

Disclosure Quality, Cost of Capital, and Investors' Welfare*

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Abstract

It is widely believed that disclosure quality improves investors' welfare by reducing cost of capital in a competitive market. This paper examines this conventional wisdom by studying a production economy in which disclosure influences a firm's investment decisions. I demonstrate three points. First, cost of capital could increase with disclosure quality when new investment is sufficiently elastic. Second, there are plausible conditions under which disclosure quality reduces the welfare of current and/or new investors. Finally, cost of capital is not a sufficient statistic for the impacts of disclosure quality on the welfare of either current or new investors. These results may help interpret the mixed empirical findings on the relationship between disclosure quality and cost of capital, inform the empirical efforts to measure the economic consequences of accounting disclosure, and add to the ongoing debate on the reform of financial reporting and disclosure regulation.

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1 Introduction

Regulators and firms are concerned about the welfare impact of ex ante disclosure policies. Because it is difficult to empirically measure investors' welfare, a great deal of recent efforts have focused on the relationship between disclosure quality and cost of capital, as an intermediate step to the ultimate goal of understanding the welfare impact of disclosure quality. For example, Arthur Levitt, the former chairman of the Securities and Exchange Commission, has claimed, "The truth is, high [accounting] standards lower the cost of capital. And that's a goal we share"(Levitt (1998)). This remark, as well as many similar arguments pervasive in policy discussions, has been frequently cited as the motivation for studying the relationship between disclosure quality and cost of capital. One interpretation of this remark is that cost of capital summarizes the impact of disclosure quality on investors' welfare. This paper explicitly examines this underlying assumption.

Moreover, even on the relationship between disclosure quality and cost of capital, there has been a gap between the empirical evidence and theoretical research. While the empirical findings on the relationship have been disturbingly mixed, as surveyed by Leuz and Wysocki (2007), most theoretical studies have examined a competitive pure exchange economy and predicted that disclosure quality monotonically reduces cost of capital. Although empirical challenges may have contributed to the inconsistent empirical findings, such as the self-selection problem and the measurement errors in proxies for cost of capital and disclosure quality, nonetheless, this paper provides one theoretical explanation for the mixed empirical relationship, by introducing the production consequences of disclosure.

In sum, I address two questions in this paper. First, how does disclosure quality affect cost of capital, current shareholders' welfare, and new shareholders' welfare when disclosure influences a firm's real decisions? Second, under what conditions is cost of capital a sufficient statistic for the impact of disclosure quality on the welfare of current and/or new shareholders? I first construct an economy in which disclosure affects a firm's investment decisions by influencing investors' valuations. Then, I identify the necessary and sufficient conditions under which disclosure quality reduces cost of capital and improves the welfare of current and new shareholders. Finally, I compare these conditions to show that they are not equivalent, nor do they subsume each other. Therefore, cost of capital is not a sufficient statistic for the welfare of either current or new shareholders in the analysis of the economic consequences of disclosure quality.

The production consequences of disclosure are instrumental in its impact on cost of capital. Disclosure reduces investors' uncertainty about the firm's marginal profitability and thus they would like to pay a higher

price for the firm's shares on average. Given the fixed investment, higher price implies lower cost of capital. That would be the end of the story in a pure exchange economy and we could conclude that disclosure quality monotonically reduces cost of capital. However, when new investment is possible, as in my model, lower cost of capital guides the firm to make more investment on average. As a result, the demand for capital increases and drives up the cost of capital. The increasing cost of capital then discourages the firm from expanding. Therefore, as disclosure quality changes, both the supply and demand sides are affected. A priori, it is not clear whether the cost of capital is higher or lower in equilibrium. The first result of the paper shows that cost of capital increases with disclosure quality if and only if the adjustment cost of new investment is sufficiently low and the prior expected profitability of existing investment is sufficiently high. Disclosure quality increases cost of capital if the new investment is sufficiently elastic to changes in the cost of capital.

Disclosure affects the firm's investment decisions by revealing its information to the market. Such information revelation influences investors' beliefs and valuations which in turn guide the firm's investment. The firm's investment decisions affect the stock price, and the stock price has feedback effect on the firm's investment choices. In a rational expectations equilibrium, both the investment decisions and the valuation decisions are determined consistently.

The investment effect is also important for the welfare consequences of disclosure quality. Not only does it generate one-sided prediction about the impact of disclosure quality on cost of capital, the framework of the pure exchange economy also implies that disclosure could reduce the welfare of both current and new shareholders. For current shareholders, disclosure creates a trade-off between a higher average level and a higher volatility of the stock price. On one hand, disclosure reduces new shareholders' uncertainty about the firm's future cash flow and therefore current shareholders could sell the ownership of the cash flow at a higher price on average; on the other hand, the early resolution of the cash flow risk makes the stock price more volatile, creating a price risk for current shareholders. Therefore, disclosure does not eliminate risk in the economy; instead, it only substitutes the price risk for the cash flow risk and thus allocates the risk between current and new shareholders. When current shareholders are sufficiently risk averse relative to new shareholders, disclosure quality makes current shareholders worse off by preventing them from transferring more risk to new shareholders. This adverse risk-allocation effect of disclosure in the pure exchange economy has long been recognized in the literature (e.g., Hirshleifer (1971) and Dye (1990)). However, it has not received enough attention partly because of the conjecture that disclosure could influence the firm's production decisions and the production benefit could swamp the adverse risk allocation effect.

The second result of the paper demonstrates that current shareholders are worse off with higher disclosure quality if and only if current shareholders are sufficiently risk averse relative to new shareholders and the adjustment cost of new investment is sufficiently high. Current shareholders' high risk aversion guarantees that the risk allocation effect decreases their welfare and the high adjustment cost of new investment ensures that the investment effect is too marginal to offset the adverse risk allocation effect.

Finally, disclosure quality always makes new shareholders worse off in the pure exchange economy. New shareholders gain surplus from trading by contributing their risk tolerance to the market. Early resolution of uncertainty reduces the amount of risk left in the market and thus decreases the demand for their risk-taking capacity. As a result, they gain less surplus from bearing risk for current shareholders. In the presence of the investment effect, the overall risk of the firm's cash flow is a function of both the risk of per-unit investment and the total investment. While disclosure reduces the risk of per-unit investment, it could increase the total investment. The third result of the paper reveals that disclosure reduces new shareholders' welfare if and only if both the adjustment cost of new investment and the level of existing investment are sufficiently high.

The above analysis reveals that the economic forces behind the impacts of disclosure quality on cost of capital, current shareholders' welfare, and new shareholders' welfare are different and do not subsume each other. Therefore, cost of capital is not a sufficient statistic for the welfare of either current or new shareholders. In particular, disclosure quality could increase cost of capital when it increases the overall risk of the firm's cash flow. Such an endogenous increase in risk could benefit current investors if it is accompanied by a simultaneous increase in the level of the firm's cash flow, and could benefit new investors as well because it makes their risk tolerance more valuable.

The results have a number of implications for policy discussions and empirical studies. The conventional wisdom that disclosure quality improves investors' welfare by reducing cost of capital is flawed in two aspects. Neither does disclosure quality monotonically reduce cost of capital in the presence of the investment effect, nor is lower (higher) cost of capital necessarily associated with higher (lower) welfare for either current or new investors. The model has three major implications for empirical studies. First, we should be careful in drawing prescriptive suggestions from research on the relationship between disclosure quality and cost of capital. Second, we may sort out the mixed empirical findings on the relationship between disclosure quality and cost of capital if we take into account the investment effect of disclosure. Finally, the intensity of the investment effect is an important determinant of the firm's disclosure policy if we assume that the firm chooses disclosure policy to maximize current shareholders' welfare. Firms with

lower adjustment cost of new investment is more likely to commit to higher disclosure quality. Similarly, exchanges and legal regimes with differential requirements of disclosure attract different groups of firms based on their flexibility of investment. The key to testing these predictions is to measure the adjustment cost of new investment, the proxy for the intensity of the investment effect in the model. Verdi (2006) has begun to empirically characterize how disclosure quality influences the firm's investment efficiency.

In terms of modeling, this study synthesizes three somewhat separate lines of research on disclosure: the link between disclosure quality and cost of capital, the welfare consequences of disclosure, and the real effect of disclosure.

First, this paper extends the research on the relationship between disclosure quality and cost of capital from a pure exchange economy to a production economy (e.g., Easley and O'Hara (2004); Yee (2006); Lambert, Leuz, and Verrecchia (2006, 2007); Hughes, Liu, and Liu (2007)). A common theme in previous literature is that disclosure quality reduces cost of capital by reducing the conditional variance (or covariance) of the firm's future payoffs in a pure exchange economy. One exception is Lambert, Leuz, and Verrecchia (2007) who also study the indirect effect of disclosure. They point out that cost of capital may increase with disclosure quality if disclosure changes the firm's real decisions and thus changes both the mean and variance of the firm's cash flow. However, they do not link this result directly to disclosure quality. Building on their insight, I study the investment effect and identify conditions for a positive relationship between disclosure quality and cost of capital.

In addition, the finding about the discrepancy between cost of capital and investors' welfare reconciles the intuition in Easley and O'Hara (2004) with the results in Lambert, Leuz, and Verrecchia (2006).¹ The latter paper demonstrates that cost of capital in a competitive market is determined by investors' average information precision, not by information asymmetry as claimed in Easley and O'Hara (2004). Nonetheless, the intuition in Easley and O'Hara (2004) that information asymmetry always puts uninformed investors on the wrong side of trading is still appealing. The reconciliation lies in the conclusion of this paper that cost of capital is not monotonically related to investors' welfare. Reduction in information asymmetry improves uninformed investors' welfare relative to informed investors', as advocated in Easley and O'Hara (2004), although it does not directly affect cost of capital, as demonstrated in Lambert, Leuz, and Verrecchia (2006).

Second, this paper contributes to the broad literature on the efficiency of disclosure quality by examining the investment effect of disclosure. The welfare impact of an ex ante disclosure policy in general is

¹In a companion project, I develop this idea by extending the model to allow for information asymmetry among (new) investors.

ambiguous.² In a capital market setting with perfect competition, a central result is that disclosure quality weakly reduces investors' welfare in a pure exchange economy.³ Subsequent research introduces private information acquisition (e.g., Diamond (1985)), relaxes the assumption of perfect competition (e.g., Kyle (1985); Diamond and Verrecchia (1991); Baiman and Verrecchia (1996)), or incorporates production use of information (e.g., Kunkel (1982); Christensen and Feltham (1988); Pae (1999, 2002); Yee (2007)).⁴ While it fits into the last category, my paper differs from Yee (2007) in that disclosure affects the firm's investment decisions in my paper but *only* influences investors' inter-temporal allocation decisions in Yee (2007).

Moreover, despite the popularity of the inter-temporal model in this literature early on, many subsequent studies replace it with an overlapping generation model (e.g., Dye (1990); Dye and Sridhar (2007)). Trading typically does not occur after disclosure in an inter-temporal model, due to "no-trading" theorem in Milgrom and Stokey (1982). In contrast, the overlapping generation model is an extreme example of the liquidity motivated trading by *assuming* that current generation of investors have to sell their holdings to next generation after disclosure. Using the same overlapping generation model, my paper extends Dye (1990) by studying the welfare impact of disclosure quality in a production economy. Although both Dye (1990) and Dye and Sridhar (2007) also consider the real effect of disclosure quality, they directly assume how disclosure quality changes the distribution of the firm's cash flow.

Finally, this paper draws heavily on the research about the real effect of disclosure in capital market. A firm's disclosure influences investors' perceptions which in turn guide the firm's real decisions, and both the investors' perceptions and the firm's real decisions are consistently determined in a rational expectations equilibrium.⁵ This notion, developed by Kanodia (1980), has been used to study the effect of periodical performance reports (e.g., Kanodia and Lee (1998)), measuring intangibles (e.g., Kanodia, Sapra, and Venu-

²While more information is always useful in a single-person single-period decision making, the value of accounting disclosure in a multi-person or/and multi-period setting is much less clear. For example, mandating more disclosure could reduce a firm's value by altering market competition (e.g., Verrecchia (1983)) or reduce the principal's welfare in a principal-agent relationship (e.g., Dye (1988); Arya, Glover, and Sunder (1998, 2003)).

³Interested readers are referred to Hirshleifer (1971); Marshall (1974); Ng (1975); Hakansson, Kunkel, and Ohlson (1982); Dye (2001); Eckwert and Zilcha (2001); Schlee (2001); Verrecchia (2001); Campbell (2004). Verrecchia (1982) and Watts (1982) survey this early literature. See also Holmstrom and Tirole (1993) and Dow and Rahi (2003) for the concern of the adverse welfare effect of public information in models in economics and finance.

⁴See Verrecchia (2001) and Dye (2001) for an inspiring discussion about the development of the literature.

⁵In general, Prakash and Rappaport (1977) distinguish "information inductance" from "information use" and define the former as "the process whereby the behavior of an individual is affected by the information he is required to communicate." The real effect here could be considered as one example of "information inductance," and much of the agency theory arguably devotes to identifying specific channels of "information inductance."

gopalan (2004)), and accounting for derivatives (e.g., Melumad, Weyns, and Ziv (1999); Kanodia, Mukherji, Sapra, and Venugopalan (2000); Sapra (2002); Sapra and Shin (2007)).⁶ The paper closely related to mine is Kanodia, Singh, and Spero (2005) who study the real effect of the imprecision in measuring investment in a risk neutral market. The imprecision allows the firm to use investment to convey its private information to market and thus improves the use of information in investment decisions. Given the different focuses, I abstract from the signaling game and elaborate on the market process that determines cost of capital and allocates risk.

The rest of the paper proceeds as follows. Section 2 develops the model and studies the effect of disclosure quality on the distribution of the firm's cash flow. Section 3 examines and compares the impacts of disclosure quality on cost of capital, current investors' welfare, and new investors' welfare. Section 4 explores a number of empirical implications of the results. Section 5 discusses some possible extensions. Section 6 concludes. All proofs are in the appendix.

2 The Model and Equilibrium

This section describes and solves the model. It is a disclosing-and-then-trading model that allows disclosure to influence the firm's investment. After solving for the unique equilibrium, I discuss five properties of the equilibrium and in particular examine how disclosure quality changes the characteristics of the distribution of the firm's cash flow.

2.1 The Model

I study a large economy to allow for risk sharing in a competitive market. The number of risky assets (firms) per capita is finite, although the number of investors and risky assets could be infinite. Therefore, I could describe the model in terms of per capita without loss of generality.

In particular, the risky shares of a representative firm are traded between current and new investors after disclosure and the number of shares per capita is normalized to be one. There is also a risk free asset, which acts as a numeraire and whose return is normalized to zero.

Figure 1 describes the time line of events.

⁶Another variant of the real effect further incorporates the Hayesian view that market price aggregates the diverse information among investors. The real effect then arises because disclosure interferes with agents' attempt to extract information from market price (e.g., Brennan and Schwartz (1982); Sunder (1989); Dye and Sridhar (2002)).

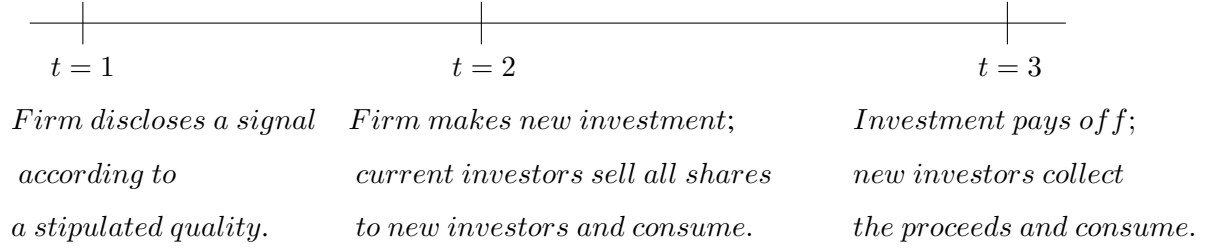


Figure 1 : The Time Line of Events

At $t=1$, the firm, which has m units of existing investment, discloses a public signal about its profitability, according to a pre-specified disclosure policy.⁷ In particular, new investors' prior belief about the profitability of the firm's per-unit investment is characterized by a mean μ_0 plus a future innovation $\tilde{\mu}$. Before disclosure, investors perceive that $\tilde{\mu}$ has a prior distribution of $N(0, \frac{1}{\alpha})$. The disclosure, denoted by \tilde{y} , provides new investors with an unbiased estimator of $\tilde{\mu}$, and takes the form as follows:

$$\tilde{y} = \tilde{\mu} + \tilde{\epsilon}, \quad \tilde{\epsilon} \sim N(0, \frac{1}{\beta})$$

where $\tilde{\epsilon}$ is independent of $\tilde{\mu}$. β is the disclosure quality and the main variable of interest. As β increases, the disclosure conveys more information to new investors about the profitability of the firm's per-unit investment.

New investors use the signal y to update their belief about the profitability of the firm's per unit investment. Conditional on y , they perceive that $\tilde{\mu}$ has a posterior distribution of $N(E[\tilde{\mu}|y], Var[\tilde{\mu}|y])$ where

$$E[\tilde{\mu}|y] = \frac{\beta}{\alpha + \beta}y$$

$$Var[\tilde{\mu}|y] = \frac{1}{\alpha + \beta}$$

Given α , β has a one-to-one correspondence to the posterior variance $Var[\tilde{\mu}|y]$. Therefore, I use both β and $Var[\tilde{\mu}|y]$ to refer to (inverse) disclosure quality, whichever is convenient.

Note that I have only described the information structure of new investors. Current investors' information set is inconsequential in this model because they do not have decisions to make. They have to sell all of their shares of the firm after disclosure, and the firm will be assumed to make investment to maximize its stock price. Current investors' forced sale is typically assumed in studies of the capital market consequences

⁷The disclosure policy is costless. Taking into account the direct cost of the disclosure policy does not qualitatively change the main results.

of accounting information. The role of information in capital market is usually reflected in its influence on investors' trading behavior and prices. However, information per se does not motivate trading in a complete market with common priors and rational expectations.⁸ As a result, models of trading typically rely on some element of non-information related motivation, such as heterogeneous priors and liquidity reasons (e.g., Grossman and Stiglitz (1980); Diamond and Verrecchia (1981)). The inter-generational reason for trading used in the overlapping generation model here is a similar modeling device and an extreme example of liquidity motivated trading. Given that current investors have to sell all of their shares after disclosure, it is reasonable to assume that the firm is motivated by current investors to choose investment level to maximize its stock price.

Furthermore, the disclosure is a garbling or subset of the information the firm has.⁹ As we shall see soon, the firm's information set does not affect the equilibrium because the firm can not use investment decisions to convey its information credibly to the market. The firm only uses its information to the extent that the information is priced by new investors. This way of modeling the real effect of disclosure enables me to go further to study the impacts of disclosure quality on cost of capital and investors' welfare.

At $t=2$, the firm makes additional investment k to maximize its expected stock price, and then current investors sell their shares to new investors.

The net cash flow from k units of new investment takes a quadratic form. Thus, new investors perceive that the firm's cash flow is as follows:

$$\tilde{F} = m(\mu_0 + \tilde{\mu}) + k\tilde{\mu} - \frac{z}{2}k^2 \quad (1)$$

For new investors, \tilde{F} is the stochastic net cash flow at $t = 3$, if the firm has m units of existing investment and makes k units of new investment at $t = 2$. The first component $m(\mu_0 + \tilde{\mu})$ is the cash flow from the existing investment. The other component, $k\tilde{\mu} - \frac{z}{2}k^2$, is the *net* cash flow from the new investment k . z is the adjustment cost of new investment; as we shall see soon, it captures the degree to which disclosure quality influences the firm's investment. Thus, m , μ_0 , and z are fixed parameters, k is the firm's choice variable, and $\tilde{\mu}$ is the only source of uncertainty in the firm's cash flow.

After the firm makes the new investment, current investors sell all of their shares to new investors in a competitive market, consume the proceeds, and leave the market. Based on the firm's disclosure and new

⁸For more details about the "no-trading theorem," see Aumann (1976); Milgrom and Stokey (1982); Samuelson (2004).

⁹Imagine that both γ and β are integers. The firm installs an information technology which generates γ unbiased signals with unit precision, but is only required to disclose or commits to disclosing the first β signals. \tilde{y} is a sufficient statistic for these β signals and a garbling of the γ signals.

investment, new investors submit their demands for the firm's shares. Market clearing yields the stock price, which is the market valuation of the firm's stochastic cash flow \tilde{F} .

Although I describe the investment decision and trading as two sequential steps, the order does not matter because rational expectations guarantee that the firm's investment decisions and new investors' valuation decisions are consistent in equilibrium. Furthermore, if the firm is instructed to maximize new investors' utility by making investment after trading, the equilibrium price and investment level will change but the main conclusions of the paper will still hold.

At $t=3$, the firm's investment pays off, the firm is liquidated, and new investors consume.

Both current and new investors have CARA utility functions, with coefficients of risk tolerance of τ_c and τ_n , respectively. The subscripts "c" and "n" represent "current investors" and "new investors." Using "W" to denote the end-period wealth or consumption, the utility function of a representative investor i is as follows:

$$U(W_i) = -\exp\left(-\frac{W_i}{\tau_i}\right), i \in \{c, n\}$$

2.2 The Equilibrium: Trading Price and Optimal Investment

In this subsection, I solve for the unique equilibrium of the model, which consists of a trading price and firm's optimal investment (Lemma 1). Then, I characterize the investment and risk allocation effects of disclosure quality, define three special economies, and examine the impact of disclosure quality on the distribution of the firm's cash flow (Lemma 2). These metrics are the building blocks for the main discussion of the paper in the next section.

For expositional ease, I assume that all parameters of the model are well defined. In particular, both the adjustment cost z and the units of the existing investment m are positive and bounded, except in three special economies defined later.

A rational expectations equilibrium is a pair of a trading price function $p(y, k(y))$ and an investment function $k(y)$, such that, for any signal y , the pair $(k(y), p(y, k(y)))$ satisfies:

1. given $k(y)$, $p(y, k(y))$ clears the market;
2. given the functional form of $p(y, k(y))$, $k(y)$ maximizes $p(y, k(y))$.

Lemma 1 (The Equilibrium). *For any signal y , the unique equilibrium $(k(y), p(y, k(y)))$ is as follows:*

$$\begin{aligned} k(y) &= \frac{E[\tilde{\mu}|y]}{z + \frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y]} - \frac{\frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y]}{z + \frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y]} m \\ p(y, k(y)) &= E[\tilde{F}|(y, k(y))] - \frac{1}{\tau_n} \text{Var}[\tilde{F}|(y, k(y))] = p(y) \end{aligned}$$

While there are many interesting properties of this equilibrium, I focus on five of them: the uniqueness of the equilibrium, the investment effect, the risk allocation effect, the overall impacts of disclosure quality on the mean and variance of the firm's cash flow, and the distribution of the stock price. First, the equilibrium is unique. There is no signaling equilibrium. The trading price $p(y, k(y))$ equals the new investors' posterior mean of the firm's cash flow minus a risk premium whose size is determined by new investors' posterior variance of the firm's cash flow and their risk tolerance. The firm's optimal investment $k(y)$ is a function of new investors' posterior beliefs about the profitability of the firm's per unit investment, not a function of the firm's superior information. Thus, the driving force of the equilibrium is new investors' posterior beliefs about $\tilde{\mu}$. Furthermore, new investors use only the disclosure to update their beliefs about $\tilde{\mu}$ and discard the information value of the firm's investment $k(y)$. Had they tried to extract information from $k(y)$, the firm would have pretended to be a better type than it actually is by opportunistically distorting its investment decisions. Since the firm maximizes its expected stock price that occurs right after disclosure, there is no disciplinary cost for such opportunism. Therefore, the equilibrium in which new investors do not extract information from the investment and the firm does not use investment to send a signal is unique.¹⁰ Since new investors' information set is simply y , $p(y, k(y))$ could be simplified to $p(y)$.

Second, the adjustment cost of new investment z measures the intensity of the investment effect. One proxy for the impact of disclosure on the firm's investment decisions is the unconditional variance of the firm's new investment. New investment becomes more volatile ex ante when disclosure influences the firm's investment decisions in a more substantial way.

$$\text{Var}[k(y)] = \frac{\text{Var}[E[\tilde{\mu}|y]]}{(z + \frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y])^2} = \frac{\text{Var}[\tilde{\mu}] - \text{Var}[\tilde{\mu}|y]}{(z + \frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y])^2}$$

The second equality follows from the law of total variance. The unconditional variance of the firm's new investment decreases in the remaining cash flow risk of the firm's per-unit investment $\text{Var}[\tilde{\mu}|y]$. As

¹⁰Kanodia and Lee (1998) and Kanodia, Singh, and Spero (2005) study signaling games in which the firm could convey information through its investment choice. In Kanodia and Lee (1998), the uncompromisable performance report, which occurs after the firm's investment decisions but before the trading, imposes differential cost on different types of firms. In Kanodia, Singh, and Spero (2005), the cost of distorted investment, the reduction in the private short-term value of the investment, is higher for the firm's with unfavorable information. In contrast, the absence of such differential cost in my model precludes any signaling equilibrium.

disclosure quality β increases, the remaining uncertainty about the profitability of the firm's investment dissipates and the firm's investment becomes more aggressive.

$Var[k(y)]$ decreases monotonically in the adjustment cost z , given disclosure quality β (and thus $Var[\tilde{\mu}|y]$). Therefore, z measures the degree of the investment effect. On one hand, if z is infinitely large, the optimal investment level is always zero. Thus, disclosure does not affect the investment decisions at all, and the economy becomes the pure exchange economy. On the other hand, as z approaches zero, the investment decisions become extremely responsive to disclosure, and the firm's new investment exhibits the property of constant return to scale.

Third, the risk allocation effect of disclosure quality is at work because the firm has m units of existing investment. Since the investment effect interacts with the risk allocation effect, I focus on the "residual" risk allocation effect by keeping the total investment fixed. In the absence of the investment effect, disclosure quality does not eliminate the risk of the firm's investment; instead, it only allocates the risk between current and new investors. I term the ex ante uncertainty of the trading price $Var[p(y)] = Var[E[\tilde{\mu}|y]]$ the price risk, and the remaining uncertainty of the firm's cash flow $Var[\tilde{\mu}|y]$ the cash flow risk. Current investors bear the price risk, and new investors take the cash flow risk in return for a risk premium. Disclosure quality substitutes the price risk for the cash flow risk. Figure 2 illustrates the risk allocation effect of disclosure quality in the absence of the investment effect.¹¹

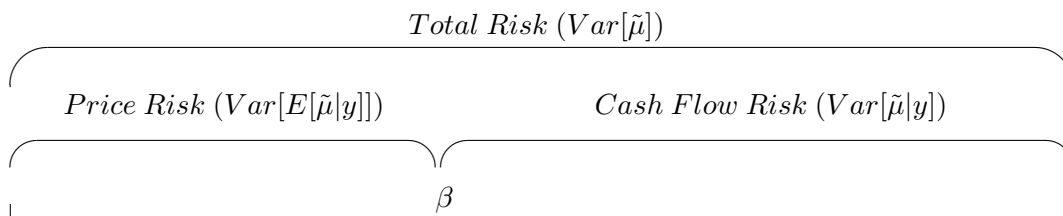


Figure 2 : The Risk Allocation Effect

I prefer the label "risk allocation" to "risk sharing." The essence of risk sharing in the sense of Wilson (1968) is that trading reduces the total risk by creating correlation among investors' holdings. Optimal risk sharing requires that all investors hold the same portfolio (the market portfolio). Such risk sharing exists in an inter-temporal model. For example, suppose two investors who have the same CARA utility functions are endowed with two risky assets, \tilde{x}_1 and \tilde{x}_2 respectively. Trading between them then results in

¹¹See Dye (1990) for additional discussions of the risk allocation effect of disclosure quality. Dye (1990) analyzes the welfare impact of disclosure quality in the pure exchange economy, but does not link cost of capital to investors' welfare.

the allocation $(\frac{\tilde{x}_1+\tilde{x}_2}{2}, \frac{\tilde{x}_1+\tilde{x}_2}{2})$. The total variance of this allocation is smaller than the initial sum of variance: $2Var[\frac{\tilde{x}_1+\tilde{x}_2}{2}] = \frac{Var[\tilde{x}_1]+Var[\tilde{x}_2]+2Cov[\tilde{x}_1,\tilde{x}_2]}{2} \leq Var[\tilde{x}_1] + Var[\tilde{x}_2]$. However, in an overlapping generation model, at any level of disclosure quality, the risk current investors face is independent of that new investors face. Thus, disclosure allocates the risk between current and new investors, but does not reduce the total risk.

The presence of both the investment and risk allocation effects and the interaction between them make the model complicated. While I prove the main results of the paper for the general model, I also analyze three special economies to enhance the intuition for the general results. The first two special economies, the pure exchange economy and the economy with constant return to scale (the CRTS economy), represent two extreme cases of the investment effect; the third special economy, the economy without existing investment, isolates the investment effect from the risk allocation effect. There is only the risk allocation effect in the pure exchange economy and only the investment effect in the economy without existing investment.

Definition 1. *The pure exchange economy is an economy in which the firm can not change investment after disclosure. Mathematically, it is achieved by setting the adjustment cost of new investment z to infinity. In addition, I normalize m to one unit in this case. Thus, $\tilde{F}_{pe} = \lim_{z \rightarrow \infty, m \rightarrow 1} \tilde{F} = \mu_0 + \tilde{\mu}$. The subscript “pe” stands for “pure exchange.”*

Definition 2. *The CRTS economy is an economy in which the firm’s new investment exhibits the property of constant return to scale. It is achieved by setting the adjustment cost of new investment z to zero. Thus, $\tilde{F}_{crt_s} = \lim_{z \rightarrow 0} \tilde{F} = m(\mu_0 + \tilde{\mu}) + k\tilde{\mu}$. The subscript “crt_s” stands for “constant return to scale.”*

Definition 3. *The economy without existing investment is an economy in which the firm does not have existing investment before disclosure. It is achieved by setting the existing investment level m to zero. Thus, $\tilde{F}_{we} = \lim_{m \rightarrow 0} \tilde{F} = k\tilde{\mu} - \frac{z}{2}k^2$. The subscript “we” stands for “without endowment.”*

Fourth, having analyzed the investment effect and the risk allocation effect, now we are ready to examine the impact of disclosure quality on the distribution of the firm’s cash flow through its due effect. The ex post distribution of the firm’s cash flow, $\tilde{F}|y$, is normal and depends on the realization of the signal y . To focus on the impact of ex ante disclosure quality, I look at the expected (average) mean and variance of the ex post distributions of the firm’s cash flow, denoted as E and V respectively. The expected (average) stock price before disclosure, denoted as P , is then a function of E and V .

$$E \equiv E[E[\tilde{F}|y]] \quad (2)$$

$$V \equiv E[Var[\tilde{F}|y]] \quad (3)$$

$$P \equiv E[p(y)] = E - \frac{V}{\tau_n} \quad (4)$$

E , V , and P are taken expectations with respect to disclosure y . For simplicity, I call $E[\tilde{F}|y]$ and $Var[\tilde{F}|y]$ the mean and variance of the ex post distribution of the firm's cash flow, E and V the mean and the variance of the firm's cash flow, and P the stock price, whenever there is no confusion.

Lemma 2 (Disclosure Quality and the Distribution of the Firm's Cash Flow). *As disclosure quality improves, both the mean of the firm's cash flow (E) and the stock price (P) increase, but the variance of the firm's cash flow (V) increases if and only if the adjustment cost of new investment is sufficiently low ($z < z^*$).*

The cutoff z^* is given in expression A-15 in the appendix.

The main point in Lemma 2 is that with the investment effect, disclosure quality changes both the mean and variance of the firm's cash flow, and that the variance of the firm's cash flow could increase with disclosure quality. Therefore, the investment effect is important for the economic consequences of disclosure quality, given that all the main variables of interest — cost of capital, current investors' welfare, and new investors' welfare — are related to the characteristics of the distribution of the firm's cash flow. The importance becomes more obvious when Lemma 3 reveals that the impact of disclosure quality on the distribution of the firm's cash flow varies dramatically in three special economies.

Lemma 3 (Disclosure Quality and the Distribution of the Firm's Cash Flow in the Special Economies). *As disclosure quality improves,*

1. *in the pure exchange economy, the mean is constant, the variance decreases, and the stock price increases;*
2. *in the CRTS economy, the mean, the variance, and the stock price all increase;*
3. *in the economy without existing investment, the mean and the stock price increase, but the variance increases if and only if the adjustment cost is sufficiently low ($z < \frac{2}{(\beta-\alpha)\tau_n}$).*

Table 1 summarizes Lemma 2 and Lemma 3, and Figure 3 illustrates Lemma 3.

Insert Table 1 here.

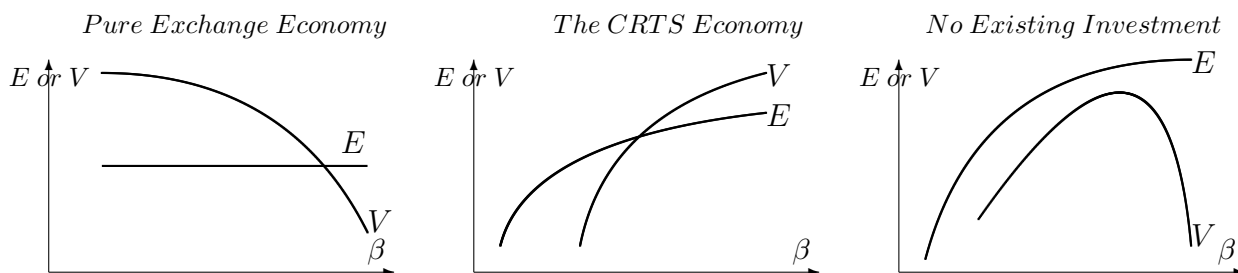


Figure 3 : The Impacts of β on E and V in Three Special Economies

Finally, the fifth property of the equilibrium I focus on is the distribution of the trading price $p(y)$. As given in equation A-6 in the appendix, $p(y)$ is non-linear in the signal y , and thus is not normally distributed. In fact, it has a Chi-square distribution. Economically, if we interpret the disclosure as earnings announcement, the non-linear relationship between disclosure and price suggests that the earnings-price relationship becomes non-linear after we take into account the investment effect of disclosure. For example, the liquidation option in Hayn (1995) may be interpreted as one particular type of the investment effect: upon the receipt of persistent bad news, the firm could liquidate itself (reverse its investment) to maximize the shareholder value. Future research may understand the non-linear earnings-price relationship better by considering the investment effect of disclosure. Technically, previous literature relies heavily on the framework of CARA utility plus normally distributed wealth to solve for the closed-form expression of investors' welfare (their ex ante expected utility) that facilitates comparative statics. The Chi-square distribution of the trading price adds substantial challenges to this task. As a result, while I still manage to obtain the closed-form solution and some comparative statics, some structural beauty of the previous framework, such as expressing investors' welfare as a linear combination of the mean and variance of the firm's cash flow, inevitably gets lost.

3 Disclosure Quality, Cost of Capital, and Investors' Welfare

Having characterized the equilibrium, I conduct comparative statics in this section to address the main research questions. I first identify the necessary and sufficient conditions under which disclosure quality reduces cost of capital and improves the welfare of current and new investors. Then, I compare these conditions to show that they are not equivalent, nor do they subsume each other, as summarized in Table 2. Therefore, cost of capital does not summarize the impact of disclosure quality on the welfare of either

current or new investors.

Insert Table 2 here.

3.1 Disclosure Quality and Cost of Capital

I define cost of capital as the expected return on the firm's equity.

$$E[\tilde{R}] = \frac{E - P}{P} \quad (5)$$

This definition is similar to that in Lambert, Leuz, and Verrecchia (2007) except that I use the unconditional expected return whereas they use the conditional expected return $E[\tilde{R}|y]$. Given the representation of information as a draw from a normal distribution, the conditional expected return could be negative. Besides its practical undesirability, the negative cost of capital also flips the sign of the impact of disclosure quality on cost of capital. The unconditional expected return circumvents this issue by averaging out the particular realizations of the signal y . As a result, the unconditional expected return is always positive under the regularity condition 6

$$\mu_0 > \hat{\mu}_0 = \frac{2\alpha z m^2 - \beta \tau_n}{4\alpha m + 2\alpha^2 z m \tau_n + 2\alpha \beta z m \tau_n} \quad (6)$$

Note that $\hat{\mu}_0$ is independent of the signal y . Moreover, because the unconditional expected return $E[\tilde{R}]$ is the value weighted average of the conditional expected returns $E[\tilde{R}|y]$, it is the obtainable return for an investor who invests in the same firm over time or simultaneously in many similar firms.¹²

Proposition 1 (Disclosure Quality and Cost of Capital). *As disclosure quality improves, cost of capital decreases if and only if the adjustment cost of new investment is sufficiently high ($z > z^*$) or the prior belief of the firm's profitability is sufficiently low ($\mu_0 < \mu_0^*$).*

The cutoff z^* is the same as that in Lemma 2, and the cutoff μ_0^* is given in expression A-18 in the appendix.

Proposition 1 extends the relationship between disclosure quality and cost of capital to a production economy and confirms the conjecture in Lambert, Leuz, and Verrecchia (2007).¹³ The intuition behind

¹²

$$E[\tilde{R}] = \frac{E - P}{P} = \int_{-\infty}^{\infty} \frac{E[\tilde{F}|y] - p(y)}{p(y)} \frac{p(y)}{\int_{-\infty}^{\infty} p(y)\phi(y)dy} \phi(y)dy = \int_{-\infty}^{\infty} E[\tilde{R}|y] \frac{p(y)}{\int_{-\infty}^{\infty} p(y)\phi(y)dy} \phi(y)dy$$

where $\phi(y)$ is the probability density function of \tilde{y} .

¹³See Proposition 4 in Lambert, Leuz, and Verrecchia (2007), page 410.

Proposition 1 centers on the impacts of disclosure quality on the characteristics of the distribution of the firm's cash flow (Lemma 2). Cost of capital measures the per-dollar risk premium. The size of the overall risk premium increases with the variance of the firm's cash flow, and the scaling variable (i.e. the stock price) increases with the firm's prior profitability. Disclosure quality could increase cost of capital if it increases the variance and the variance grows faster than the stock price. A sufficiently low adjustment cost guarantees the increasing variance and a sufficiently high prior belief of the firm's profitability further ensures that the per-dollar variance is increasing. This intuition is borne out by the following analysis.

We can rewrite cost of capital as a function of the variance-mean ratio of the firm's cash flow by plugging equation 4 to equation 5.

$$E[\tilde{R}] = \frac{1}{\frac{\tau_n}{V} - 1} \quad (7)$$

Cost of capital increases monotonically with the variance-mean ratio ($\frac{V}{E}$) and decreases with new investors' risk tolerance (τ_n). Thus, cost of capital increases with disclosure quality if and only if the sign of the following partial derivative is positive.

$$\frac{\partial E[\tilde{R}]}{\partial \beta} = \frac{EE'\tau_n}{(\tau_n E - V)^2} \left(\frac{V'}{E'} - \frac{V}{E} \right) \quad (8)$$

The prime “'” denotes the partial derivative with respect to β .

When does $\frac{\partial E[\tilde{R}]}{\partial \beta} > 0$? First, a positive V' is a necessary condition for the derivative to be positive. All variables in equation 8 are always positive except V' .¹⁴ If $V' < 0$, then $\frac{V'}{E'} < 0$, $\frac{\partial E[\tilde{R}]}{\partial \beta} < 0$, and disclosure quality monotonically reduces cost of capital. By Lemma 2, $V' < 0$ is equivalent to the condition that the adjustment cost of the firm's new investment is sufficiently high ($z > z^*$). This explains the condition about the adjustment cost z in Proposition 1.

Second, when $V' > 0$, the sign of the derivative is determined solely by the sign of the difference between two variance-mean ratios, $\frac{V'}{E'} - \frac{V}{E}$. The economic intuition of these two ratios is as follows. Consider a marginal increase in disclosure quality which causes an incremental change in the firm's cash flow. The firm's new cash flow becomes a weighted average of the pre-change cash flow with a variance-mean ratio of $\frac{V}{E}$, and the incremental cash flow with a variance-mean ratio of $\frac{V'}{E'}$. If the variance-mean ratio of the incremental cash flow ($\frac{V'}{E'}$) is greater than that of the pre-change cash flow ($\frac{V}{E}$), the new (weighted average) variance-mean ratio becomes greater and cost of capital increases.

¹⁴Recall that under condition 6, the price P is positive. Since the variance V is positive, $E = P + \frac{1}{\tau_n}V$ is also positive. Finally, Lemma 2 proves that E' is positive.

Finally, how are the variance-mean ratios determined? Note that the prior profitability μ_0 does not change the incremental cash flow, but affects the pre-change cash flow by altering the mean E . All else being equal, when μ_0 is greater, E is greater, and thus $\frac{V}{E}$ is smaller. When μ_0 is great enough, $\frac{V'}{E'}$ exceeds $\frac{V}{E}$ and $\frac{\partial E[\tilde{R}]}{\partial \beta} > 0$. Therefore, disclosure quality increases cost of capital when the investment effect is sufficiently substantial and the prior profitability of the firm's investment is sufficiently optimistic.

The intuition that disclosure quality influences cost of capital through its impact on the variance-mean ratio of the firm's cash flow becomes more transparent in three special economies.

Corollary 1 (Disclosure Quality and Cost of Capital in the Special Economies). *As disclosure quality improves, cost of capital decreases in the pure exchange economy and in the economy without existing investment, but increases in the CRTS economy.*

The variance-mean ratio of the firm's cash flow in the pure exchange economy is as follows:

$$\left(\frac{V}{E}\right)_{pe} = \lim_{z \rightarrow \infty, m \rightarrow 1} \frac{V}{E} = \frac{Var[\tilde{\mu}|y]}{\mu_0}$$

Disclosure quality monotonically reduces $Var[\tilde{\mu}|y]$ and thus cost of capital. Disclosure quality does not change the mean but always reduces the conditional variance of the firm's cash flow, which equals the conditional variance of the profitability of per unit investment, resulting in a decreasing variance-mean ratio.

When the investment effect is present, disclosure quality affects both the mean and variance of the firm's cash flow. As a result, the impact of disclosure quality on cost of capital becomes more subtle. In the economy without existing investment, the variance-mean ratio is as follows:

$$\left(\frac{V}{E}\right)_{we} = \lim_{m \rightarrow 0} \frac{V}{E} = \frac{2\tau_n}{4 + \frac{z\tau_n}{Var[\tilde{\mu}|y]}}$$

Disclosure quality also monotonically reduces $Var[\tilde{\mu}|y]$ and thus cost of capital. In this economy, the mean of the firm's cash flow monotonically increases with disclosure quality, while the variance has a one-peak shape. The mean turns out to grow faster than the variance. As a result, disclosure quality also decreases the variance-mean ratio.¹⁵

In contrast, the CRTS economy provides an example in which the variance outpaces the mean. In this economy, the variance-mean ratio is as follows:

$$\left(\frac{V}{E}\right)_{crt_s} = \lim_{z \rightarrow 0} \frac{V}{E} = \frac{\tau_n}{2 + \frac{m\mu_0\tau_n}{V_{crt_s}}}$$

¹⁵Lambert, Leuz, and Verrecchia (2007) analyze a similar example of the production economy without existing investment.

Disclosure quality monotonically increases V_{crt_s} and thus cost of capital. In the CRTS economy, as disclosure quality improves, both the mean and variance of the firm's cash flow increase, but the variance grows faster than the mean, leading to an increasing variance-mean ratio.

Note that Proposition 1 is robust to different definitions of cost of capital. While Lambert, Leuz, and Verrecchia (2007) and my paper define cost of capital in the return space, Easley and O'Hara (2004) and Hughes, Liu, and Liu (2007) define it in the price space. That is, $E[\tilde{R}] = E - P = \frac{V}{\tau_n}$. Disclosure quality influences cost of capital only through its impact on the variance of the firm's cash flow. Given Lemma 2, when the cost of capital is defined in the price space, disclosure quality increases cost of capital if and only if the adjustment cost z is sufficiently low.

In sum, disclosure quality affects cost of capital through its impact on the variance-mean ratio of the firm's cash flow. In the presence of the investment effect, disclosure quality affects both the mean and variance of the firm's cash flow. As a result, there are plausible conditions under which disclosure quality increases cost of capital.

3.2 Disclosure Quality and Current Investors' Welfare

In this subsection, I analyze how disclosure quality affects current investors' welfare and identify the necessary and sufficient conditions under which disclosure quality improves current investors' welfare. By comparing the impacts of disclosure quality on cost of capital and on current investors' welfare, I demonstrate that cost of capital is not a sufficient statistic for current investors' welfare. The third column in Table 2 summarizes the results in this subsection.

I define investors' welfare as their ex ante expected utility: the utility after the disclosure quality has been set, but before the signal comes out. In particular, current investors' welfare is as follows:

$$\begin{aligned}
E[U(W_c)] &= E[E[U(W_c)|y]] \\
&= -E[E[\exp(-\frac{p}{\tau_c})|y]] \\
&= -E[\exp(-\frac{1}{\tau_c}p(y))] \\
&= M_1 \exp(M_2)
\end{aligned} \tag{9}$$

where M_1 and M_2 are expressions of the basic parameters and are given in expressions (A-21) and (A-22) in the appendix.

The complexity of M_1 and M_2 results from the investment effect, which induces a Chi-square distribution of $p(y)$. As a result, the convenient framework of CARA utility plus normally distributed wealth is not

applicable to the calculation of the welfare. Instead, the calculation involves Lemma 5 which is given and proved in the appendix.

Proposition 2 (Disclosure Quality and Current Investors' Welfare). *As disclosure quality improves, current investors are better off if and only if they are sufficiently risk tolerant relative to new investors ($\tau_c > \frac{\tau_n}{2}$) or the adjustment cost of new investment is sufficiently low ($z < z_c^*$).*

The cutoff z_c^* is characterized in expression (A-23) in the appendix.

Besides extending the results in Dye (1990) by studying the welfare impact of disclosure quality in a production economy, Proposition 2, together with Proposition 1, reveals that the conditions for disclosure quality to reduce cost of capital and to improve current investors' welfare are different and do not subsume each other, as summarized in Remark 1.

Remark 1 (Cost of Capital and Current Investors' Welfare). *In the analysis of the economic consequences of disclosure quality, cost of capital is not a sufficient statistic for current investors' welfare.*

The intuition for Proposition 2 lies in the dual effect of disclosure quality of facilitating investment and allocating risk. On one hand, disclosure quality coordinates the firm's investment decisions better with the market's expectations, which enhances current investors' welfare. On the other hand, disclosure quality also allocates the risk between current and new investors by resolving the uncertainty before current investors transfer it to new investors. Whether this risk allocation effect improves current investors' welfare or not depends on the relative risk tolerance of current and new investors. When current investors are sufficiently risk averse and the improvement in investment decisions is marginal, disclosure quality could reduce current investors' welfare.

The special economies provide transparent intuition for Proposition 2 and Remark 1. The pure exchange economy illustrates the welfare consequences of the risk allocation effect; the economy without existing investment demonstrates the welfare impact of the investment effect; and all three special economies are informative about the discrepancy between cost of capital and current investors' welfare in Remark 1.

Corollary 2 (Disclosure Quality and Current Investors' Welfare in the Special Economies). *As disclosure quality improves, current investors are better off in the pure exchange economy if and only if they are sufficiently risk tolerant ($\tau_c > \frac{\tau_n}{2}$), and they are always better off in both the economy without existing investment and the CRTS economy.*

In the pure exchange economy, disclosure divides the firm's risk into the price risk and the cash flow risk. Disclosure quality reduces the cash flow risk but increases the price risk, creating a trade-off for current investors' welfare. Formally, the certainty equivalent of the welfare of current investors is as follows:

$$(CE_c)_{pe} = P - \frac{1}{2\tau_c} Var[p(y)] \quad (10)$$

$$= \mu_0 - \frac{1}{\tau_n} \underbrace{Var[\tilde{\mu}|y]}_{\text{Cash Flow Risk}} - \frac{1}{2\tau_c} \underbrace{Var[E[\tilde{\mu}|y]]}_{\text{Price Risk}} \quad (11)$$

$$= \mu_0 - \frac{1}{2\tau_c} \frac{1}{\alpha} + \left(\frac{1}{2\tau_c} - \frac{1}{\tau_n} \right) Var[\tilde{\mu}|y] \quad (12)$$

Equation 10 indicates that current investors care about not only the average level but also the ex ante uncertainty of their ex post wealth $p(y)$. Equation 11 shows that current investors suffer from both the cash flow risk and the price risk, which constitute the initial risk of the firm's cash flow ($Var[\tilde{\mu}|y]$) by the law of total variance. Disclosure quality substitutes the price risk for the cash flow risk. Loosely speaking, one more unit of the price risk costs current investors a relative disutility of $\frac{1}{2\tau_c}$ utility, and one more unit of the cash flow risk costs them $\frac{1}{\tau_n}$ utility. Equation 12 reveals the trade-off for current investors. The reduction in the cash flow risk improves current investors welfare if and only if $\frac{1}{2\tau_c} - \frac{1}{\tau_n} < 0$, which is equivalent to $\tau_c > \frac{\tau_n}{2}$. When it is relatively more expensive to bear the risk by themselves, current investors would rather pay new investors to take the risk for them. In this case, by resolving uncertainty before trading, disclosure quality prevents current investors from transferring more risk to new investors and makes current investors worse off.

Having analyzed how disclosure quality affects current investors' welfare in the pure exchange economy, now I discuss the intuition behind Remark 1 that cost of capital is an incomplete measure of current investors' welfare. On one hand, this observation seems to be intuitive. From the perspective of current investors, cost of capital measures the cost they pay new investors to bear the risk for them. When they are sufficiently more risk averse than new investors, saving the cost of "outsourcing" the risk reduces, not improves, their welfare. On the other hand, conventional wisdom conjectures that lower cost of capital increases the present value of a given distribution of cash flow, resulting in higher welfare for current investors. I formally show that the conventional wisdom is only a partial equilibrium observation. In the pure exchange economy, cost of capital measures only the average level of current investors' ex post wealth, but does not capture the ex ante uncertainty of their wealth. Disclosure quality affects both cost of capital and the ex ante uncertainty of their wealth simultaneously, making cost of capital an incomplete measure of the impact of disclosure quality on current investors' welfare.

I rewrite current investors' certainty equivalent of expression 10, using the definition of cost of capital in expression 5.

$$(CE_c)_{pe} = \frac{\mu_0}{1 + E[\tilde{R}]} - \frac{1}{2\tau_c} Var[E[\tilde{\mu}|y]] \quad (13)$$

Current investors' welfare has two components. The first component is the discounted value of the firm's expected cash flow and the other is their utility loss from the price risk. The conventional wisdom is applicable to the case where the price risk is held constant while cost of capital is decreasing. For example, according to equation 7, an increase in new investors' risk tolerance (τ_n) reduces cost of capital $E[\tilde{R}]$ and keeps the price risk $Var[E[\tilde{\mu}|y]]$ unchanged. As a result, the decrease in cost of capital in this case does improve the welfare of current investors by reducing the risk premium new investors require.

However, in the analysis of the economic consequences of disclosure quality, the conventional wisdom is flawed. Disclosure quality reduces cost of capital by substituting the price risk for the cash flow risk. By expediting the resolution of uncertainty, disclosure quality simultaneously affects cost of capital and the price risk. Lower cost of capital does reduce the risk premium current investors pay to new investors, but the benefit comes at the cost of more exposure to the price risk. When current investors are sufficiently risk averse, the saving in risk premium can not compensate for their disutility from the increased exposure to the price risk. As a result, they are worse off although cost of capital decreases. Therefore, cost of capital is not a comprehensive measure of current investors' welfare.

The other two special economies illustrate the welfare impact of the investment effect. Furthermore, they demonstrate that cost of capital is not a comprehensive measure of even current investors' average ex post wealth after controlling for its ex ante uncertainty.

In the absence of existing investment, there is no risk before disclosure, and thus the risk allocation effect is muted. In this economy without existing investment, current investors' welfare is as follow:

$$(E[U(W_c)])_{we} = \lim_{m \rightarrow 0} E[U(W_c)] = -\frac{1}{\sqrt{1 + \frac{2}{\tau_c} P_{we}}}$$

Disclosure quality affects current investors' welfare only through its impact on the average level of their ex post wealth and the ex ante uncertainty of their ex post wealth does not play a role.¹⁶ Since disclosure quality monotonically increases the stock price, the investment effect enhances current investors' welfare.

Furthermore, cost of capital is not a comprehensive measure of the impact of disclosure quality on the average level of current investors' payoffs. The stock price is a function of both the mean of the firm's cash

¹⁶A non-central Chi-square distribution is completely characterized by the number of degrees of freedom and the location parameter. Since the mean contains both parameters, its possible that the mean could happen to capture other higher order moments.

flow and cost of capital.

$$P = \frac{E}{1 + E[\tilde{R}]}$$

Disclosure quality improves the mean and reduces cost of capital at the same time. Therefore, cost of capital is not the only channel for disclosure quality to influence current investors' welfare. This observation substantiates Remark 1.

In the CRTS economy, the risk associated with the existing investment is also absent. When the adjustment cost of the firm's new investment is zero, the firm could always undo the existing investment: $k(y) = -m + \frac{\tau_m}{2} \frac{E[\tilde{\mu}|y]}{Var[\tilde{\mu}|y]}$. Thus, the firm acts as if it first reverses the existing investment and then chooses an optimal new investment level. Current investors' welfare in this economy is as follows:

$$(E[U(W_c)])_{crt_s} = \lim_{z \rightarrow 0} E[U(W_c)] = -\frac{\exp\left(-\frac{m\mu_0}{\tau_c}\right)}{\sqrt{1 + \frac{2(P_{crt_s} - m\mu_0)}{\tau_c}}}$$

Therefore, current investors only care about the stock price P and only the investment effect of disclosure quality is at work, implying that current investors benefit from better disclosure.

Remark 1 is more evident in the CRTS economy because both cost of capital and current investors' welfare increase with disclosure quality. While disclosure quality increases cost of capital, it also improves the mean of the firm's cash flow. The welfare gain from the increased mean dominates the welfare loss from the increased cost of capital, leading to the overall improved welfare for current investors.

In sum, cost of capital is not a sufficient statistic for current investors' welfare in the analysis of the economic consequences of disclosure quality. Current investors care about both the average level and the ex ante uncertainty of their payoffs. Cost of capital does not capture the ex ante uncertainty of current investors' payoffs and is only associated with one component of the average level of current investors' payoffs. Disclosure quality changes cost of capital and other components of current investors' welfare simultaneously.

3.3 Disclosure Quality and New Investors' Welfare

Having examined the impact of disclosure quality on current investors' welfare and the discrepancy between cost of capital and current investors' welfare, I analyze the welfare impact of disclosure quality on new investors in this subsection and identify the necessary and sufficient conditions for disclosure quality to improve new investors' welfare. By comparing the impacts of disclosure quality on cost of capital and on

new investors' welfare, I demonstrate that cost of capital is not a sufficient statistic for new investors' welfare, either. In addition, I show that disclosure quality creates a tension between current and new investors. The last column of Table 2 summarizes the results of this subsection.

Similarly, the welfare of new investors is their ex ante expected utility.

$$\begin{aligned}
E[U(W_n)] &= -E[E[U(W_n)|y]] \\
&= -E[E[\exp(-\frac{1}{\tau_n}(\tilde{F} - p))|y]] \\
&= -E[\exp(-\frac{1}{\tau_n}(E[\tilde{F}|y] - p(y) - \frac{1}{2\tau_n}Var[\tilde{F}|y]))] \\
&= -E[\exp(-\frac{1}{2\tau_n^2}Var[\tilde{F}|y])] \tag{14} \\
&= N_1 \exp(N_2) \tag{15}
\end{aligned}$$

where N_1 and N_2 are expressions of the basic parameters and are given in expressions (A-26) and (A-27) in the appendix. Again, the calculation of the ex ante expected utility involves Lemma 5, resulting in the complexity of N_1 and N_2 .

Proposition 3 (Disclosure Quality and New Investors' Welfare). *As disclosure quality improves, new investors are better off if and only if one of the following two conditions holds.*

1. *If the initial disclosure quality is low ($\beta < \alpha$), then either the adjustment cost of new investment is sufficiently low ($z < z_n^*$), or the level of existing investment is sufficiently low ($m < m_n^*$);*
2. *If the initial disclosure quality is high ($\beta > \alpha$), then either the adjustment cost of new investment is sufficiently low ($z < z_n^*$), or the adjustment cost of new investment is modest (i.e., $z_n^* < z < z_n^{**}$) and the level of existing investment is sufficiently low ($m < m_n^*$).*

The cut-offs, z_n^* , z_n^{**} , and m_n^* , are given in expressions A-28, A-29, and A-30 in the appendix. The subscription “ n ” of the cut-offs stands for “new investors.” Proposition 3 is also illustrated in Figure 4. Disclosure quality increases new investors' welfare in the grid areas.

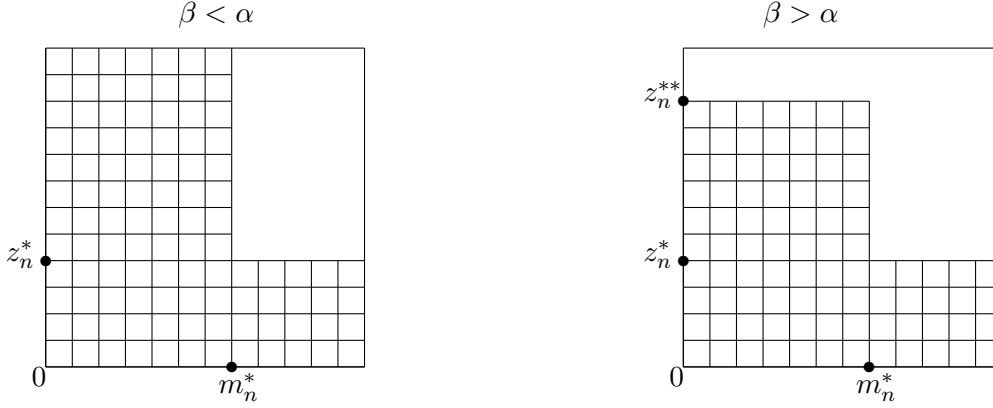


Figure 4 : The Impact of Disclosure Quality on New Investors' Welfare

Besides stipulating the necessary and sufficient conditions under which new investors are better off with better disclosure, Proposition 3 indicates that disclosure quality influences the welfare of new investors in different ways than it affects cost of capital, as summarized in Remark 2.

Remark 2 (Cost of Capital and New Investors' Welfare). *In the analysis of the economic consequences of disclosure quality, cost of capital is not a sufficient statistic for new investors' welfare.*

In addition, the comparison between Proposition 2 and Proposition 3 reveals that current and new investors have conflicting demands for disclosure quality, as represented in Remark 3. Not only does disclosure quality allocate the risk associated with the existing investment between current and new investors, but the investment effect also affects them asymmetrically.

Remark 3 (The Tension between Current and New Investors). *Disclosure quality creates a tension between current and new investors.*

There are two elements in the intuition behind Proposition 2. First, new investors' conditional expected utility increases with the cash flow risk, or the variance of the ex post distribution of the firm's cash flow ($Var[\tilde{F}|y]$). Second, they are averse to the ex ante uncertainty of their conditional expected utility.

First, new investors' conditional expected utility increases with the cash flow risk ($Var[\tilde{F}|y]$). This is evident in equation 14. The reason lies in the risk aversion of new investors. Concave utility induces a downward-sloping demand for the firm's risky shares:

$$D = \tau_n \frac{E[\tilde{F}|y] - p(y)}{Var[\tilde{F}|y]} \quad (16)$$

D is the demand for the firm's shares of a representative new investor, as shown in the appendix (equation A-3). The downward-sloping demand yields diminishing marginal utility ($MU = E[\tilde{F}|y] - \frac{Var[\tilde{F}|y]}{\tau_n} D$). In equilibrium, the price $p(y)$, which equals the marginal utility, is lower than the average utility ($AU = E[\tilde{F}|y] - \frac{Var[\tilde{F}|y]}{2\tau_n} D$). The gap between MU and AU, $\frac{Var[\tilde{F}|y]}{2\tau_n}$, is the source of new investors' surplus from trading in a competitive market. In contrast, when new investors become risk neutral in the limit, the gap between MU and AU disappears and $p(y) = E[\tilde{F}|y]$. As a result, new investors always pay a "fair" price for whatever they get, consistent with the intuition that trading is a fair game for risk-neutral investors in a competitive market. New investors' welfare is not directly affected by whatever impacts disclosure has on the mean of the future cash flow (E) because the adjustment of the price absorbs such impacts. Therefore, new investors gain surplus from trading because of their risk aversion.

Competition among new investors does affect and reduce the surplus they gain from trading, but in a subtle way. When the cash flow risk ($Var[\tilde{F}|y]$) is lower, new investors' demands for the firm's shares in equation 16 become more sensitive to price. That is, the slope of their demand function ($-\frac{Var[\tilde{F}|y]}{\tau_n}$) becomes much flatter. More sensitive demands amount to fiercer competition among themselves, reducing the gap between MU and AU and thus their surplus. Therefore, not only do new investors get positive surplus from trading, but the size of their surplus also increases with the cash flow risk ($Var[\tilde{F}|y]$).

The forced nature of current investors' sale increases, but does not generate, new investors' surplus. When current investors have to leave the market after disclosure, the total risk-taking capacity in the market shrinks, reducing the overall competition for the firm's risky shares and improving the reward for risk-taking by new investors. However, even if current investors stay in the market, new investors still gain surplus from trading, although both the gap between MU and AU and their equilibrium holding become smaller, leading to lower surplus for them.

Second, new investors' welfare is the (probability) weighted average of their conditional expected utility. Since they are risk averse, new investors are averse to the ex ante uncertainty of their conditional expected utility. From the perspective of new investors before disclosure, one realization of y leads to one ex post distribution of the firm's cash flow, $\tilde{F}|y$. In the presence of the investment effect, this family of distributions have different mean and variance, and $E \equiv E[E[\tilde{F}|y]]$ and $V \equiv E[Var[\tilde{F}|y]]$ only measure the average of the mean and variance of these distributions. Since new investors' conditional expected utility is associated with the cash flow risk $Var[\tilde{F}|y]$, they are also averse to the ex ante uncertainty of $Var[\tilde{F}|y]$.

How does disclosure quality affect the average level and the ex ante uncertainty of the cash flow risk ($Var[\tilde{F}|y]$)? On one hand, although the risk allocation effect of disclosure quality always reduces

$Var[\tilde{F}|y]$, the investment effect could increase it. Overall, disclosure quality increases V , the average level of $Var[\tilde{F}|y]$, if and only if the adjustment cost of new investment is sufficiently lower, according to Lemma 2. On the other hand, the investment effect, whose impact on the $Var[\tilde{F}|y]$ depends on the realization of the signal y , induces the ex ante uncertainty about $Var[\tilde{F}|y]$.

Overall, disclosure quality improves new investors' welfare if and only if it increases the variance of the firm's cash flow and the increase in variance is large enough to offset their welfare loss from the increased ex ante uncertainty in their conditional expected utility.

The special economies make the above intuition more transparent and illustrate Remark 2 and 3.

Corollary 3 (Disclosure Quality and New Investors' Welfare in the Special Economies). *As disclosure quality improves, new investors are always worse off in the pure exchange economy, always better off in the CRTS economy, and better off in the economy without existing investment if and only if the adjustment cost of new investment is sufficiently low ($z < \frac{2}{(\beta-\alpha)\tau_n}$).*

In the pure exchange economy, new investors' welfare is as follows:

$$(E[U(W_n)])_{pe} = \lim_{z \rightarrow \infty, m \rightarrow 1} E[U(W_n)] = -\exp\left(-\frac{1}{2t_n^2} Var[\tilde{\mu}|y]\right)$$

Disclosure quality decreases new investors' welfare by leaving less risk for them to take through trading. Moreover, cost of capital does not link disclosure quality to new investors' welfare, either. If anything, cost of capital effect is on the opposite side of the welfare effect of disclosure quality on new investors. High disclosure quality reduces cost of capital by materializing more risk before trading, but this early resolution of uncertainty reduces the need for new investors' risk tolerance and thus reduces their welfare. Therefore, cost of capital is a comprehensive measure of the welfare of neither current nor new investors. Finally, Remark 3 is also evident in the pure exchange economy. While current investors' preference for disclosure quality depends on their relative risk tolerance, new investors always prefer lower disclosure quality. When current investors are sufficiently risk tolerant, their preference for disclosure quality is at odds with new investors'.

In the economy without existing investment, the new investors' welfare is as follows:

$$(E[U(W_n)])_{we} = \lim_{m \rightarrow 0} E[U(W_n)] = -\frac{1}{\sqrt{1 + \frac{1}{\tau_n^2} V_{we}}}$$

New investors' welfare increases monotonically with the variance of the firm's cash flow. Since the variance of the firm's cash flow has a one-peak shape, new investors benefit from better disclosure quality when the

variance is increasing, that is, when $z < \frac{2}{(\beta-\alpha)\tau_n}$, according to Lemma 3. Moreover, this economy provides another example of the discrepancy between cost of capital and new investors' welfare. Driven by the decreasing variance-mean ratio, cost of capital decreases with disclosure quality. In contrast, new investors' welfare is driven by the variance alone, and thus could either increase or decrease with disclosure quality. Finally, this economy also lends support to Remark 3. When $z > \frac{2}{(\beta-\alpha)\tau_n}$, current investors advocate more transparency while new investors prefer less.

In the CRTS economy, new investors' welfare is as follows:

$$(E[U(W_n)])_{crt_s} = \lim_{z \rightarrow 0} E[U(W_n)] = -\frac{1}{\sqrt{1 + \frac{1}{\tau_n^2} V_{crt_s}}} \quad (17)$$

New investors' welfare increases with the variance of the firm's cash flow, which increases with disclosure quality in the CRTS economy. Thus, they are better off with better disclosure quality. Moreover, Remark 2 is striking in the CRTS economy. New investors' welfare increases with disclosure quality. So does cost of capital! We can rewrite new investors' welfare in equation 17 as a function of cost of capital.

$$(E[U(W_n)])_{crt_s} = -\frac{1}{\sqrt{1 + \frac{m\mu_0}{\tau_n} \frac{E[\tilde{R}]}{1-E[\tilde{R}]}}}$$

Since $E[\tilde{R}] \in (0, 1)$, current investors' welfare *increases* with cost of capital. Disclosure quality increases both the mean and variance of the firm's cash flow, but the variance outpaces the mean. As a result, as disclosure quality improves, cost of capital increases because of the increasing variance-mean ratio, and new investors' welfare also increases because of the increasing variance. Thus, disclosure quality does not summarize the impact of disclosure quality on new investors' welfare. Finally, although disclosure quality increases the welfare of both current and new investors, it does so through different channels. Current investors benefit from the improved mean of the firm's cash flow but suffer from the accompanying increase in the variance, whereas new investors enjoy only the increase in the variance.

In all three special economies, new investors' preference for disclosure quality could be summarized by the impact of disclosure quality on the the average level of their conditional expected utility (or the variance of the firm's cash flow V). When the risk allocation effect interacts with the investment effect, the ex ante uncertainty of the cash flow risk ($Var[\tilde{F}|y]$) also plays a role in new investors' welfare. This interaction leads to the difference between the conditions in Proposition 3 about the impact of disclosure quality on new investors' welfare and the conditions in Lemma 2 about the impact of disclosure quality on the variance of the firm's cash flow.

In sum, cost of capital is not a sufficient statistic for new investors' welfare, either. New investors earn surplus from risk-bearing in equilibrium. Their welfare is determined by both the average level and the ex ante uncertainty of the amount of the cash flow risk they could take from trading. Cost of capital is only associated with the first component; even for this component, cost of capital measures new investors' welfare in the "wrong" way.

4 Empirical Implications

The results have a number of empirical implications for the relationship between disclosure quality and cost of capital, the economic consequences of disclosure quality in general, and the evaluations of disclosure regulation and financial reporting standards.

The empirical literature often cites Levitt (1998) as the motivation for examining the relationship between disclosure quality and cost of capital, and Easley and O'Hara (2004) as the theoretical foundation of the empirical hypothesis that disclosure quality reduces cost of capital by leveling "the playground" among investors. Lambert, Leuz, and Verrecchia (2006) demonstrate that, in Easley and O'Hara (2004), disclosure quality reduces cost of capital by increasing the average information precision, not by reducing information asymmetry per se. This study further shows that the implicit assumption about the monotonic link between cost of capital and investors' welfare is not well justified. This raises a question about how we should interpret and use the empirical evidence on the relationship between disclosure quality and cost of capital in the public debate about evaluating disclosure regulation and financial reporting standards. While future theoretical research may identify the necessary and/or sufficient conditions under which cost of capital or other proxies provide sufficient statistics for investors' welfare, more empirical evidence on the relationship between disclosure quality and cost of capital could also facilitate the theoretical search.

In terms of the relationship between disclosure quality and cost of capital, the results in this study suggest that the impact of disclosure quality on cost of capital crucially depends on the intensity of the investment effect. Lambert, Leuz, and Verrecchia (2007) caution that cross-sectional studies in this area may only capture the "average" impact of the investment effect; this paper further identifies one intermediate variable, the adjustment cost of new investment, to help sort out the directional effects of disclosure quality on cost of capital. We could better understand the mixed empirical evidence on the relationship between disclosure quality and cost of capital if we incorporate the investment effect of disclosure quality.

The model is agnostic about *whether* information risk is a systematic risk factor over and above tradi-

tional risk factors. To some extent, identifying a risk factor beyond CAPM beta is a purely empirical issue, and information risk is no exception. One common theme in the theoretical literature is that the impact of disclosure quality could be summarized by its impact on the traditional variance (or covariance) of the firm's cash flow (or with the cash flow of the market portfolio). Given that the literature starts with the framework of CAPM or APT, it is difficult to use this framework to prove or disprove an additional risk factor. In addition, while my model predicts how disclosure quality affects cost of capital, it is silent on the issue that through which component(s), the factor premium or/and the factor loading, disclosure quality affects cost of capital. The answer to this issue depends on whether we measure cost of capital in the return space or in the price space, as demonstrated in Hughes, Liu, and Liu (2007) and Lambert, Leuz, and Verrecchia (2007).

As a result, a more direct test of my theory about the consequences of the improvement in disclosure quality is to examine how changes in disclosure quality influence the distribution of the firm's cash flow and whether such influence cross-sectionally varies with the firm's flexibility of new investment. Similarly, the theory predicts that firms, whose investment decisions could be improved substantially by disclosure quality and whose current owners have strong risk-taking capacity, are more likely to choose high disclosure quality. For example, it may explain that why some firms choose public financing or cross-listing while other remain private or listed domestically. In addition, it also predicts that exchanges with differential disclosure requirements have distinct clienteles who vary in their flexibility of new investment.

Finally, the empirical testing of the investment effect could be a promising direction. While there are a number of theoretical channels through which disclosure quality could influence the firm's investment decisions, empirically we still know little about them. Verdi (2006) provides empirical evidence on the possible mechanisms through which disclosure quality affects a firm's investment efficiency. Further understanding of the empirical determinants of the investment effect will provide better inputs to the empirical examination of the relationship between disclosure quality and cost of capital, as well as other predictions of this paper.

5 Possible Extensions

So far, I have used a simplistic model to make my arguments. This subsection discusses several possible extensions and generalizations to the model and their impacts on my results.

5.1 Diversification

Although I only study a single-firm economy, the analysis is robust to diversification in a multi-firm economy, thanks to Lambert, Leuz, and Verrecchia (2007). On one hand, we can interpret the variance of the firm's cash flow used in this study as the covariance of the firm's cash flow with the cash flow of the market portfolio. The Bayes update rule for covariance is similar to that for variance, and thus the major proofs can go through with covariance.¹⁷ On the other hand, in the presence of the investment effect, the impact of the idiosyncratic disclosure about the firm's profitability can not be diversified away, because changes in investment decisions induced by disclosure are not independent. Therefore, focusing on a single-firm economy is without loss of generality.

5.2 Pre-disclosure Trading

This paper focuses on the post-disclosure trading. I do not study the pre-disclosure trading and its preemptive effect on the impact of disclosure quality in capital market. As discussed in the setup of the model, trading is exogenous to this as well as many other models that study the consequences of accounting disclosure in capital market, due to the "no-trading" theorem. Replacing the forced sale assumption with probabilistic liquidity-driven sale should not qualitatively affect my results.

Given the forced sale assumption, liquidity-based pre- and post-disclosure tradings are independent of each other, and thus the results in this paper about the post-disclosure trading will not be altered by the inclusion of the possible pre-disclosure trading. In addition, empirically, we observe significant abnormal trading volume after both scheduled and unscheduled corporate announcements (e.g., Chae (2005)), showing the relevance of the post-disclosure trading in reality.

In addition, the pre-disclosure trading captures the price that occurs after the disclosure quality is set but before the disclosure is made. Empirically, it corresponds to an event study where we test the market reaction right after the disclosure quality is changed. In contrast, the post-disclosure trading yields the price that prevails after the disclosure comes out and thus corresponds to an association study. Since it is usually difficult to determine the exact time news about changes in disclosure quality arrives in the market, the association study is currently more popular in this area.

¹⁷See Proposition 2 on page 399 of Lambert, Leuz, and Verrecchia (2007).

5.3 Information Asymmetry

There could be three types of information asymmetry: information asymmetry between current and new investors, between the firm's manager and current investors, and among new investors. The information asymmetry between current and new investors is innocuous because of the forced sale assumption.

Moreover, this paper does not explicitly model how the manager of the firm is motivated to act on the shareholders' interest, which has been the focus of many studies in the agency literature (e.g., Dye (1988)). Conceptually, the driving force in my model is that disclosure quality changes both the ex ante mean and variance of the firm's cash flow. In general, studies in agency theory show that disclosure quality *changes* the characteristics of the distribution of the firm's cash flow through its impact on the principal-agent relationship (e.g., Lambert (2001)). Therefore, although incorporating the agency issue in the model may generate a different cash flow function, the main conclusion about the relationship between cost of capital and investors' welfare is expected to be preserved.

Finally, Easley and O'Hara (2004) address the question of how accounting disclosure "levels the playground" among asymmetrically informed new investors. However, Lambert, Leuz, and Verrecchia (2006) show that in a market with perfect competition, what affects cost of capital is investors' average information precision, not the degree of information asymmetry among investors *per se*. Since I adopt the perfect competition framework, the abstraction from the information asymmetry among new investors does not incur any loss of generality. In addition, in a companion project, I show that reduction in information asymmetry increases the welfare of uninformed investors *relative to* informed investors. It does not necessarily improve the absolute level of the welfare of uninformed investors. I further show that the discrepancy between cost of capital and investors' welfare still exists after taking into account the role of disclosure in reducing information asymmetry.

6 Conclusion

This paper scrutinizes the popular wisdom that disclosure quality improves investors' welfare by reducing cost of capital. In particular, I study the impacts of disclosure quality on cost of capital, current investors' welfare, and new investors' welfare in a production economy in which disclosure changes a firm's investment decisions. I identify the necessary and sufficient conditions under which disclosure quality reduces cost of capital and improves the welfare of current and new investors. Cost of capital could increase with disclosure quality and there are plausible conditions under which disclosure reduces the welfare of current and new

investors. Then, I show that these conditions are not equivalent, nor do they subsume each other. Therefore, cost of capital does not summarize the impact of disclosure quality on the welfare of either current or new investors. In addition, disclosure quality also creates a tension between current and new investors.

With the caveat that they are derived from the particular model of perfect competition and overlapping generations of investors, these results may help reconcile the mixed empirical evidence on the relationship between disclosure quality and cost of capital, inform the empirical efforts to measure the economic consequences of accounting disclosure, and add to the ongoing debate on the reform of financial reporting and disclosure regulation.

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Appendix

The following proofs involve Lemma 4 and 5. I state and prove them first.

Lemma 4. $f(\cdot)$ is a continuous function, $f^{-1}(\cdot)$ is the inverse function of $f(\cdot)$, and $f'(\cdot)$ is the first derivative of $f(\cdot)$. If $f'(x) > 0 (< 0)$, then

$$y > f(x) \iff x < (>)f^{-1}(y)$$

Proof of Lemma 4.

$$\begin{aligned} y > f(x) &\iff y - f(x) > 0 \\ &\iff f(f^{-1}(y)) - f(x) > 0 \end{aligned}$$

By the Lagrange Mean Value theorem, there exists

$x_0 \in (x, f^{-1}(y))$ if $x < f^{-1}(y)$, or $x_0 \in (f^{-1}(y), x)$ if $x > f^{-1}(y)$

such that

$$f(f^{-1}(y)) - f(x) = f'(x_0)(f^{-1}(y) - x) > 0$$

Since $f'(x_0) > (<)0$, thus

$$f^{-1}(y) - x > (<)0 \iff x < (>)f^{-1}(y)$$

□

Lemma 5. Suppose x is a normally distributed random variable with mean zero and variance σ^2 . If $1 - 2a\sigma^2 > 0$, then

$$E[\exp(ax^2 + bx + c)] = \frac{1}{\sqrt{1 - 2a\sigma^2}} \exp\left(\frac{\frac{1}{2}b^2\sigma^2}{1 - 2a\sigma^2} + c\right)$$

Proof of Lemma 5. Since x is a normally distributed random variable with mean zero and variance σ^2 , and $1 - 2a\sigma^2 > 0$,

$$\begin{aligned} E[\exp(ax^2 + bx + c)] &= \frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{\infty} \exp(ax^2 + bx + c) \exp\left(-\frac{1}{2}\frac{x^2}{\sigma^2}\right) dx \\ &= \frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{\infty} \exp\left(-\frac{1 - 2a\sigma^2}{2\sigma^2}(x^2 - 2\frac{b\sigma^2}{1 - 2a\sigma^2}x) + c\right) dx \\ &= \frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{\infty} \exp\left(-\frac{1}{2}\frac{(x - \frac{b\sigma^2}{1 - 2a\sigma^2})^2}{\frac{\sigma^2}{(1 - 2a\sigma^2)}}\right) \exp\left(\frac{\frac{1}{2}b^2\sigma^2}{1 - 2a\sigma^2} + c\right) dx \\ &= \frac{1}{\sqrt{1 - 2a\sigma^2}} \exp\left(\frac{\frac{1}{2}b^2\sigma^2}{1 - 2a\sigma^2} + c\right) \int_{-\infty}^{\infty} \frac{1}{\sqrt{\frac{2\pi\sigma^2}{(1 - 2a\sigma^2)}}} \exp\left(-\frac{1}{2}\frac{(x - \frac{b\sigma^2}{1 - 2a\sigma^2})^2}{\frac{\sigma^2}{(1 - 2a\sigma^2)}}\right) dx \\ &= \frac{1}{\sqrt{1 - 2a\sigma^2}} \exp\left(\frac{\frac{1}{2}b^2\sigma^2}{1 - 2a\sigma^2} + c\right) \end{aligned}$$

□

Proof of Lemma 1. First, I solve for the price $p(y, k(y))$, given new investors' conjecture about the firm's investment decision $k(y)$, which is consistent with the firm's true choice in equilibrium. Based on the argument about the non-existence of any signaling equilibrium, the firm's investment decisions do not have information value. Given their knowledge of β and y , and their conjecture $k(y)$, new investors perceive that the firm's cash flow has a normal distribution with mean $E[\tilde{F}|(y, k(y))]$ and $Var[\tilde{F}|(y, k(y))]$,

$$E[\tilde{F}|(y, k(y))] = m(\mu_0 + E[\tilde{\mu}|y]) + kE[\tilde{\mu}|y] - \frac{z}{2}k^2 \quad (\text{A-1})$$

$$Var[\tilde{F}|(y, k(y))] = (m + k)^2 Var[\tilde{\mu}|y] \quad (\text{A-2})$$

A representative new investor i chooses her demand D_i to maximize her expected utility by solving the following program (P1).

$$\begin{aligned} (P1) \max_{D_i} E[U(W_n)|(y, k(y))] &= -E \left[\exp \left(-\frac{1}{\tau_n} D_i (\tilde{F} - p) \right) | (y, k(y)) \right] \\ &= -\exp \left(-\frac{D_i}{\tau_n} (E[\tilde{F}|(y, k(y))] - p(y, k(y))) - \frac{D_i}{2\tau_n} \text{Var}[\tilde{F}|(y, k(y))] \right) \end{aligned}$$

The first-order condition gives the optimal demand function:

$$D_i^* = \tau_n \frac{E[\tilde{F}|(y, k(y))] - p(y, k(y))}{\text{Var}[\tilde{F}|(y, k(y))]} \quad (\text{A-3})$$

The second-order condition is $-\frac{\text{Var}[\tilde{F}|(y, k(y))]}{\tau_n} < 0$, guaranteeing that D_i^* is the maximum solution.

Since the per capita supply of shares is normalized to one unit, market clearing requires that

$$1 = \int_0^1 D_i^* di = \tau_n \frac{E[\tilde{F}|(y, k(y))] - p(y, k(y))}{\text{Var}[\tilde{F}|(y, k(y))]}$$

Thus, I get the trading price

$$p(y, k(y)) = E[\tilde{F}|(y, k(y))] - \frac{1}{\tau_n} \text{Var}[\tilde{F}|(y, k(y))] \quad (\text{A-4})$$

Second, anticipating the trading price $p(y, k(y))$, the firm makes the investment decision $k(y)$ to maximize the stock price by solving the following program.

$$\begin{aligned} (P2) \max_{k(y)} E[p(y, k(y))|y] &= p(y, k(y)) \\ &= E[\tilde{F}|(y, k(y))] - \frac{1}{\tau_n} \text{Var}[\tilde{F}|(y, k(y))] \\ &= m\mu_0 + (m + k(y))E[\tilde{\mu}|y] - \frac{z}{2}k^2(y) - \frac{(m + k(y))^2 \text{Var}[\tilde{\mu}|y]}{\tau_n} \end{aligned}$$

The first-order condition gives the optimal new investment function:

$$k(y) = \frac{E[\tilde{\mu}|y]}{z + \frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y]} - \frac{\frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y]}{z + \frac{2}{\tau_n} \text{Var}[\tilde{\mu}|y]} m \quad (\text{A-5})$$

The second-order condition is $-z - \frac{2\text{Var}[\tilde{\mu}|y]}{\tau_n} < 0$, guaranteeing that $k(y)$ is the maximum solution.

Since the optimal investment $k(y)$ is a function of y , I could substitute $k(y)$ in the trading price and

simplify $p(y, k)$ as $p(y)$. After substitution, the trading price $p(y)$ is a quadratic function of the signal y .

$$p(y) = E[\tilde{F}|y] - \frac{1}{\tau_n} \text{Var}[\tilde{F}|y] \quad (\text{A-6})$$

$$E[\tilde{F}|y] = m\mu_0 - \frac{2zm^2 \text{Var}[\tilde{\mu}|y]^2}{(z\tau_n + 2\text{Var}[\tilde{\mu}|y])^2} + \frac{zm\tau_n(z\tau_n + 4\text{Var}[\tilde{\mu}|y])}{(z\tau_n + 2\text{Var}[\tilde{\mu}|y])^2} E[\tilde{\mu}|y] + \frac{\tau_n(z\tau_n + 4\text{Var}[\tilde{\mu}|y])}{2(z\tau_n + 2\text{Var}[\tilde{\mu}|y])^2} E[\tilde{\mu}|y]^2 \quad (\text{A-7})$$

$$\text{Var}[\tilde{F}|y] = \frac{z^2m^2\tau_n^2 \text{Var}[\tilde{\mu}|y]}{(z\tau_n + 2\text{Var}[\tilde{\mu}|y])^2} + \frac{2zm\tau_n^2 \text{Var}[\tilde{\mu}|y]}{(z\tau_n + 2\text{Var}[\tilde{\mu}|y])^2} E[\tilde{\mu}|y] + \frac{\tau_n^2 \text{Var}[\tilde{\mu}|y]}{(z\tau_n + 2\text{Var}[\tilde{\mu}|y])^2} E[\tilde{\mu}|y]^2 \quad (\text{A-8})$$

□

Proof of Lemma 2. The expected mean, variance, and price are

$$E \equiv E[E[\tilde{F}|y]] = m\mu_0 - \frac{4\alpha zm^2 + \beta\tau_n(4 + (\alpha + \beta)z\tau_n)}{2\alpha(2 + z\tau_n(\alpha + \beta))^2} \quad (\text{A-9})$$

$$V \equiv E[\text{Var}[\tilde{F}|y]] = \frac{(\beta + \alpha^2 z^2 m^2 + \alpha\beta z^2 m^2)\tau_n^2}{\alpha(2 + z\tau_n(\alpha + \beta))^2} \quad (\text{A-10})$$

$$P \equiv E[E[\tilde{F}|y] - \frac{1}{\tau_n} \text{Var}[\tilde{F}|y]] = E - \frac{1}{\tau_n} V \quad (\text{A-11})$$

By taking the partial derivative of equation A-9 and A-11 with respect to β , and solving for $\frac{\partial E}{\partial \beta} > 0$ and $\frac{\partial P}{\partial \beta} > 0$, I get

$$\frac{\partial E}{\partial \beta} = \frac{tn(8 + \alpha z(8zm^2 + 6\tau_n + \beta z\tau_n^2))}{2\alpha(2 + \alpha z\tau_n + \beta z\tau_n)^3} > 0$$

$$\frac{\partial P}{\partial \beta} = \frac{\tau_n(2 + \alpha z(2zm^2 + \tau_n))}{2\alpha(2 + \alpha z\tau_n + \beta z\tau_n)^2} > 0$$

By taking the partial derivative of equation A-10 with respect to β and solving for $\frac{\partial V}{\partial \beta} > 0$, I get the solution $\{\alpha < \alpha^*(z), \beta < \beta^*(z)\}$ where

$$\alpha^*(z) = \frac{2zm^2 + \tau_n}{2z^2m^2\tau_n} + \frac{1}{2} \sqrt{\frac{4z^2m^4 + 12zm^2\tau_n + \tau_n^2}{z^4m^4\tau_n^2}} \quad (\text{A-12})$$

$$\beta^*(z) = \frac{2 + 2\alpha z^2m^2 + \alpha z\tau_n - \alpha^2 z^3m^2\tau_n}{z\tau_n + \alpha z^3m^2\tau_n} \quad (\text{A-13})$$

Both the cutoffs $\alpha^*(z)$ and $\beta^*(z)$ are decreasing in z , because

$$\frac{\partial \alpha^*(z)}{\partial z} = -\frac{1}{z^3m^2\tau_n} \left(zm^2 + \tau_n + \frac{(2z^2m^4 + 9zm^2\tau_n + \tau_n^2)}{\sqrt{4z^2m^4 + 12zm^2\tau_n + \tau_n^2}} \right) < 0$$

$$\frac{\partial \beta^*(z)}{\partial z} = -\frac{2(1 + 2\alpha z^2m^2 + \alpha^2 z^3m^2(zm^2 + 2\tau_n))}{\tau_n(z + \alpha z^3m^2)^2} < 0$$

Thus, by Lemma 4

$$\begin{aligned} \{\alpha < \alpha^*(z), \beta < \beta^*(z)\} &\iff \{z < z_\alpha(\alpha), z < z_\beta(\beta)\} \\ &\iff z < z^* \end{aligned} \quad (\text{A-14})$$

where $z_\alpha(\alpha)$ and $z_\beta(\beta)$ are the inverse functions of $\alpha^*(z)$ and $\beta^*(z)$ evaluated at α and β , respectively, and

$$z^* = \min(z_\alpha(\alpha), z_\beta(\beta)) \quad (\text{A-15})$$

□

Proof of Lemma 3. Lemma 3 is proved by taking the limit ($z \rightarrow \infty, z \rightarrow 0, m \rightarrow 0$) of the conditions in Lemma 2. □

Proof of Proposition 1. Cost of capital is defined as

$$E[\tilde{R}] = \frac{E - P}{P} \quad (\text{A-16})$$

By equations A-9 and A-10,

$$E[\tilde{R}] = \frac{2(\beta + \alpha^2 z^2 m^2 + \alpha \beta z^2 m^2) \tau_n}{(2 + \alpha z \tau_n + \beta z \tau_n)(\beta \tau_n + 2\alpha^2 z m \tau_n \mu_0 + 2\alpha m(2\mu_0 + \beta z \tau_n \mu_0 - z m))} \quad (\text{A-17})$$

By taking the partial derivative of equation (A-17) with respect to β , and solving for $\frac{\partial E[\tilde{R}]}{\partial \beta} > 0$ with respect to $\{\alpha, \beta, \mu_0\}$, I obtain the solution $\{\alpha < \alpha^*(z), \beta < \beta^*(z), \mu_0 > \mu_0^*\}$ where

$$\begin{aligned} \alpha^*(z) &= \frac{2zm^2 + \tau_n}{2z^2m^2\tau_n} + \frac{1}{2} \sqrt{\frac{4z^2m^4 + 12zm^2\tau_n + \tau_n^2}{z^4m^4\tau_n^2}} \\ \beta^*(z) &= \frac{2 + 2\alpha z^2m^2 + \alpha z \tau_n - \alpha^2 z^3 m^2 \tau_n}{z \tau_n + \alpha z^3 m^2 \tau_n} \\ \mu_0^* &= \frac{z(\beta^2 \tau_n^2 + \alpha m^2(4 + 4\alpha z(zm^2 + \tau_n) + (\alpha + \beta)^2 z^2 \tau_n^2))}{2\alpha m(2 + \alpha z \tau_n + \beta z \tau_n)(2 + (\alpha - \beta)z \tau_n + \alpha z^2 m^2(2 - (\alpha + \beta)z \tau_n))} \end{aligned} \quad (\text{A-18})$$

According to the proof of Lemma 2,

$$\{\alpha < \alpha^*(z), \beta < \beta^*(z), \mu_0 > \mu_0^*\} \iff \{z < z^*, \mu_0 > \mu_0^*\}$$

Therefore, $\frac{\partial E[\tilde{R}]}{\partial \beta} < 0 \iff \{\{z < z^*\}, \{\mu_0 > \mu_0^*\}\}$ □

Proof of Corollary 1. Corollary 1 is proved by taking the limit ($z \rightarrow \infty, z \rightarrow 0, m \rightarrow 0$) of the conditions in Proposition 1. \square

Proof of Proposition 2. Current investors' welfare is

$$\begin{aligned}
E[U(W_c)] &= E[E[U(W_c)|y]] \\
&= -E[E[\exp(-\frac{1}{\tau_c}p)|y]] \\
&= -E[\exp(-\frac{1}{\tau_c}p(y))] \\
&= -E[\exp(-\frac{1}{\tau_c}(m\mu_0 - \frac{zm^2}{2 + \alpha z\tau_n + \beta z\tau_n} + \frac{\beta zm\tau_n}{2 + \alpha z\tau_n + \beta z\tau_n}y + \\
&\quad + \frac{\beta^2\tau_n}{2(\alpha + \beta)(2 + \alpha z\tau_n + \beta z\tau_n)}y^2))] \tag{A-19} \\
&= M_1 \exp(M_2) \tag{A-20}
\end{aligned}$$

Where

$$M_1 = -\frac{1}{\sqrt{1 + \frac{\beta\tau_n}{\alpha\tau_c(2 + \alpha z\tau_n + \beta z\tau_n)}}} \tag{A-21}$$

$$M_2 = \frac{m^2(2\alpha z\tau_c + \beta z\tau_n)}{2\tau_c(2\alpha\tau_c + \beta\tau_n + \alpha^2 z\tau_c\tau_n + \alpha\beta z\tau_c\tau_n)} - \frac{m\mu_0}{\tau_c} \tag{A-22}$$

The last step from equation A-19 to equation A-20 involves Lemma 5. By taking the partial derivative of equation (A-20) with respect to β and solving for $\frac{\partial E[U(W_c)]}{\partial \beta} > 0$, I get $\{\{\tau_c \geq \frac{\tau_n}{2}\}, \{\tau_c < \frac{\tau_n}{2}, m < m_c^*(z)\}\}$, where

$$m_c^*(z) = \sqrt{\frac{(2 + \alpha z\tau_n)(2\alpha\tau_c + \beta\tau_n + \alpha^2 z\tau_c\tau_n + \alpha\beta z\tau_c\tau_n)}{\alpha^2 z^2(\tau_n - 2\tau_c)(2 + \alpha z\tau_n + \beta z\tau_n)}}$$

When $\tau_c < \frac{\tau_n}{2}$, $m_c^*(z)$ decreases in adjustment cost z because

$$\frac{\partial m_c^*(z)}{\partial z} = -H \sqrt{\frac{\alpha^2 z^2(\tau_n - 2\tau_c)(2 + \alpha z\tau_n + \beta z\tau_n)}{(2 + \alpha z\tau_n)(2\alpha\tau_c + \beta\tau_n + \alpha^2 z\tau_c\tau_n + \alpha\beta z\tau_c\tau_n)}} < 0$$

where

$$\begin{aligned}
H &= \frac{1}{2\alpha^2 z^3(\tau_n - 2\tau_c)(2 + (\alpha + \beta)z\tau_n)^2} (16\alpha\tau_c + 8\beta\tau_n \\
&\quad + z\tau_n(20\alpha^2\tau_c + 16\alpha\beta\tau_c + 8\alpha\beta\tau_n + 6\beta^2\tau_n + 8\alpha^3 z\tau_c\tau_n + \alpha^4 z^2\tau_c\tau_n^2 \\
&\quad + \alpha\beta z\tau_n(12\alpha\tau_c + 4\beta\tau_c + 2\alpha\tau_n + 2\alpha^2 z\tau_n + \alpha\beta z\tau_c\tau_n))) \\
&> 0
\end{aligned}$$

Thus, by Lemma 4,

$$m < m_c^*(z) \iff z < z_c^* \quad (\text{A-23})$$

where z_c^* is the inverse function of $m_c^*(z)$ evaluated at m . \square

Proof of Corollary 2. Corollary 2 is proved by taking the limit ($z \rightarrow \infty, z \rightarrow 0, m \rightarrow 0$) of the conditions in Proposition 2. \square

Proof of Proposition 3. New investors' welfare is

$$\begin{aligned} E[U(W_n)] &= E[E[U(W_n)|y]] \\ &= -E[E[\exp(-\frac{1}{\tau_n}(\tilde{F} - p))|y]] \\ &= -E[\exp(-\frac{1}{\tau_n}((E[\tilde{F}|(y, k(y))] - p(y)) - \frac{1}{2\tau_n}Var[\tilde{F}|(y, k(y))]))] \\ &= -E[\exp(-\frac{1}{2(\tau_n)^2}Var[\tilde{F}|(y, k(y))])] \\ &= -E[\exp(-\frac{1}{2(\tau_n)^2}(m+k)^2Var[\tilde{\mu}|y])] \quad (\text{A-24}) \\ &= N_1 \exp(N_2) \quad (\text{A-25}) \end{aligned}$$

Where

$$N_1 = \frac{1}{\sqrt{1 + \frac{\beta}{\alpha(2+\alpha z\tau_n + \beta z\tau_n)^2}}} \quad (\text{A-26})$$

$$N_2 = -\frac{\alpha(\alpha + \beta)z^2m^2}{2(\beta + \alpha^3z^2\tau_n^2 + 2\alpha^2z\tau_n(2 + \beta z\tau_n) + \alpha(2 + \beta z\tau_n)^2)} \quad (\text{A-27})$$

The last step from equation A-24 to A-25 involves Lemma 5. By taking the partial derivative of equation (A-25) with respect to β and solving for $\frac{\partial E[U(W_n)]}{\partial \beta} > 0$. The solution consists of four regions: $\{\beta > \alpha, z < z_n^*\}$, $\{\beta > \alpha, z_n^* < z < z_n^{**}, m < m_n^*\}$, $\{\beta \leq \alpha, z < z_n^*\}$, and $\{\beta \leq \alpha, z > z_n^*, m < m_n^*\}$ where

$$z_n^* = \frac{\sqrt{3}}{(\alpha + \beta)\tau_n} \quad (\text{A-28})$$

$$z_n^{**} = \frac{2}{(\beta - \alpha)\tau_n} \quad (\text{A-29})$$

$$m_n^* = \frac{(2 + \alpha z\tau_n - \beta z\tau_n)(4\alpha + \beta + \alpha z\tau_n(\alpha + \beta))(4 + z\tau_n(\alpha + \beta))}{\alpha^2z^2(2 + \alpha z\tau_n + \beta z\tau_n)(\alpha^2z^2\tau_n^2 + 2\alpha\beta z^2\tau_n^2 + \beta^2z^2\tau_n^2 - 3)} \quad (\text{A-30})$$

\square

Proof of Corollary 3. Corollary 3 is proved by taking the limit of the conditions in Proposition 3. \square

Tables

Table 1: Effects of Disclosure Quality on the Mean and Variance of the Firm's Cash Flow

<i>Economies</i>	<i>Cash Flow \tilde{F}</i>	<i>Mean E</i>	<i>Variance V</i>
<i>Pure Exchange</i>	$\mu_0 + \tilde{\mu}$	<i>Constant</i>	<i>Decrease</i>
<i>No Endowment</i>	$k\tilde{\mu} - \frac{z}{2}k^2$	<i>Increase</i>	<i>Increase/Decrease</i>
<i>CRTS</i>	$m(\mu_0 + \tilde{\mu}) + k\tilde{\mu}$	<i>Increase</i>	<i>Increase</i>
General Economy	$m(\mu_0 + \tilde{\mu}) + k\tilde{\mu} - \frac{z}{2}k^2$	Increase	Increase/Decrease

Table 2: Effects of Disclosure Quality on Cost of Capital and Investors' Welfare

<i>Economies</i>	<i>Cost of Capital</i>	<i>Current Investors' Welfare</i>	<i>New Investors' Welfare</i>
<i>Pure Exchange</i>	<i>Decrease</i>	<i>Increase/Decrease</i>	<i>Decrease</i>
<i>No Endowment</i>	<i>Decrease</i>	<i>Increase</i>	<i>Increase/Decrease</i>
<i>CRTS</i>	<i>Increase</i>	<i>Increase</i>	<i>Increase</i>
General Economy	Increase/Decrease[♡]	Increase/Decrease[♣]	Increase/Decrease[♠]
Note: Conditions of ♡, ♣, and ♠ differ from and do not subsume each other.			