and therefore the discounted sum of future risk premia should also be decreasing in $h$. Then, Lemma 1 suggests that the current shareholders of the firm will prefer the full disclosure regime since it maximizes their resale price of the stock. While this intuition would indeed hold in a model with exogenous investments, it does not apply in our setting. Recall that according to Proposition 1 the firm's investment increases in $h$, and this increase in investment leads to increased risk premia for future projects. It turns out that under certain circumstances, this effect of increasing investment can dominate the effect of reduced "per-project" cost of capital.

Our next result characterizes the net effect of the quality of public information on the welfare of current owners. To investigate this effect, suppose a new disclosure policy (i.e., a new value of precision for all future disclosures) takes effect when the firm is owned by generation $t$ investors between dates $t-1$ and date $t$. We assume that the disclosure policy change takes place after period $t$ investment decision is made by the firm.[7]

**Proposition 3.** *the welfare of the existing shareholders is maximized at an intermediate level of public disclosure if future investments are sufficiently large relative to the firm's end of the period assets-in-place*[8] *and*

$$b < \frac{\rho\gamma^3\sigma^2}{2(1-\gamma)}. \tag{11}$$

This finding contrasts with the result in Dutta and Nezlobin (2017b) who show that the current shareholders' welfare unambiguously increases in the informativeness of public disclosure in pure exchange settings. In contrast, Proposition 4 shows that when investments are endogenously chosen, the current shareholders' welfare is maximized at an intermediate level of disclosure when $b$ is relatively small (i.e., when investments are sufficiently elastic to the cost of capital). This result implies that even if the shareholders could increase the precision of public disclosures *costlessly*, they might still prefer financial disclosure regimes that require less than full disclosure.

The proof of Proposition 3 shows that the current shareholders' expected utility can be represented by the following certainty equivalent expression:[9]

$$CE_t = V(k_{t-1}, h) + \sum_{\tau=1}^{\infty} \gamma^\tau \left[ V(k^*_{t+\tau-1}, h) - \frac{\gamma^2}{2}\rho {k^*_{t+\tau-1}}^2 h\sigma^2 \right],$$

where $V(k^*_t, h)$ denotes the maximized value of the objective function in (7). The above expression makes clear that the current shareholders' expected utility will vary with the amount of public

[7] Our results would remain unchanged if the disclosure policy change were to take place prior to the firm's choice of investment $k_{t-1}$.

[8] Specifically, this result obtains when $\{m_{t+\tau+1}\}$ are sufficiently large relative to $k_{t-1}$. See the proof of Proposition 3 for the precise condition.

[9] We omit the additive terms related to the certainty equivalents of $c_t$ and $p_{t-1}$, since they do not vary with the precision for future disclosures.

information directly through its effect on the total risk premium (for *fixed* investment levels), as well as indirectly through the effect of public disclosures on the firm's optimal investment choices. Differentiating the above expression for $CE_t$ with respect to $h$ and applying the Envelope Theorem gives

$$\frac{dCE_t}{dh} = \frac{\partial CE_t}{\partial h} - \rho\gamma^2 h\sigma^2 \cdot \sum_{\tau=1}^{\infty} \gamma^\tau k^*_{t+\tau-1} \frac{\partial k^*_{t+\tau-1}}{\partial h}. \tag{12}$$

The first term above, $\frac{\partial CE_t}{\partial h}$, reflects the direct effect (i.e., holding investments fixed) of information disclosure on welfare and is always positive. This corresponds to the result in Dutta and Nezlobin (2017b) that when investments are exogenously fixed, the current shareholders' welfare increases in the informativeness of public disclosures. The intuition for this effect is as follows. Recall that the purchase price of the stock is a sunk cost for the current shareholders, and, therefore, a change in the future disclosure policy affects their welfare only through the resale price. Thus, holding investment levels fixed, the expected utility of current shareholders is represented by the following certainty equivalent expression:

$$CE_t = E_{t-1}(p_t) - \frac{\rho}{2} Var_{t-1}(p_t) + const. \tag{13}$$

The expected value of the resale price increases in the quality of public information (i.e., $E_{t-1}(p_t)$ increases in $h$). Though a higher quality disclosure regime also makes the resale price more volatile (i.e., $Var_{t-1}(p_t)$ also increases in $h$), the expected price effect dominates. Hence, when investments are exogenously fixed, the current shareholders' welfare monotonically increases in the precision of public information (i.e., $\frac{\partial CE_t}{\partial h} > 0$).

The second term in the right hand side of equation (12) captures the indirect effect of public disclosures on the shareholders' welfare. Since the optimal investment increases in the quality of public information, this indirect effect is always detrimental to the original shareholders' welfare. Intuitively, this effect arises because future generations of shareholders overinvest relative to the preferred amounts of investments from the perspective of the current shareholders, and the amount of overinvestment increases in the precision of public disclosure. To see this, note from the expression for $CE_t$ that while future investors will choose $k_{t+\tau}$ to maximize $V(k_{t+\tau}, h)$, the current shareholders would prefer them to maximize $V(k_{t+\tau}, h) - \frac{\gamma^2}{2}\rho k^2_{t+\tau} h\sigma^2$.

To further illustrate the intuition for this overinvestment result, it is instructive to consider a three period lived firm that has access to an investment opportunity. For notational simplicity, we will ignore discounting. The current owners sell the firm to generation 1 investors at date 1. These new shareholders invest $v(k)$ in the investment project which yields random payoffs of $xk$ at date 3, where $x \sim N(m, \sigma^2)$. At date 2, the firm releases public information about the forthcoming cash flow and generation 1 investors sell the firm to the next generation who receives a terminal dividend of $xk$ at date 3. If the firm makes full disclosure at date 2, all the uncertainty is resolved and date 2 price will be simply equal to $xk$. Consequently, generation 1 will choose $k$ to maximize the following certainty equivalent expression:

$$CE_1 = mk - v(k) - \frac{\rho}{2}k^2\sigma^2.$$

On the other hand, the firm's current owners will prefer a $k$ that maximizes the price at date 1,

$$p_1 = mk - v(k) - \rho k^2\sigma^2.$$

A comparison of the two objective functions reveals that generation 1 will overinvest relative to the preferred amount of investment from the current owners' point of view. On the other hand, if the firm made no disclosure, then date 2 price will be $p_2 = mk - \rho k^2\sigma^2$. In this case, investment preferences of the two generations become perfectly congruent.

Since this indirect detrimental effect due to overinvestment vanishes for the limiting case of no disclosure (i.e., $h = 0$), the current shareholders' welfare is always increasing in the precision of public disclosure for small values of $h$. For large values of cost parameter $b$, the optimal investment levels are relatively insensitive to the precision of public disclosure and hence the direct beneficial effect dominates, and the welfare of the current shareholders increases in the informativeness of public disclosures. When the marginal product of the current investment is large relative to the total marginal productivity of future investments, the current shareholders' welfare is primarily determined by their expected utility from the payoffs related to the current project; i.e., $V(k_{t-1}, h)$, which monotonically increases in the quality of public information. In all other cases, the current shareholders' welfare is maximized at an intermediate level of disclosure.

For analytical tractability, we have assumed that cost function $v(\cdot)$ is quadratic, which allows us to derive closed form expressions for the optimal investment choices and the relevant thresholds in Propositions 2 and 3. Though closed form expressions for the optimal investments are not available under more general assumptions on the cost of investment, the qualitative nature of our results in Propositions 2 and 3 continue to hold. To see this, consider a general cost function $v(k_t)$ that is increasing and weakly convex. Since the optimal investment $k_t^*$ increases in the precision of public disclosures, the threshold growth rate in Proposition 2 will again exceed the threshold rate of $r$ in the exogenous investment setting. Equation (12) implies that there is again a tradeoff between a *direct* beneficial effect and an *indirect* adverse effect of increasing the precision of public disclosure on the current shareholders' welfare. When $v''(\cdot)$ is relatively large and the optimal investment level is largely insensitive to the precision of public disclosure, the current shareholders' welfare increases in the informativeness of public disclosure. On the other hand when $v''(\cdot)$ is relatively small, the welfare of the current shareholders will be maximized for some intermediate precision of public disclosure.

## 4 Unobservable Investments

We have thus far examined a model in which the firm's investment choices are directly observed by the market (i.e., the buying generation of investors). Such a model is descriptive of investments in hard assets that can be credibly measured and communicated to outside investors. In this section, we consider an alternative model in which the market does not directly observe the firm's internal investment choices. Such an assumption of unobservable investments would be more valid for certain "soft" investments that cannot be verifiably separated from the firm's regular operating expenditures.[10] We seek to investigate how unobservability of investments affects the equilibrium relationships among public disclosure, investments, and shareholder welfare.

To characterize the firm's optimal investment choice, suppose the market conjectures that the firm invests $\hat{k}_t$ in period $t$. Taking this conjecture as given, the firm chooses its period $t$ investment so as to maximize the expected utility of its current (generation $t+1$) shareholders. Let $k_t^u$ denote the firm's optimal choice of investment in period $t$. In equilibrium, the market's conjecture must be rational; that is, $\hat{k}_t = k_t^u$ for each $t$.

As before, the firm chooses investment level $k_t$ to maximize the certainty equivalent of the current shareholders' date $t+1$ consumption $p_{t+1} - (1+r)v(k_t) + \Gamma$, where $\Gamma$ is a term independent of $k_t$. We note from equation (4) that for any given sequence of conjectured investments $(\hat{k}_{t-1}, \hat{k}_t, \dots)$, the market price at date $t+1$ can be written as:

$$p_{t+1} = \gamma E_{t+1}(c_{t+2}) + \alpha,$$

where $\alpha$ is a term independent of the firm's actual investment choice in period $t$. The market's date $t+1$ expectation of the one-period-ahead cash flow is given by

$$E_{t+1}(c_{t+2}) = (1-h)m_{t+2}\hat{k}_t + hS_{t+1},$$

where $S_{t+1}$ is the information disclosed at date $t+1$ about the one-period-ahead cash flow. The above expression shows that the conditional expectation of $c_{t+2}$ is a weighted average of its unconditional expectation $m_{t+2}\hat{k}_t$, (which depends on the market's conjecture $\hat{k}_t$, but not on the firm's actual investment choice $k_t$) and signal $S_t$ (which does vary with $k_t$). By the law of iterated expectations, therefore, the firm's date $t$ expectation of $E_{t+1}(c_{t+2})$ is given by

$$E_t[E_{t+1}(c_{t+2})] = m_{t+2}[(1-h)\hat{k}_t + hk_t].$$

It thus follows that

$$E_t(p_{t+1}) = \gamma m_{t+2}[(1-h)\hat{k}_t + hk_t] + \alpha. \tag{14}$$

In contrast, we recall that when investments are observable, $E_t(p_{t+1}) = \gamma m_{t+2}k_t + \alpha$. Comparing this

[10] The analysis in this section also applies in the setting where the market observes a signal about the firm's investment as long as such signal is noisy. See, for instance, Kanodia and Sapra (2016) for a discussion of this point as well as a survey of the related literature.

to the expression in equation (14) reveals that when investments are unobservable, the expected resale price $E_t(p_{t+1})$ is less sensitive to the firm's actual investment choice $k_t$ for all values of $h < 1$. Consistent with the earlier results from the real effects literature, this "expected value" effect incentivizes the firm to underinvest (e.g., Fishman and Hagerty 1989; and Kanodia and Mukherji 1996).

The proof of Proposition 4 shows that after dropping the terms unrelated to $k_t$, the firm's optimization problem can be expressed as follows:

$$\max_{k_t} \ \gamma m_{t+2}[(1-h)\hat{k}_t + k_t] - (1+r)v(k_t) - \gamma(1-h)\rho\sigma^2\hat{k}_t^2 - \frac{\gamma^2}{2}\rho h\sigma^2 k_t^2. \tag{15}$$

A comparison with the objective function in (7) reveals that when investments are unobservable, the current shareholders do not fully internalize the investment project's risk-related costs because the buying investors' demand for risk premium (i.e., $\gamma(1-h)\rho\sigma^2\hat{k}_t^2$) depends on their conjectured investment choice $\hat{k}_t$ rather than the firm's actual investment choice $k_t$. This "risk premium" effect induces the firm to invest more than what it would if the investments were directly observable. The result below shows that depending on the relative strengths of these two countervailing effects (i.e., the expected value and risk premium effects) of unobservability, the optimal level of unobservable investments $k_t^u$ can be lower or higher than the optimal level of observable investments $k_t^*$.

We again assume that the cost of investment is quadratic; i.e., $v(k_t) = bk_t^2$ for each $t$. We have the following result:

**Proposition 4.** *i. The optimal levels of unobservable investments $k_t^u$ increase in the precision of public disclosure and are given by*

$$k_t^u = \frac{\gamma^2 m_{t+2} h}{2b + \gamma^3\rho\sigma^2 h}. \tag{16}$$

*ii. With perfect public disclosures, the optimal investment levels are the same under unobservable and observable settings. That is, $k_t^u = k_t^*$ when $h = 1$.*

*iii. For all $h < 1$, the optimal levels of unobservable investments $k_t^u$ are higher (lower) than the optimal levels of observable investments $k_t^*$ if the marginal cost parameter $b$ is less (more) than a threshold $\bar{b}$, where*

$$\bar{b} \equiv \gamma^2 h\rho\sigma^2\left(1 - \frac{\gamma}{2}\right). \tag{17}$$

Note that the threshold level $\bar{b}$ increases in the precision of public disclosure $h$ and the level of risk as parameterized by the product $\rho\sigma^2$. If the investors are risk-neutral (i.e., $\rho = 0$), $\bar{b} = 0$ and hence $k_t^u$ is lower than $k_t^*$ for all $h < 1$. With risk neutrality, there are no risk-related costs of investment. The optimal investment level thus simply equates the marginal increase in the expected resale price to the marginal cost of direct investment. With observable investments, a dollar of investment is fully reflected in the resale price; that is, it increases the expected resale price by $\gamma^2 m_{t+2}$. Hence, the firm invests the first-best amount (i.e., $\frac{\gamma^2 m_{t+2}}{2b}$) for all disclosure policies. When investments are unobservable, however, the resale price is less sensitive to the firm's actual investment choice. Because of this expected value effect, the optimal level of unobservable investment is lower than the optimal level of observable investment for all $h < 1$.

When the cost parameter $b$ is relatively large, the direct cost of investment outweighs the risk-related cost, and hence the expected value effect dominates the risk premium effect. In such cases, $k_t^u$ is lower than $k_t^*$ for the same reason as in the risk-neutral setting. On the other hand when $b$ is relatively small, the marginal cost of investment is primarily determined by the investment's risk related costs. In such cases, the risk premium effect of unobservability dominates the expected value effect. Thus, when $b$ is sufficiently small, the overinvestment incentives due to the risk premium effect outweigh the underinvestment incentives due to the expected value effect and $k_t^u > k_t^*$.

A standard finding in the real effects literature is that when investments are unobservable, the firm underinvests. In contrast, Proposition 4 shows that unobservability of investments can lead the firm to invest more than what it would if investments were observable. This difference arises because while we consider a model of risk averse investors, much of the real effects literature focuses on models of risk neutral investors. Consequently, the risk premium effect of unobservability of investments identified above, which pushes the firm to overinvest, is absent from the previous real effects studies.

We now investigate the impact of information disclosure on investors' welfare. With regard to the welfare of the firm's *future* prospective shareholders, it can be verified that their welfare varies with the informativeness of public disclosures in qualitatively the same fashion as in the observable investment setting. Specifically, it can be confirmed that the welfare of future investors of generation $t + \tau$ increases (decreases) in the precision of public information if the endogenous growth rate is higher (lower) than a certain threshold. The threshold growth rate is defined by the condition that $\frac{m_{t+\tau+1}^2}{m_{t+\tau}^2} = (1+r)^2 - l^u(h)$, where

$$l^u(h) = \frac{4b(1+r)^2}{h(6b + \rho\sigma^2\gamma^3 h)}.$$

Our next result characterizes the effect of a change in the quality of public information on the welfare of the firm's current shareholders. As before, we assume that a new disclosure policy (i.e., a new value of precision for all future disclosures) takes effect in period $t$ after the firm has made its current investment choice.

**Proposition 5.** *With unobservable investments, the welfare of the existing shareholders is maximized at an intermediate level of disclosure if future investments are sufficiently large relative to the firm's end of the period assets-in-place*[11] *and*

$$b > \frac{\rho\sigma^2\gamma^3(1-\gamma)}{2(2\gamma-1)}. \tag{18}$$

As before, the expected utility of the current shareholders can be represented by a certainty

[11] See the proof of Proposition 4 for the precise condition.

equivalent expression $CE_t$, which varies with the precision of future disclosures $h$ directly as well as indirectly through the effect of $h$ on future investment choices $k^u_{t+\tau}$. We show in the proof of Proposition 5 that

$$\frac{dCE_t}{dh} = \frac{\partial CE_t}{\partial h} + \sum_{\tau=1}^{\infty} \gamma^\tau \left[\gamma m_{t+2}(1-h) - 2\gamma(1-h)\rho\sigma^2 k^u_{t+\tau-1} - \gamma^2 h\rho\sigma^2 k^u_{t+\tau-1}\right] \frac{\partial k^u_{t+\tau-1}}{\partial h}. \quad (19)$$

The first term above, $\frac{\partial CE_t}{\partial h}$, represents the direct effect of $h$ on the current owners' welfare. As discussed earlier, this effect is always positive. The second term of (19) captures the indirect effect of information disclosure on shareholder welfare. For relatively precise public disclosures (i.e., $h$ close to 1), the term inside the square bracket inside the summation is negative. Since the optimal investment increases in $h$, this indirect effect is negative for large values of $h$. Again, this effect arises because for large values of $h$, future shareholders overinvest relative to the preferred amount of investments from the current shareholders' perspective. The amount of overinvestment increases in $h$. With unobservable investments, however, the optimal investments are more sensitive to $h$ for larger values of $b$. Thus, when $b$ is relatively large, this overinvestment effect dominates and the current shareholders' welfare decreases in $h$ for large values of $h$. Therefore, the current owners' welfare is maximized at an intermediate level of disclosure for relatively large values of $b$.

This contrasts with the result in Proposition 3 which shows that the current shareholders' welfare is maximized at an intermediate level of disclosure for relatively *small* values of $b$. In both observable and unobservable investment scenarios, the indirect detrimental effect of more precise public disclosures on the current owners' welfare arises because future investors overinvest and the amount of overinvestment increases in $h$. A necessary condition for this indirect detrimental effect to outweigh the direct beneficial effect of public disclosures is that the optimal investment choices are sufficiently sensitive to the precision of public disclosures. For observable investments, the optimal investment level is more sensitive to the precision of public disclosures for relatively small values of $b$. Specifically, it can be verified that while $\frac{\partial}{\partial b}\left(\frac{\partial k^u_t}{\partial h}\right) > 0$, $\frac{\partial}{\partial b}\left(\frac{\partial k^*_t}{\partial h}\right) < 0$. For observable (unobservable) investments, therefore, the indirect effect is more likely to dominate the direct effect for relatively small (large) values of $b$.

To conclude this section, we investigate whether the potential investors will prefer a reporting regime which credibly reveals the firm's investment choices (observable investments) or the one in which the firm's internal investment choices remain the firm's private information (unobservable investments). In models that study the real effects of accounting disclosure in a risk-neutral setting, the firm's future shareholders are indifferent between the observable and unobservable investment regimes because in both regimes the purchase price of the firm's stock is equal to the discounted sum of the expected dividends and the resale price of the stock, i.e., future shareholders exactly break even in expectation (e.g., Dutta and Nezlobin 2017a). In our setting with risk aversion, we have the following result:

**Proposition 6.** *If public disclosures are perfect (i.e., $h = 1$), future investors are indifferent between the observable and unobservable investment regimes. For all $h < 1$, future investors prefer a* *disclosure regime with unobservable (observable) investments if the cost parameter $b$ is less (greater) than $\bar{b}$, where $\bar{b}$ is as given by (17).*

The proof of Proposition 2 shows that the expected utility of the representative investor of future generation $\tau$ can be represented by the following certainty equivalent expression:

$$CE_{\tau+1} = \frac{1}{2} RP_{\tau+1},$$

where

$$RP_{\tau+1} = \rho\sigma^2 \left[k_{\tau-1}^2(1-h) + \gamma^2 k_\tau^2 h\right]$$

is the risk premium in period $\tau+1$. This implies that the expected utility of future potential investors is *positively* related to the risk premium in the period during which they plan to hold the firm. As noted earlier, higher risk premium means not only greater risk exposure, but also lower asset price and hence higher expected return. The expected return effect dominates, and hence the investors' welfare increases in the risk premium in our CARA-Normal framework. Since the risk premium increases in the level of investment, the investors prefer (i) the unobservable investment regime if $k_t^u > k_t^*$, which occurs when $b < \bar{b}$, and (ii) the observable investment regime if $k_t^* < k_t^u$, which occurs when $b > \bar{b}$. When public disclosures are perfectly informative (i.e., $h = 1$), the observable and unobservable investment regimes both induce identical investment choices (i.e. $k_t^u = k_t^*$) and hence the investors are indifferent between the two regimes.[12]

# 5 Conclusion

In this paper, we have studied the relation between the quality of public disclosures of a firm and the welfare of its current and future shareholders in a dynamic production setting. Higher quality disclosure leads to higher investment but does not always improve shareholder welfare. While Nezlobin and Dutta (2017b) show that the firm's current shareholders always prefer the maximum level of disclosure in a pure-exchange economy, we find that the current shareholders can prefer less than full disclosure in the production setting considered in this paper. In particular, we have shown that the shareholders of firms with significant growth opportunities and either i) observable investments that are elastic to the cost of capital, or ii) unobservable investments that are inelastic to the cost of capital, prefer imprecise disclosure regimes. For the firm's future shareholders, introducing production into the model has the opposite effect: future shareholders prefer more informative disclosure regimes for a wider range of parameters in our production economy than in a comparable pure exchange economy. We have further shown that the firm's future shareholders

[12]While we do not formally characterize the preferences of the firm's *existing* shareholders between the observable and unobservable investment regimes, several insights on this question are readily available from Propositions 3, 4, and 5. First, Proposition 4 implies that the firm's current shareholders prefer the observable investment regime when $h = 0$ and are indifferent between the two regimes for $h = 1$. It then follows from Propositions 3 and 5 that the *unobservable* investment regime will be preferred by the current shareholders at least for some intermediate values of $h$ when the parameter $b$ is sufficiently large.

prefer the regime with unobservable investments when the firm's investment is sufficiently elastic with respect to the cost of capital.

Our model demonstrates that it is important to distinguish between two different notions of the cost of capital—one reflecting the risk premium per period of time and another reflecting the risk premium per project. While the traditional intuition that disclosure reduces the cost of capital applies to the per project concept, the effect of disclosure quality on the periodic risk premia is generally ambiguous. It is, however, the periodic risk premia that directly determine the future expected stock returns and shareholder welfare.

We have focused on an economy with a single risky asset. As a consequence, all risk in our model is systematic and priced accordingly by the stock market. Some earlier studies (e.g., Hughes et al. 2007 and Dutta and Nezlobin 2017b) have shown that the effects of information disclosure identified in single-security settings are also present in large economies. Extending our results to a multi-security setting is an interesting direction for future research. Lastly, for tractability, our analysis has focused on a setting in which cash flows are independently distributed across projects. In future research, it will be interesting to investigate how our findings change when project payoffs are positively correlated.

# Appendix

**Proof of Lemma 1.**

Consider the asset choice problem of the representative investor of generation $t$. Suppose the investor conjectures that the firm's date $t$ price is as given by (4). With CARA preferences, it is without loss of generality to assume that the investor has no initial wealth and pays for the purchase cost of shares by borrowing at the risk-free rate of $r$. If the representative investor of generation $t$ buys $\delta$ fraction of the firm's shares outstanding at date $t-1$, her date $t$ wealth is given by

$$\omega_t = \delta \left[ c_t - v(k_t) + p_t - (1+r)p_{t-1} \right]. \tag{20}$$

Taking price $p_{t-1}$ as given, the investor chooses $\delta$ to maximize his expected utility of wealth $\omega_t$.

We next show that the investors' date $t$ wealth $\omega_t$ is normally distributed if the conjectured price $p_t$ is as given by (4). To prove this, we note that $E_t(x_{t+\tau}) = m_{t+\tau+1}$ for all $\tau > 1$ because signal $s_t$ is uninformative about $x_{t+\tau}$ for all $\tau > 1$. It thus follows that $E_t(x_{t+1}) = hs_t + (1-h)m_{t+1}$, where $h \equiv \frac{\sigma^2}{\sigma^2+\sigma_\varepsilon^2}$. Hence, the pricing function in (4) can be expressed as follows:

$$p_t = \beta_t + \gamma h k_{t-1} s_t, \tag{21}$$

where $\beta_t$ is a constant. Equation (21) implies that $p_t$ is normal from the perspective of date $t-1$, since signal $s_t$ is normally distributed. Since $c_t = x_t k_{t-2}$ is also normally distributed, it follows that the investor's terminal wealth $\omega_t$, as given by (20), is a normally distributed random variable.

Given CARA preferences, therefore, maximizing expected utility is equivalent to maximizing the following certainty equivalent expression:

$$CE_{t-1}(\delta) = \delta \left[ E_{t-1}\left(c_t + p_t\right) - v(k_t) - (1+r)p_{t-1} \right] - \frac{\rho}{2}\delta^2 Var_{t-1}\left(c_t + p_t\right).$$

The optimal $\delta$ is given by the following first-order condition:

$$E_{t-1}\left(c_t + p_t\right) - v(k_t) - (1+r)p_{t-1} - \rho\delta Var_{t-1}\left(c_t + p_t\right) = 0.$$

Imposing the market clearing condition (i.e., $\delta = 1$) and solving for $p_{t-1}$ yields

$$p_{t-1} = \gamma \left[ E_{t-1}\left(c_t + p_t\right) - v(k_t) - \rho Var_{t-1}\left(c_t + p_t\right) \right]. \tag{22}$$

By definition, the risk premium in period $t$ is given by

$$RP_t = E_{t-1}[c_t + p_t - v(k_t)] - (1+r)p_{t-1}.$$

Substituting for $p_{t-1}$ from equation (22) into the above equation reveals that the equilibrium risk premium in period $t$ is given by

$$RP_t = \rho Var_{t-1}(c_t + p_t).$$

We note that $Var_{t-1}(c_t) = k_{t-2}^2(1-h)\sigma^2$ and equation (21) implies $Var_t(p_t) = \gamma^2 k_{t-1}^2 h\sigma^2$. Since $p_t$, as conjectured in equation (4), is independent of $c_t$, it follows that

$$\begin{aligned} RP_t &= \rho\left[Var_{t-1}(c_t) + Var_{t-1}(p_t)\right] \\ &= \rho\sigma^2\left[(1-h)k_{t-2}^2 + \gamma^2 h k_{t-1}^2\right]. \end{aligned}$$

To finish the proof, we need to verify that the market clearing condition (22) indeed holds for each $t$ if the prices are given by equation (4). To prove this, we note that equation (4) implies

$$p_{t-1} = \sum_{\tau=1}^{\infty} \gamma^{\tau}\left[E_{t-1}(c_{t+\tau-1}) - v(k_{t+\tau-1}) - RP_{t+\tau-1}\right],$$

which can be written as

$$\begin{aligned} p_{t-1} &= \gamma\left[E_{t-1}(c_t) - v(k_t) - RP_t\right] + \gamma\sum_{\tau=1}^{\infty}\gamma^{\tau}\left[E_{t-1}(c_{t+\tau}) - v(k_{t+\tau}) - RP_{t+\tau}\right] \\ &= \gamma\left[E_{t-1}(c_t + p_t) - v(k_t) - RP_t\right]. \end{aligned}$$

Therefore the conjectured pricing function in (4) satisfies the market clearing condition in (22) at all dates.

□

**Proof of Proposition 1.**

Taking the price process (4) as given, the representative investor of generation $t+1$ chooses $k_t$ to maximize the expected utility of his date $t+1$ consumption, $c_{t+1} - v(k_{t+1}) + p_{t+1} - (1+r)[v(k_t) - v(k_t^*)] - (1+r)p_t$, where $k_t^*$ denotes the amount of period $t$ investment anticipated by the firm and $v(k_t^*)$ is the corresponding amount of cash retained in the firm. In equilibrium, the current shareholder's optimal choice of investment will coincide with the conjectured amount $k_t^*$. Generation $t+1$ shareholder's expected utility of his date $t+1$ consumption can be represented by the following certainty equivalent expression:

$$CE_{t+1} = E_t(p_{t+1}) - (1+r)v(k_t) - \frac{\rho}{2}Var_t(p_{t+1}) + \Gamma,$$

where $\Gamma \equiv E_t(c_{t+1}) - \frac{\rho}{2}Var_t(c_{t+1}) - (1+r)(p_t - v(k_t^*))$ does not depend on the investors' choice of $k_t$.

Applying equation (4), we get:

$$E_t(p_{t+1}) - \frac{\rho}{2}Var_t(p_{t+1}) = \gamma m_{t+2}k_t - \rho\gamma(1-h)\sigma^2 k_t^2 - \frac{\rho}{2}\gamma^2 h\sigma^2 k_t^2 + A_{t+1},$$

where $A_{t+1}$ does not depend on $k_t$. Therefore, generation $t+1$ investor's optimization problem can be written as:

$$\max_{k_t} V(k_t, h) \equiv \gamma m_{t+2} k_t - (1+r)v(k_t) - \rho\gamma(1-h)\sigma^2 k_t^2 - \frac{\rho}{2}\gamma^2 h \sigma^2 k_t^2.$$

Equation (8) follows from the first-order condition of the above maximization problem.

Implicitly differentiating equation (8) with respect to $h$ yields

$$\frac{dk_t^*}{dh} = \frac{(2-\gamma)\gamma\rho\sigma^2 k_t^*}{(1+r)v''(k_t^*) + \gamma\rho\sigma^2[2(1-h)+\gamma h]}.$$

Since $v''(\cdot) > 0$, it follows that $\frac{dk_t^*}{dh} > 0$.

□

**Proof of Proposition 2:** To prove the result, we will first show that generation $t+\tau$ shareholders' expected utility increases in the risk premium during the period in which they hold the firm; i.e., $RP_{t+\tau}$. The expected utility of the representative investor of generation $t+\tau$ investor is monotonically increasing in following certainty equivalent:

$$CE_{t+\tau} = E_{t+\tau-1}(c_{t+\tau} + p_{t+\tau}) - v(k_{t+\tau}) - (1+r)p_{t+\tau-1} - \frac{\rho}{2}Var_{t+\tau-1}(c_{t+\tau} + p_{t+\tau}).$$

Substituting for $p_t$ from equation (4) yields

$$CE_{t+\tau} = \frac{1}{2}\rho Var_{t+\tau-1}(c_{t+\tau} + p_{t+\tau}).$$

In the proof of Lemma 1, we have shown that $RP_{t+\tau} = \rho Var_{t+\tau-1}(c_{t+\tau} + p_{t+\tau})$, and therefore $CE_{t+\tau} = \frac{RP_{t+\tau}}{2}$. It thus follows that the expected utility of the representative investor of generation $t+\tau$ decreases (increases) in the precision of public disclosures if $RP_{t+\tau}$ decreases (increases) in $h$..

We now investigate how the risk premium varies with the quality of information. For given investment levels $k_{t+\tau-2}^*$ and $k_{t+\tau-1}^*$, the risk premium in period $t+\tau$ is given by $RP_{t+\tau} = \rho\sigma^2[(k_{t+\tau-2}^*)^2(1-h) + \gamma^2(k_{t+\tau-1}^*)^2 h]$. Substituting for the optimal investments from (9) yields

$$RP_{t+\tau} = \frac{\rho\gamma^4\sigma^2\left[(1-h)m_{t+\tau}^2 + \gamma^2 h m_{t+\tau+1}^2\right]}{\left[2\rho\gamma^2\sigma^2(1-h) + \rho\gamma^3\sigma^2 h + 2b\right]^2}.$$

Differentiating with respect to $h$ reveals that

$$sgn\left[\frac{\partial RP_{t+\tau}}{\partial h}\right] = sgn\left[\frac{m_{t+\tau+1}^2}{m_{t+\tau}^2} - \frac{2b - 2\left(1-\gamma\right)\rho\gamma^2\sigma^2 + \left(2-\gamma\right)\gamma^2\rho h\sigma^2}{\gamma^2\left(2b + 2\rho\gamma^2\sigma^2 + \left(2-\gamma\right)\rho\gamma^2 h\sigma^2\right)}\right]$$

Therefore, $\frac{\partial RP_{t+\tau}}{\partial h} \geq 0$ if and only if

$$\frac{m_{t+\tau+1}^2}{m_{t+\tau}^2} \geq \frac{2b - 2\left(1-\gamma\right)\rho\gamma^2\sigma^2 + \left(2-\gamma\right)\gamma^2\rho h\sigma^2}{\gamma^2\left(2b + 2\rho\gamma^2\sigma^2 + \left(2-\gamma\right)\rho\gamma^2 h\sigma^2\right)}.$$

The inequality above can be simplified as follows:

$$\frac{m_{t+\tau+1}^2}{m_{t+\tau}^2} \geq (1+r)^2 - l(h),$$

where

$$l(h) = \frac{(4-2\gamma)\,\rho\sigma^2}{2b + \gamma^2\rho\sigma^2\left[2+(2-\gamma)h\right]}.$$

We note that $l(h)$ is decreasing in $h$ and positive for all $h \in [0,1]$. $\square$

**Proof of Proposition 3:** We will first show that holding investment amounts exogenously fixed, the expected utility of the existing shareholders of generation $t$ increases in the precision of public disclosure. The expected utility of the current shareholders is monotonically increasing in the following certainty equivalent expression:

$$CE_t = E_{t-1}(p_t) - \frac{\rho}{2}Var_{t-1}(p_t) + \beta_t, \tag{23}$$

where $\beta_t \equiv E_{t-1}(c_t) - v\left(k_t\right) - (1+r)p_t - \frac{\rho}{2}Var_{t-1}(c_t)$ does not depend on the precision of future disclosures. By the law of iterated expectations, equation (4) yields

$$E_{t-1}(p_t) = \sum_{\tau=1}^{\infty}\gamma^{\tau}\left[m_{t+\tau}k_{t+\tau-2} - v(k_{t+\tau}) - RP_{t+\tau}\right].$$

Furthermore, observe that $Var_{t-1}(p_t) = \gamma^2 h\sigma^2 k_{t-1}^2$. Substituting these into (23) yields

$$CE_t = A_t - \frac{\rho}{2}\gamma^2 h\sigma^2 k_{t-1}^2 - \sum_{\tau=1}^{\infty}\gamma^{\tau}RP_{t+\tau},$$

where $A_t$ summarizes the terms independent of the precision of future disclosures.

Now note that

$$\begin{aligned}\sum_{\tau=1}^{\infty}\gamma^{\tau}RP_{t+\tau} &= \rho\sigma^2\sum_{\tau=1}^{\infty}\gamma^{\tau}\left((1-h)k_{t+\tau-2}^2 + \gamma^2 h k_{t+\tau-1}^2\right)\\ &= \rho\gamma k_{t-1}^2(1-h)\sigma^2 + \rho\sigma^2\sum_{\tau=1}^{\infty}\gamma^{\tau+1}((1-h)+\gamma h)k_{t+\tau-1}^2.\end{aligned}$$

Therefore,

$$CE_t = A_t - \rho\gamma\sigma^2\left[(1-h) + \frac{\gamma}{2}h\right]k_{t-1}^2 - \rho\sigma^2\sum_{\tau=1}^{\infty}\gamma^{\tau+1}((1-h)+\gamma h)k_{t+\tau-1}^2.$$

Differentiating with respect to $h$ gives

$$\frac{\partial CE_t}{\partial h} = \rho\gamma\sigma^2\left(1-\frac{\gamma}{2}\right)k_{t-1}^2 + \rho\sigma^2\gamma\left(1-\gamma\right)\sum_{\tau=1}^{\infty}\gamma^{\tau}k_{t+\tau-1}^2, \tag{24}$$

which is positive.

Substituting for the equilibrium price at date $t$ from equation (4) and rearranging terms, it can be verified that equation (23) yields

$$CE_t = B + V(k_{t-1}, h) + \sum_{\tau=1}^{\infty} \gamma^{\tau} \left[ V(k^*_{t+\tau-1}, h) - \frac{\gamma^2}{2} \rho (k^*_{t+\tau-1})^2 h \sigma^2 \right],$$

where $V(k^*_\tau, h) \equiv \gamma m_{\tau+2} k^*_\tau - (1+r) b (k^*_\tau)^2 - \gamma \rho (k^*_\tau)^2 (1-h) \sigma^2 - \frac{\gamma^2}{2} \rho (k^*_\tau)^2 h \sigma^2$ denotes the maximized value of the firm's period $\tau$ objective function, as defined in (7). To emphasize that date $t-1$ investment does not vary with the precision of future disclosures, we do not use any superscript on $k_{t-1}$. Differentiating with respect to $h$ and applying the Envelope Theorem yields

$$\frac{dCE_t}{dh} = \frac{\partial CE_t}{\partial h} - \rho \gamma^2 h \sigma^2 \cdot \sum_{\tau=1}^{\infty} \gamma^{\tau} k^*_{t+\tau-1} \frac{\partial k^*_{t+\tau-1}}{\partial h}.$$

We note that $\frac{dCE_t}{dh} > 0$ at $h = 0$ because (i) equation (24) shows that $\frac{\partial CE_t}{\partial h} > 0$ for all $h \in [0, 1]$, and (ii) the second term on the right hand side of the above expression is zero for $h = 0$. It thus follows from continuity that there exists a $h_L \in (0, 1]$ such that the existing shareholders' welfare increases in $h$ for all $h \in [0, h_L]$.

Substituting $\frac{\partial CE_t}{\partial h} = \rho \gamma \sigma^2 \left(1 - \frac{\gamma}{2}\right) k^2_{t-1} + \rho \sigma^2 \gamma (1 - \gamma) \sum_{\tau=1}^{\infty} \gamma^{\tau} k^2_{t+\tau-1}$ from equation (24), the optimal investments $k^*_{t+\tau}$ from (9), and simplifying reveal that

$$\left. \frac{dCE_t}{dh} \right|_{h=1} = \frac{\rho \gamma (2-\gamma)}{2} k^2_{t-1} - \frac{\rho \gamma^5 [\rho \gamma^3 \sigma^2 - 2(1-\gamma) b]}{[2b + \rho \gamma^3 \sigma^2]^3} \sum_{\tau=1}^{\infty} \gamma^{\tau} m^2_{t+\tau+1}.$$

The above equation implies that $\left. \frac{dCE_t}{dh} \right|_{h=1} < 0$ if

$$2(1-\gamma) b < \rho \gamma^3 \sigma^2 \tag{25}$$

and

$$\sum_{\tau=1}^{\infty} \gamma^{\tau} m^2_{t+\tau+1} > \frac{(2-\gamma)[2b + \rho \gamma^3 \sigma^2]^3}{2\gamma^4 [\rho \gamma^3 \sigma^2 - 2(1-\gamma) b]} \cdot k^2_{t-1}. \tag{26}$$

It then follows from continuity that if the inequalities in (25-26) hold, there exists a $h_H \in (h_L, 1)$ such that $CE_t$ decreases in $h$ for all $h \in [h_H, 1]$. This proves that when (25-26) hold, the existing shareholders' welfare is maximized at some $h \in [h_L, h_H]$.

□

**Proof of Proposition 4.**

The representative investor of generation $t+1$ chooses $k_t$ to maximize the expected utility of his date $t+1$ consumption, $c_{t+1} - v(k_{t+1}) + p_{t+1} - (1+r)[v(k_t) - v(\hat{k}_t)] - (1+r) p_t$, where $\hat{k}_t$ denotes the conjectured amount of period $t$ investment and $v(\hat{k}_t)$ is the corresponding amount of cash retained in the firm. In equilibrium, the current shareholder's optimal choice of investment $k^u_t$ will coincide with the conjectured amount $\hat{k}_t$; i.e., $\hat{k}_t = k_t^u$. As in the proof of Proposition 1, generation $t+1$ shareholder's expected utility of his date $t+1$ consumption can be represented by the following certainty equivalent expression:

$$CE_{t+1} = E_t(p_{t+1}) - (1+r)v(k_t) - \frac{\rho}{2}Var_t\left(p_{t+1}\right) + \Gamma,$$

where $\Gamma \equiv E_t(c_{t+1}) - \frac{\rho}{2}Var_t(c_{t+1}) - (1+r)(p_t - v(\hat{k}_t))$ does not depend on the firm's choice of $k_t$.

Applying equation (4), we get:

$$E_t\left(p_{t+1}\right) - \frac{\rho}{2}Var_t\left(p_{t+1}\right) = \gamma m_{t+2}[(1-h)\hat{k}_t + hk_t] - \rho\gamma(1-h)\sigma^2\hat{k}_t^2 - \frac{\rho}{2}\gamma^2 h\sigma^2 k_t^2 + A_{t+1},$$

where $A_{t+1}$ does not depend on $k_t$. Therefore, generation $t+1$ investor's optimization problem can be written as:

$$\max_{k_t} \gamma m_{t+2}[(1-h)\hat{k}_t + hk_t] - (1+r)bk_t^2 - \rho\gamma(1-h)\sigma^2\hat{k}_t^2 - \frac{\rho}{2}\gamma^2 h\sigma^2 k_t^2.$$

Equation (16) follows from the first-order condition of the above maximization problem.

Equations (9) and (16) reveal that when $h=1$,

$$k_t^u = k_t^* = \frac{\gamma^2 m_{t+2}}{2b + \gamma^3\rho\sigma^2}.$$

Differentiating equation (16) with respect to $h$ yields

$$\frac{dk_t^u}{dh} = \frac{2b\gamma^2 m_{t+2}}{(2b + \gamma^3\rho\sigma^2 h)^2}, \tag{27}$$

which is always positive.

□

**Proof of Proposition 5.**

After dropping the terms that do not depend on the precision of future disclosures, the expected utility of the current shareholders can be represented by the following certainty equivalent expression:

$$\begin{aligned} CE_t &= w(k_{t-1}, h) \\ &\quad + \sum_{\tau+1}^{\infty}\gamma^\tau\left[w(k_{t+\tau-1}^u, h) + \gamma m_{t+\tau+1}(1-h)k_{t+\tau-1}^u - \gamma\rho(1-h)\sigma^2(k_{t+\tau-1}^u)^2 - \frac{\gamma^2}{2}\rho h\sigma^2(k_{t+\tau-1}^u)^2\right], \end{aligned}$$

where $w(k_\tau^u, h) \equiv \gamma m_{\tau+2}hk_\tau^u - (1+r)v(k_\tau^u) - \frac{\rho}{2}\gamma^2 h\sigma^2(k_\tau^u)^2$. From the proof of Proposition 4, we note that $k_\tau^u$ is the maximizer of function $w(k_\tau, h)$. Differentiating the above expression with respect to

$h$ and applying the Envelope Theorem yields

$$\frac{dCE_t}{dh} = \frac{\partial CE_t}{\partial h} + \sum_{\tau=1}^{\infty} \gamma^{\tau} \left[ \gamma m_{t+\tau+1}(1-h) - 2\gamma(1-h)\rho\sigma^2 k^u_{t+\tau-1} - \gamma^2 h\rho\sigma^2 k^u_{t+\tau-1} \right] \frac{dk^u_{t+\tau-1}}{dh}, \quad (28)$$

where $\frac{\partial CE_t}{\partial h}$ is always positive and given by equation (24) in the proof of Proposition 3.

We note that $\frac{dCE_t}{dh} > 0$ at $h = 0$ because (i) $\frac{\partial CE_t}{\partial h} > 0$ for all $h \in [0, 1]$, and (ii) the second term on the right hand side of equation (28) simplifies to

$$\sum_{\tau=1}^{\infty} \gamma^{\tau+1} m_{t+\tau+1} \frac{dk^u_{t+\tau-1}}{dh} > 0$$

for $h = 0$. In deriving the above expression, we have used the fact that when $h = 0$, $k_{t+\tau-1} = 0$ for all $\tau \geq 1$. It thus follows from continuity that there exists a $h_L \in (0, 1]$ such that the existing shareholders' welfare increases in $h$ for all $h \in [0, h_L]$.

Using (16) for the optimal investment choice $k^u_\tau$, equation (27) can be expressed as follows for $h > 0$:

$$\frac{dk^u_\tau}{dh} = k^u_\tau \cdot \frac{2b}{h(2b + \rho\sigma^2\gamma^3 h)}.$$

Substituting this and the expression for $\frac{\partial CE_t}{\partial h}$ from equation (24) into equation (28) yields

$$\left.\frac{dCE_t}{dh}\right|_{h=1} = \gamma\rho\sigma^2 \left(1 - \frac{\gamma}{2}\right) k^2_{t-1} - \gamma\rho\sigma^2 \left[ \frac{2b\gamma}{2b + \rho\sigma^2\gamma^3} - (1-\gamma) \right] \sum_{\tau=1} \gamma^{\tau} (k^u_{t+\tau-1})^2. \quad (29)$$

Thus, a necessary condition for $\left.\frac{dCE_t}{dh}\right|_{h=1} < 0$ is that

$$\Delta \equiv \frac{2b\gamma}{2b + \rho\sigma^2\gamma^3} - (1-\gamma) > 0, \quad (30)$$

which is equivalent to the condition in (18). Substituting for $k^u_{t+\tau-1}$ from (16) into (29), it follows that if $\Delta > 0$ and

$$\left(1 - \frac{\gamma}{2}\right) k^2_{t-1} < \frac{\gamma^4 \Delta}{(2b + \gamma^3\rho\sigma^2)^2} \sum_{\tau=1}^{\infty} \gamma^{\tau} m^2_{t+\tau+1}, \quad (31)$$

then $\left.\frac{dCE_t}{dh}\right|_{h=1} < 0$. It then follows from continuity that if the inequalities in (30-31) hold, there exists a $h_H \in (h_L, 1)$ such that $CE_t$ decreases in $h$ for all $h \in [h_H, 1]$. This proves that when (30-31) hold, the existing shareholders' welfare is maximized at some $h \in [h_L, h_H]$.

$\square$

**Proof of Proposition 6.**

The proof of Proposition 2 shows that for any given investment amounts $k_{t-2}$ and $k_{t-1}$, the expected utility of generation $t$ investor can be represented by the following certainty equivalent expression:

$$CE_t = \frac{1}{2} RP_t,$$

where

$$RP_t = \rho\sigma^2[k_{t-2}^2(1-h) + \gamma^2 k_{t-1}^2 h]$$

denotes the risk premium in period $t$. This implies that the welfare of future investors is increasing in the investment amounts $k_{t-2}$ and $k_{t-1}$. It thus follows that the investors will prefer the reporting regime that induces higher investment amounts. For $h = 1$, Proposition 4 shows that the observable and unobservable reporting regimes induce identical investments (i.e., $k_\tau^u = k_\tau^*$) and hence the investors are indifferent between the two reporting regimes. For all $h < 1$, the investors prefer (i) the unobservable investment regime when $k_\tau^u > k_\tau^*$ for all $\tau$, and (ii) the observable investment regime when $k_\tau^* < k_\tau^u$. Proposition 4 shows that $k_\tau^u$ is more (less) than $k_\tau^*$ when the cost parameter $b$ is less (more) than $\bar{b}$.

$\square$

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