Firms' Capital Allocation Choices, Information Quality, and the Cost of Capital*

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Abstract

In this paper, we establish a link between information quality, firms' capital investment decisions and their cost of capital. We characterize asset prices in a market equilibrium framework with perfect competition for firm shares and derive a pricing equation that is equivalent to the CAPM. Using this characterization, we show that higher information quality leads to a lower cost of capital via its effect on expected cash flows. Better information improves the coordination between firms and investors with respect to capital investment decisions, which investors price in equilibrium by discounting firms' expected cash flows at a higher rate. This effect survives the forces of diversification in a capital market with perfect competition, even when information quality is uncorrelated across firms.

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1 Introduction

In this paper, we examine the link between information quality and a firm's cost of capital, which we define as the rate of return with which market participants discount the firm's future cash flows.[1] We ask whether there is theoretical support for the notion that a firm's cost of capital decreases in the quality of its reports to the market, or equivalently, whether investors discount cash flows of firms with lower information quality at a higher rate of return.

A key issue in answering this question is whether differences in information quality across firms survive the forces of diversification if investors can create portfolios of many assets. A common argument for why information quality is *not* reflected in firms' cost of capital is that information quality results in idiosyncratic risk, i.e., uncorrelated across firms, and hence diversifiable in portfolios of many assets. That is, the quality of individual firms' reports "averages out" across firms in the portfolio. We show that this intuition can be misleading, even in the world of the Capital Asset Pricing Model (CAPM).

In the first part of our paper, we characterize asset prices in a market equilibrium framework with perfect competition for firm shares and risk-averse investors. Within this framework, we derive a pricing equation for firm shares that is equivalent to the CAPM in that only systematic risk, i.e., the firm's covariance with the market portfolio, is priced. Using this characterization, we show that, somewhat surprisingly, shocks to the level of expected cash flows are reflected in the firm's cost of capital, i.e., the rate with which the market discounts the firm's expected cash flows. Thus, to the extent that information quality has an impact on expected cash flows it can

[1] This definition is frequently used in corporate finance, for instance, in firm valuation, capital budgeting, and in estimating the cost of capital implied in market valuations and forecasts of future cash flows (e.g., Fama, 1976, Fama and French, 1999; Gebhardt et al., 2001).

also alter the firm's cost of capital. This statement is true, even if information quality itself is idiosyncratic, i.e., uncorrelated across firms.

In the second part of our analysis, we illustrate *why* and *how* such cash flow effects of information quality can occur. We model an economy in which a firm reports on its investment opportunities to the market. Managers select projects that maximize market value, where market value reflects the firm's report to the market. In this setting, the quality of the report affects investment choice, which in turn affects the level of expected cash flows. This setting attempts to capture the notion that equity markets play a role in allocating capital and directing firms' investment choices (e.g., Tobin, 1982). Given this function, the quality of financial reporting is important because it affects the market's ability to direct firms' capital allocation choices. Our model captures this idea in that firm reports coordinate the activities of managers and investors with respect to the firm's capital investment. As a consequence, information quality affects firms' future cash flows, not just the *perceptions* of these cash flows by market participants. While our approach may overstate the role of reporting quality in the generation of firms' cash flows, we view our analysis more as an illustration of *how* information quality can affect firms' capital allocation choices and *why* this results in a relation between information quality and firms' cost of capital.

We show that, in this case, higher information quality reduces the firm's cost of capital, even if information quality is uncorrelated across firms. The intuition is that higher information quality improves the coordination between firms and investors with respect to capital investment decisions. This effect results in an increase in expected cash flows without a commensurate increase in the firm's covariance with the market, which given the first part of our analysis has a negative effect on the firm's cost of capital. In essence, we show that investors price the misalignment risk that stems from poor reporting in firms' cost of capital.

Despite the fact that the link between information quality and the cost of capital is one of the most fundamental tenets in finance and accounting, there is surprisingly little theoretical work analyzing this link. Several recent empirical studies suggest that disclosure or information quality metrics are negatively associated to the firm's cost of capital, measuring the latter as the discount factor implied by market prices and forecasts of future cash flows (e.g., Botosan, 1997; Botosan and Plumlee, 2002; Francis et al., 2005). This line of research generally presupposes that there is a theoretical link between information quality and the firm's cost of capital *and* that this link does not disappear when investors form portfolios of many firms. In essence, differences in information quality across firms have to result in non-diversifiable differences in risk. Our model shows that the cash flow effects of information quality are reflected in firms' cost of capital. This result extends the literature in providing a direct link between the information quality of the firm's reports and its cost of capital in a competitive equilibrium framework.

Prior work suggests that better information can reduce the rate of return demanded by investors by enlarging the firm's investor base, thereby improving risk sharing (Merton, 1987), and by reducing estimation risk (Barry and Brown, 1985). However, the effect of the investor base is susceptible to arbitrage (Merton, 1987; Easley and O'Hara, 2004) and there is much debate about the diversifiability and pricing of estimation risk (e.g., Clarkson et al., 1996; Lewellen and Shanken, 2002), both of which raise the issue of whether these effects are likely to explain the empirical evidence. In contrast, our effect is robust to arbitrage, and we explicitly show that it exists in a CAPM world where investors can hold shares in many assets.

Another strand of literature suggests an indirect link between information quality and firms' cost of capital via market liquidity. The disclosure literature shows that a firm's commitment to disclosure reduces information asymmetries between investors, which, in turn, increases the liquidity of equity markets (Verrecchia, 2001; Leuz and Verrecchia, 2000). It is unclear, however, whether a reduction in information asymmetry also lowers the firm's cost of capital. Standard liquidity-based models do not provide such a link (e.g., Diamond and Verrecchia, 1991; Baiman and Verrecchia, 1996). In these models, uninformed investors anticipate that they may face a future liquidity shock forcing them to sell shares to potentially better-informed traders. This adverse selection problem reduces the willingness of uninformed investors to transact in firm shares and decreases the amount they bid for the shares.[2] For the same reason, firms receive less for their shares when issuing equity in an IPO or SEO. Thus, the adverse selection problem results in transaction costs to investors and in a one-time cost of raising equity to firms, but it does not result in systematic differences in risk that are reflected in expected returns.

There are, however, liquidity-based models that indirectly link information quality and firms' expected returns. Amihud and Mendelson (1986) analyze a model in which investors with different expected holding periods prefer to trade assets with different relative spreads because they demand compensation for the spreads. This clientele effects give rise to return differentials, i.e., expected returns are increasing in the spread (or the amount of information asymmetry). Easley and O'Hara (2004) develop a model in which investors demand a lower return for stocks with greater public and less private information. The basic idea of their model is that private information imposes risk on uninformed investors because they are not able to adjust their

[2] On the flip side, uninformed sellers increase the amount at which they are willing to sell the share. The price protection on both sides gives rise to the information-asymmetry component of the bid-ask spread.

portfolios weights in the same way as informed investors. In equilibrium, uninformed investors demand a risk premium for holding a portfolio that is not optimal based on both private and public information. In both models, the link between disclosure and the firm's cost of capital arises due to information asymmetries between traders in secondary markets.

This paper is not built on liquidity effects. Our innovation is twofold. First, we show that changes in expected cash flow impact the firm's cost of capital, even in a CAPM world. Second, we introduce a link between information quality and the firm's cash flows. The model captures the interaction between firms and investors in equity markets, and the fundamental role of information in improving the efficiency of firms' investment decisions. Reporting quality has real effects that manifest in firms' cost of capital. Poor information quality leads to misaligned investment, which rational investors anticipate and price in equilibrium by discounting firms' expected cash flows at a higher rate of return. We view this link to be in the spirit of empirical studies that directly estimate the relation between disclosure and information metrics and firms' cost of capital, without reference to market liquidity (e.g., Botosan, 1997; Botosan and Plumlee, 2002; Francis et al., 2005).

We emphasize, however, that we do not dispute the possible roles of investor recognition, estimation risk or market liquidity. In fact, several papers document that liquidity measures and returns are negatively associated, suggesting that information asymmetry among traders in secondary markets are priced in returns (e.g., Amihud and Mendelson, 1986; Chordia et al., 2001; Easley et al., 2002; Pastor and Stambaugh, 2003). Our paper simply suggests an alternative explanation as to how information quality and the firm's cost of capital are linked.

The paper is organized as follows. Section 2 delineates the assumptions of our analysis and characterizes market prices. Section 3 analyzes which factors reduce a firm's cost of capital. Section 4 introduces the notion of perfect competition and discusses its implications for the determinants of the cost of capital. Section 5 extends the model to include a role for information. Section 6 concludes the paper.

2 Assumptions of the analysis

2.1 Cost of capital

Consider an economy with M firms, indexed by the subscript $j = 1, 2, ..., M$, and a risk-free bond. Without loss of generality, we assume throughout the analysis that the risk-free rate of return is 0; that is, an investment of \$1 in the risk-free bond yields a return of \$1. Let $\tilde{c}_j$ and P_j represent the uncertain cash flows of firm j and the market equilibrium price of firm j, respectively. We characterize firm j's cost of capital (henceforth, CoC) as the rate of return R_j that results from the equating the price of firm j to its expected cash flow in the relation

$$P_j = \frac{E\left[\tilde{c}_j\right]}{1 + R_j},$$

or, equivalently,

$$1 + R_j = \frac{E\left[\tilde{c}_j\right]}{P_j}.$$

This characterization of the cost of capital is widespread in accounting and finance (e.g., Fama, 1976). For instance, it is used in discounted cash flow models valuing firms or in capital budgeting. Similarly, it is employed in estimating the implied cost of capital from analyst forecasts (e.g., Botosan, 1997; Gebhardt et al., 2001).

Let n_j represent some measure of the quality or quantity of the information firm j discloses to investors and the market. For convenience, we refer to n_j as firm j's information quality. The motivation for our analysis is to determine when an increase (decrease) in firm j's information quality results in a corresponding decrease (increase) in firm j's CoC, R_j. Viewed as a comparative static, our goal is to determine when $\frac{d}{dn_j}R_j < 0$.

To elaborate briefly, a special (or trivial) case in which a change in n_j has no effect on firm j's CoC occurs when the market equilibrium price of firm j is equal to its expected cash flows: that is, $P_j = E[\tilde{c}_j]$. Here $R_j = 0$; hence changes in the distributional characteristics of firm cash flows and/or information about that distribution have no effect on the firm's CoC. While a circumstance in which the price of the firm equals its expected cash flows illustrates the absence of a relation between n_j and R_j, this case is arguably uninteresting. It amounts to a risk-neutral world where uncertainty underlying firm j's cash flows are not "priced," i.e., they are not reflected in P_j. In such a world, an analysis of CoC and its relation with information quality is moot. Consequently, in the next subsection we consider a more general case in which risk and uncertainty are "priced."

2.2 Investors

Along with the M firms, we introduce a perfectly competitive market for firm shares comprised of N investors, where N is large. We index investors by the subscript $i = 1, 2, ..., N$. We assume that investors are risk-averse. Without risk aversion, it is difficult to have a meaningful discussion about CoC. As we discussed in the prior subsection, in the absence of risk and uncertainty our measure of CoC, R_j, would be 0 for all firms $j = 1, 2, ...M$.

Let $U(c)$ represent investor i's utility preference for an amount of cash c. Each investor has a negative exponential utility function: that is, $U(c)$ is defined by

$$U(c) = \tau\left(1 - \exp\left[-\frac{1}{\tau}c\right]\right),$$

where $\tau > 0$ describes each investor's (constant) tolerance for risk. Note that this characterization of the negative exponential has the feature that as risk tolerance becomes unbounded, $U(c)$ converges asymptotically to risk neutrality:

$$\lim_{\tau\to\infty} U(c) = \lim_{\tau\to\infty} \tau \left(1 - \exp\left[-\frac{1}{\tau}c\right]\right) \to c.$$

In addition, $U(\cdot)$ is standardized such that $U(0) = 0$.

2.3 Market prices

Now consider the market price for firm j that prevails in a perfectly competitive market in which N investors compete to hold shares in each firm, as well as a risk-free bond. Let $\bar{D}_i = \{D_{i1}, D_{i2}, ..., D_{ij}, ..., D_{iM}\}$ represent the $1 \times M$ vector of investor i's demand for ownership in M firms, where D_{ij} represents investor i's demand for firm j expressed as percentage of the total firm; let $\bar{D}_i^* = \left\{D_{i1}^*, D_{i2}^*, ..., D_{ij}^*, ..., D_{iM}^*\right\}$ represent her vector of endowed ownership in firms, where D_{ij}^* represents her endowment in firm j expressed as a percentage of the total firm; and let $\bar{P} = \{P_1, P_2, ..., P_j, ..., P_M\}$ represent the vector of firm prices, where once again P_j represents the price of firm j. Let B_i and B_i^* represent investor i's demand for a risk-free bond and her endowment in bonds, respectively. Each investor solves

$$\max_{\bar{D}_i, B_i} E[\tau(1 - \exp[-\frac{1}{\tau}(\bar{D}_i\{\tilde{c}_1, \tilde{c}_2, ..., \tilde{c}_M\}' + B_i)])] \tag{1}$$

subject to the budget constraint

$$\bar{D}_i\bar{P}' + B_i = \bar{D}_i^*\bar{P}' + B_i^*.$$

Note that eqn. (1) reduces to

$$\max_{\bar{D}_i, B_i} \tau(1 - \exp[-\frac{1}{\tau}(\bar{D}_i\{E[\tilde{c}_1] - P_1, E[\tilde{c}_2] - P_2, ..., E[\tilde{c}_M] - P_M\}' + \bar{D}_i^*\bar{P}' + B_i^*) + \frac{1}{2}\frac{1}{\tau^2}\bar{D}_i V \bar{D}_i']), \tag{2}$$

where V is an $M \times M$ covariance matrix whose s, t-th term is $Cov[\tilde{c}_s \cdot \tilde{c}_t]$.

The first-order condition that maximizes eqn. (2) with respect to D_{ij} reduces to

$$0 = E[\tilde{c}_j] - P_j - \frac{1}{\tau} \sum_{s=1}^{M} D_{is} Cov[\tilde{c}_j \cdot \tilde{c}_s]. \tag{3}$$

Because collectively investors have claims to the cash flows of the entire firm, for each s it must be the case that $\sum_{i=1}^{N} D_{is} = 1$. Thus, summing over both sides of eqn. (3) with respect to i yields

$$0 = N(E[\tilde{c}_j] - P_j) - \frac{1}{\tau} \sum_{i=1}^{N} \sum_{s=1}^{M} D_{is} Cov[\tilde{c}_j \cdot \tilde{c}_s],$$

or

$$0 = N(E[\tilde{c}_j] - P_j) - \frac{1}{\tau} \sum_{s=1}^{M} Cov[\tilde{c}_j \cdot \tilde{c}_s].$$

This, in turn, implies that the price for firm j is given by

$$P_j = E[\tilde{c}_j] - \frac{1}{N\tau} \sum_{s=1}^{M} Cov[\tilde{c}_j \cdot \tilde{c}_s]. \tag{4}$$

It is important to note that this expression for the price for firm j is equivalent to the one that arises from the Capital Asset Pricing Model (CAPM).[3] To illustrate this claim, let $\tilde{c}_0$ represent the sum of the cash flows of all firms in the economy (or market portfolio), σ_0^2 the variance of the sum of all the cash flows, and P_0 the sum of the price of all firms, respectively: that is, $\tilde{c}_0 = \sum_{j=1}^{M} \tilde{c}_j$, $\sigma_0^2 = E\left[(\tilde{c}_0 - E[\tilde{c}_0])^2\right]$, and $P_0 = \sum_{j=1}^{M} P_j$. In the context of our notation, and allowing for the fact that the risk-free rate is 0, Fama (1976) characterizes the CAPM as a market equilibrium pricing equation that yields the following relation among firm prices and firm cash flows (see eqn. [87], p. 312):

$$P_j = E[\tilde{c}_j] - \left(\frac{E[\tilde{c}_0] - P_0}{\sigma_0^2}\right) Cov[\tilde{c}_j \cdot \tilde{c}_0].$$

[3] See Sharpe (1964) and Lintner (1965).

In our analysis,

$$P_j = E[\tilde{c}_j] - \frac{1}{N\tau} Cov[\tilde{c}_j \cdot \tilde{c}_0],$$

which implies

$$\begin{aligned} P_0 &= \sum_{j=1}^{M} P_j \\ &= \sum_{j=1}^{M} E[\tilde{c}_j] - \frac{1}{N\tau} \sum_{j=1}^{M} \sum_{s=1}^{M} Cov[\tilde{c}_j \cdot \tilde{c}_s] \\ &= E[\tilde{c}_0] - \frac{1}{N\tau} \sigma_0^2. \end{aligned}$$

This, in turn, implies

$$\frac{E[\tilde{c}_0] - P_0}{\sigma_0^2} = \frac{1}{N\tau},$$

which in essence constitutes the market price of covariance (or non-diversifiable) risk in the economy. Hence, our derivation of the price of firm j as

$$P_j = E[\tilde{c}_j] - \frac{1}{N\tau} Cov[\tilde{c}_j \cdot \tilde{c}_0] \tag{5}$$

is equivalent to Fama's characterization of the CAPM as a market equilibrium pricing equation.

3 Cost of capital

3.1 Factors that reduce cost of capital

In this section we consider factors that reduce CoC based on our derivation of the firm's equilibrium price as expressed in eqn. (5). Toward that purpose, it is useful first to introduce a characterization of firm j's cash flows. Specifically, we assume that firm j's cash flows can be characterized by

$$\tilde{c}_j = \alpha_j + \beta_j \tilde{\theta} + \gamma_j \tilde{\pi}_j,$$

where: $\tilde{\theta}$ and $\tilde{\pi}_j$ are independent, normally distributed random variables with a mean of 0 and (finite) precisions of q and h_j, respectively; α_j is an intercept term; and β_j and γ_j are (finite) coefficients associated with the random variables $\tilde{\theta}$ and $\tilde{\pi}_j$, respectively. In addition, we assume that the $\tilde{\pi}_j$'s are uncorrelated across firms: that is, $E\left[\tilde{\pi}_j \cdot \tilde{\pi}_s\right] = 0$. In effect, we assume that firm j's cash flows have an element of common variation across firms through $\tilde{\theta}$, and an element of idiosyncratic variation through $\tilde{\pi}_j$. This characterization captures the notion that industry- or economy-wide events affect the cash flows of many or all firms, while firm-specific, or idiosyncratic, events only affect that cash flows of a specific firm (e.g., a fire in firm j's factory). The latter set of events is typically considered diversifiable and not priced in a CAPM setting.

With this characterization of cash flows, note that

$$\begin{aligned} Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right] &= Cov\left[\tilde{c}_j \cdot \sum_{s=1}^{M} \tilde{c}_s\right] \\ &= \beta_j \sum_{s=1}^{M} \beta_s E\left[\tilde{\theta}^2\right] + \gamma_j^2 E\left[\tilde{\pi}_j^2\right] \\ &= \beta_j \sum_{s=1}^{M} \beta_s \frac{1}{q} + \gamma_j^2 \frac{1}{h_j}. \end{aligned}$$

We interpret $\beta_j \sum_{s=1}^{M} \beta_s \frac{1}{q}$ as the element of common variation in firm j's cash flows with the market and $\gamma_j^2 \frac{1}{h_j}$ as the element of idiosyncratic variation. Substituting this into our derivation of P_j yields

$$P_j = E\left[\tilde{c}_j\right] - \frac{1}{N\tau}\left(\beta_j \sum_{s=1}^{M} \beta_s \frac{1}{q} + \gamma_j^2 \frac{1}{h_j}\right),$$

and the following characterization of R_j

$$\begin{aligned} R_j &= \frac{E\left[\tilde{c}_j\right]}{P_j} - 1 \\ &= \frac{\frac{1}{N\tau}\left(\beta_j \sum_{s=1}^{M} \beta_s \frac{1}{q} + \gamma_j^2 \frac{1}{h_j}\right)}{E\left[\tilde{c}_j\right] - \frac{1}{N\tau}\left(\beta_j \sum_{s=1}^{M} \beta_s \frac{1}{q} + \gamma_j^2 \frac{1}{h_j}\right)}. \end{aligned} \qquad (6)$$

Eqn. (6) makes clear that there are a number of factors that lead to a reduction in firm j's CoC. They include:

1) The variance in the idiosyncratic variation in firm j's cash flows, h_j^{-1}, declines;

2) The variance in the common variation in firm j's cash flows with the market, q^{-1}, declines;

3) The shareholder base of the economy increases, which is to say that the number of investors who participate in the market, N, increases;

4) The risk tolerance of the market, τ, increases; and/or

5) Firm j's expected cash flows increase.

The first two factors confirm the intuition that, in a risk-averse world, less risk implies a lower cost of capital. The CAPM notion is that, in equilibrium, only common variation in firm j's cash flows with the market (or covariance risk) is priced, i.e., is reflected in the firm's CoC. Idiosyncratic variation in firm j's cash flows is typically considered diversifiable by holding a portfolio of many firms. That is, investors do not have to bear this risk and, hence, it is not compensated in equilibrium. We show this in the next section.

The third factor represents the shareholder base effect described in Merton (1987). A larger shareholder base implies that the market price of risk decreases because (non-diversifiable) risk in the economy can be spread over a large number of investors. A similar intuition applies to the fourth factor. The market price of risk decreases if investors are less risk averse. In the limit, where investors are risk neutral, there is no compensation for any risk.

Finally, and perhaps somewhat surprisingly, the level of firm j's cash flows also matters. An increase in expected cash flows not only has a "numerator" effect, but also affects the firm's cost of capital R_j. The reason is that, as expected cash flows increase, the price P_j at which the market values the firm j's shares generally increases at a different rate. Thus, the effect on R_j depends on how fast price increases relative to the expected cash flows, which in turn depends on the other parameters of characterization, e.g., the covariance of the cash flows with the market or the degree of risk aversion. We will return to this key insight of our characterization.

The primary motivation for our analysis is to determine when an increase (decrease) in firm j's information quality results in a corresponding decrease (increase) in firm j's CoC, R_j. Based on the above characterization, it is obvious that an increase in firm j's information quality reduces either the variance in the idiosyncratic variation in firm j's cash flows, or investors' perceptions of that variance, firm j's CoC declines. The latter notion is discussed in the literature on estimation risk or parameter uncertainty (e.g., Barry and Brown, 1985; Coles et al., 1995). The idea is that an increase in disclosure (or information about the firm) reduces investors' uncertainty about the parameters that are relevant in pricing the firm. Arguably, however, such effects are largely diversifiable (e.g., Clarkson et al. 1996).

4 Cost of capital with a large number of investors

4.1 Perfect competition

In this section we consider the CoC when the number of investors becomes sufficiently large as to eliminate a role for the variance in the idiosyncratic variation in the market valuation of the firm's cash flows. The motivation for this setting arises from the fact that perfect competition requires that the number of investors in the economy, N, be large enough that each investor behaves as if his or her demand for shares in a firm has no effect on price. In the language of mathematics, perfect competition is interpreted typically as a requirement that N be countably infinite.

The requirement that N be countably infinite is potentially problematic in that it can lead to the expression $\frac{1}{N}Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right]$ "disappearing," or going off to zero entirely, as $N \to \infty$. When $\frac{1}{N}Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right]$ "disappears," the price of firm j is simply the expected value of its cash flows, and there is no role for risk and uncertainty: that is, $P_j = E\left[\tilde{c}_j\right]$. In light of this issue, a standard convention in the rational expectations literature is to assume that aggregate risk becomes large enough such that, in equilibrium, each investor must absorb some risk (e.g., Hellwig, 1980; Verrecchia, 1982; Admati, 1985). One justification for why this happens is that M, the number of firms in the economy, grows in proportion to N, the number of investors in the economy, such that $\lim_{N\to\infty}\frac{1}{N}\sum_{j=1}^{M}\beta_j = \beta_0$, where β_0 is positive and finite valued (i.e., β_0 does not go off to 0 as N becomes large). This, in turn, implies that $\frac{1}{N\tau}Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right]$ does not "disappear" as N becomes large.

When we assume $\lim_{N\to\infty}\frac{1}{N}\sum_{j=1}^{M}\beta_j = \beta_0$, we can characterize $\lim_{N\to\infty}\frac{1}{N}Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right]$ as

$$\begin{aligned}\lim_{N\to\infty}\frac{1}{N}Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right] &= \lim_{N\to\infty}\frac{1}{N}Cov\left[\tilde{c}_j \cdot \sum_{s=1}^{M}\tilde{c}_s\right] \\ &= \beta_j \lim_{N\to\infty}\frac{1}{N}\sum_{s=1}^{M}\beta_s E\left[\tilde{\theta}^2\right] + \lim_{N\to\infty}\frac{1}{N}\gamma_j^2 E\left[\tilde{\pi}_j^2\right] \\ &= \beta_j\beta_0\frac{1}{q}, \end{aligned} \qquad (7)$$

where the last equality follows from the observation that

$$\lim_{N\to\infty}\frac{1}{N}\gamma_j^2 E\left[\tilde{\pi}_j^2\right] = \lim_{N\to\infty}\frac{1}{N}\gamma_j^2\frac{1}{h_j} \to 0.$$

In words, eqn. (7) implies that as the number of investors becomes large, $\frac{1}{N}Cov\left[\tilde{c}_j \cdot \tilde{c}_0\right]$

converges to the product of firm j's coefficient with the element of common variation, β_j, and the market's coefficient with common variation, β_0, times the variance in the common variation, $\frac{1}{q}$. In the language to the CAPM, the expression $\beta_j \beta_0 \frac{1}{q}$ can be interpreted as firm j's "beta": that is, the degree to which firm j's cash flows covary with the total market cash flows. In contrast, firm j's idiosyncratic component disappears as N becomes large because $\gamma_j^2 \frac{1}{h_j}$ is finite. This is consistent with the widespread notion that idiosyncratic components are diversifiable and not priced in the CoC.

4.2 Perfect competition and cost of capital

Eqn. (7) implies that as the number of investors becomes large, our derivation of P_j reduces to

$$P_j = E\left[\tilde{c}_j\right] - \beta_j \beta_0 \frac{1}{\tau q}. \tag{8}$$

In addition, we can express the CoC of firm j as

$$\begin{aligned} R_j &= \frac{E\left[\tilde{c}_j\right]}{P_j} - 1 \\ &= \frac{\beta_j \beta_0 \frac{1}{\tau q}}{E\left[\tilde{c}_j\right] - \beta_j \beta_0 \frac{1}{\tau q}}. \end{aligned} \tag{9}$$

Eqn. (9) offers a characterization of CoC that is compatible with both the CAPM and competitive equilibrium pricing, where the latter relies on the number of investors who participate in the economy being countably infinite. Despite the fact that this characterization explicitly incorporates the diversification of idiosyncratic components, information quality nonetheless can have cash flow effects and such cash flow effects can impact CoC. We illustrate this possibility in the next section.

5 Information quality and the cost of capital

5.1 Motivation

In this section we extend our model to include a role for information. To illustrate *why* and *how* information quality can affect the firm's expected cash flows, we analyze a setting where each firm j reports on its investment opportunities to the market. Firms' investment opportunities are unobservable to investors and non-contractible. Next, we assume that, to align the interests of managers with their own, investors provide managers with incentives to maximize the market value of the firm. Consequently, managers select projects that maximize market price, given the firm's report to the market. In this setting, the quality of the report affects investment choice, which in turn affects the level of expected cash flows.

More specifically, the effect of higher information quality is to improve the investment efficiency of the firm. It does not, however, alter the firm's covariance with the market: that is, $\beta_j \beta_0 \frac{1}{\tau q}$ stays fixed. The idea is that the firm's technology or investment project essentially determines the covariance of the firm's cash flows with the market. Information quality simply affects the efficiency with which this investment project is implemented. Put differently, better information quality leads to better alignment between the firm's investment opportunities and its investment choices.

This setting is meant to illustrate that even when information quality is firm specific and has no effect on the covariance of the firm's cash flows, it nevertheless affects the CoC through its impact on the level of expected cash flows. Thus, the intuition that idiosyncratic differences in information quality lead to idiosyncratic risk that is diversifiable in portfolios of many assets and hence not priced in the CoC in equilibrium is misleading.

5.2 Cash flows and reports

To start, we assume that firm j's cash flows arise from a process in which an investment of an amount k_j results in cash flows of $\tilde{c}_j = \beta_j \tilde{\theta} + k_j \tilde{\pi}_j - \frac{1}{2} k_j^2$, where: $\tilde{\theta}$ and $\tilde{\pi}_j$ are independent, normally distributed random variables with a mean of 0 and precisions of q and h_j, respectively; β_j is a positive, fixed coefficient; and k_j is firm j's investment choice.[4] In addition, we assume that the $\tilde{\pi}_j$'s are uncorrelated across firms: that is, $E[\tilde{\pi}_j \cdot \tilde{\pi}_s] = 0$. Note that setting $\alpha_j \equiv -\frac{1}{2} k_j^2$ and $\gamma_j \equiv k_j$ makes our characterization of cash flows here identical to the one in Section 3.1.

We interpret $\tilde{\pi}_j$ as firm j's revenue-per-unit-of-investment. $\tilde{\pi}_j$ is unknown or unobservable to the market. However, each firm provides the market with a report $\tilde{r}_j$ of its revenue per-unit-of-investment with some noise. That is,

$$\tilde{r}_j = \tilde{\pi}_j + \tilde{\varepsilon}_j,$$

where the noise component, $\tilde{\varepsilon}_j$, has a normal distribution with mean 0 and precision n_j. We assume that noise components in reporting across firms, i.e., the $\tilde{\varepsilon}_j$'s, are also uncorrelated across firms: that is, $E[\tilde{\varepsilon}_j \cdot \tilde{\varepsilon}_s] = 0$.

Let $P_j(r_j)$ represent the price of firm j conditional on a report $\tilde{r}_j = r_j$, where $P_j = E[P_j(\tilde{r}_j)]$. From eqn. (6), we express $P_j(r_j)$ as

$$\begin{aligned} P_j(r_j) &= E[\tilde{c}_j | r_j] - \beta_j \beta_0 \frac{1}{\tau q} \\ &= k_j E[\tilde{\pi}_j | r_j] - \frac{1}{2} k_j^2 - \beta_j \beta_0 \frac{1}{\tau q} \\ &= k_j \frac{n_j}{h_j + n_j} r_j - \frac{1}{2} k_j^2 - \beta_j \beta_0 \frac{1}{\tau q}. \end{aligned}$$

[4] Having cash flows, or net profits, be a function of investment through an expression that is similar or identical to $k_j \tilde{\pi}_j - \frac{1}{2} k_j^2$, where $-\frac{1}{2} k^2$ captures the notion that there are diminishing returns to investment, is a standard convention: see, for example, Fischer and Verrecchia (2005).

We assume that firm j's investment choice is made to maximize the market price of the firm conditional on a report $\tilde{r}_j = r_j$. Note that this assumption implies that the manager's information about $\tilde{\pi}$ plays no role; what matters is the report $\tilde{r}$ to the market. We motivate this assumption as follows. Firms' investment opportunities are unobservable to investors and not contractible. Hence, to overcome resulting agency problems, shareholders provide incentives to maximize market value. Stock-based compensation is very common in practice and is widely suggested as a way to align the interests of managers and shareholders (e.g., Lambert, 2001; Bushman and Smith, 2001). Specifically, we assume that incentives are a monotonically increasing function of the firm's market value or price.

Let $\hat{k}_j$ represent the investment choice that maximizes market price conditional on the firm's report $\tilde{r}_j = r_j$. Applying the first-order condition for maximizing $P_j(r_j)$ with respect to k_j yields

$$\hat{k}_j = \frac{n_j}{h_j + n_j} r_j.$$

Substituting $\hat{k}_j$ back into $P_j(r_j)$ implies

$$P_j(r_j) = \frac{1}{2}\left(\frac{n_j}{h_j + n_j} r_j\right)^2 - \beta_j \beta_0 \frac{1}{\tau q}.$$

This, in turn, implies that

$$\begin{aligned} P_j &= E\left[P_j(\tilde{r}_j)\right] \\ &= \frac{1}{2}\frac{n_j}{(h_j + n_j) h_j} - \beta_j \beta_0 \frac{1}{\tau q}. \end{aligned}$$

We emphasize two issues that relate to the assumption that firm j's investment choice is made to maximize the market price of the firm. First, we acknowledge that in practice firms' incentives are likely to be more complex and involve other performance measures (e.g., Paul, 1992, Bushman and Indjejikian, 1993). By the same token, and as a second point of emphasis, the assumption that firm j's investment choice is made to maximize the market price of the firm conditional on a report $\tilde{r}_j = r_j$ is not crucial for our results. In our setting this assumption is equivalent to managers maximizing the firm's cash flows conditional on a report $\tilde{r}_j = r_j$. Our preference for maximizing firm price is that it illustrates the role share markets play in firms' capital allocation choices, and that financial reporting affects the market's ability to perform this function. This highlights that reporting quality and investment decisions are linked *when* managers care about market price and market price reflects a firm's report.

Now let $c_j(r_j)$ represent the cash flows of firm j conditional on a report $\tilde{r}_j = r_j$ and an investment choice $\hat{k}_j$, where $E[\tilde{c}_j] = E[c_j(\tilde{r}_j)]$. We express $c_j(r_j)$ as

$$c_j(r_j) = \hat{k}_j \frac{n_j}{h_j + n_j} r_j - \frac{1}{2}\hat{k}_j^2.$$

Thus,

$$\begin{aligned} E[\tilde{c}_j] &= E[c_j(\tilde{r}_j)] \\ &= \frac{1}{2}\frac{n_j}{(h_j + n_j)\, h_j}. \end{aligned}$$

Finally, our expression for the price of firm j and its expected cash flows implies the following characterization of CoC

$$R_j = \frac{\beta_j \beta_0 \frac{1}{\tau q}}{\frac{1}{2}\frac{n_j}{(h_j+n_j)h_j} - \beta_j \beta_0 \frac{1}{\tau q}}. \qquad (10)$$

5.3 Comparative statics

Next, we determine how changes in various exogenous parameters are associated with a change in R_j. Consider first an increase in the information quality of firm j (i.e., an increase in n_j). Taking the derivative of R_j with respect to n_j in eqn. (10) yields

$$\frac{d}{dn_j}R_j = -\frac{2h_j^2\beta_j\beta_0\frac{1}{\tau q}}{\left(n_j - 2h_j\left(h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau q}\right)^2} < 0.$$

In short, an increase in quality results unequivocally in lower CoC. As we suggest at the beginning of this section, the intuition that underlies this comparative static is that an increase in information quality increases investment alignment. This, in turn, increases expected cash flows, while having no effect on the covariance of those cash flows with the market. Hence, the market equilibrium price of those cash flows rises faster than the expectation of those cash flows, and CoC falls.

Next, consider a reduction in either: 1) market uncertainty, as manifest in the precision of $\tilde{\theta}$, the element of common variation in firms' cash flows; or 2) investors' risk tolerance. As market uncertainty falls, i.e., as q increases, firm j's CoC declines:

$$\frac{d}{dq}R_j = -\frac{2h_jn_j\left(h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau q^2}}{\left(n_j - 2h_j\left(h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau q}\right)^2} < 0.$$

Similarly, as investors' risk tolerance increases, i.e., as τ increases, firm j's CoC declines:

$$\frac{d}{d\tau}R_j = -\frac{2h_jn_j\left(h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau^2 q}}{\left(n_j - 2h_j\left(h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau q}\right)^2} < 0.$$

Both of these results comport well with one's intuition that either less uncertainty, or greater tolerance for the uncertainty, should be manifest in a lower CoC.

Finally, consider a reduction in the variance in firm j's revenue-per-unit-of-investment; this is equivalent to an increase in h_j, the precision of $\tilde{\pi}_j$. In our model, h_j captures the "option" effect of investment opportunities. Specifically, as h_j increases, there is less variation in $\tilde{\pi}_j$, which implies that firm j has fewer opportunities to register large increases in cash flows. Consequently, as h_j increases, firm j anticipates lower cash flows with no commensurate reduction in the covariance of those cash flows with the market. Thus, an increase in h_j leads to an increase in R_j:

$$\frac{d}{dh_j}R_j = \frac{2n_j\left(2h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau q}}{\left(n_j-2h_j\left(h_j+n_j\right)\beta_j\beta_0\frac{1}{\tau q}\right)^2} > 0.$$

6 Conclusion

In this paper, we develop a simple model to analyze the relation between information quality and firms' CoC. We first characterize asset prices in a market equilibrium framework with perfect competition for firm shares and risk-averse investors. Using this characterization, we show that, even in a CAPM world, an increase in the level of expected cash flows can result in a decrease in the firm's cost of capital.

Next, we extend the model to illustrate why and how such cash flow effects of information quality can occur. We propose a setting in which a firm reports on its investment opportunities to the market. Managers select projects that maximize market value, but market value reflects the firm's report to the market. In this setting, the quality of the report affects investment choice, which in turn affects the level of expected cash flows. This setting captures the notion that reporting to capital markets plays a crucial role in allocating capital and that therefore reporting quality affects firms' future net cash flows, not just the perceptions of these net cash flows by market participants, as for instance in models of estimation risk.

In this setting, higher information quality increases expected cash flows, which in turn reduces the firm's cost of capital. Poor information quality leads to misaligned capital investment by the firm, which rational investors anticipate and price in equilibrium by discounting firms' expected cash flows at a higher rate of return. This result holds even in the stark case where information quality is idiosyncratic, i.e., uncorrelated across firms. Higher information quality improves investment efficiency leading to an increase in expected cash flows without a commensurate increase in the covariance of these cash flows with the market, which given the first result has a negative effect on the firm's cost of capital. Thus, the intuition that idiosyncratic differences in information quality lead to idiosyncratic risk that is diversifiable in portfolios of many assets and hence not priced in the CoC in equilibrium is misleading, even in a CAPM world.

Our model extends the literature in providing a direct link between information quality and cost of capital that does not rely on liquidity or shareholder base effects. Information quality has real effects on capital allocation that manifest in firms' cost of capital.

7 References

Admati, A., 1985, A noisy rational expectations equilibrium for multi-asset securities markets, Econometrica 53, 629-658.

Amihud, Y., and H. Mendelson, 1986, Asset pricing and the bid-ask spread, Journal of Financial Economics 17, 223-249.

Baiman, S., and R. Verrecchia, 1996, The relation among capital markets, Financial Disclosure, Production Efficiency, and Insider Trading, Journal of Accounting Research 34, 1-22.

Barry, C., and S. Brown, 1985, Differential information and security market equilibrium, Journal of Financial and Quantitative Analysis 20, 407-422.

Botosan, C., 1997, Disclosure level and the cost of equity capital, The Accounting Review 72, 323-349.

Botosan, C., and M. Plumlee, 2002, A re-examination of disclosure level and the expected cost of equity capital, Journal of Accounting Research 40, 21-41.

Bushman, R., and R. Indjejikian, 1993, Accounting income, stock price and managerial compensation, Journal of Accounting and Economics 16, 3-23.

Bushman, R., and A. Smith, 2001, Financial accounting information and corporate governance, Journal of Accounting and Economics 32, 237-333.

Chordia, T., R. Roll, and Avanidhar Subrahmanyam, 2001, Market liquidity and trading activity, Journal of Finance 56, 501-530.

Clarkson, P., J. Guedes, and R. Thompson, 1996, On the diversification, observability and measurement of estimation risk, Journal of Financial and Quantitative Analysis 31, 69-84.

Coles, J., U. Loewenstein, and J. Suay, 1995, On equilibrium pricing under parameter uncertainty, Journal of Financial and Quantitative Analysis 30, 347-364.

Diamond, D. and R. Verrecchia, 1991, Disclosure, liquidity, and the cost of capital, Journal of Finance 46, 1325-1360.

Easley, D, S. Hvidkjaer, and M. O'Hara, 2002, Is information risk a determinant of asset returns?, Journal of Finance 57, 2185-2222.

Easley, D., and M. O'Hara, 2004, Information and the cost of capital, Journal of Finance 59, 1553-1584.

Fama, E., 1976, Foundations of Finance, Basic Books: New York.

Fama, E., and K. French, 1999, The corporate cost of capital and the return on corporate investment, Journal of Finance 54, 1939-1967.

Fischer, P., and R. Verrecchia, 2005, Disclosure Bias, Journal of Accounting and Economics, forthcoming.

Francis, J., R. LaFond, P. Olsson, and K. Schipper, 2005, Costs of capital and earnings attributes, The Accounting Review, forthcoming.

Gebhardt, W., C. Lee, and B. Swaminathan, 2001, Toward an implied cost of capital, Journal of Accounting Research 39, 135-176.

Hellwig, M., 1980, On the aggregation of information in competitive markets, Journal of Economic Theory 22, 477-498.

Lambert, R., 2001, Contracting theory and accounting, Journal of Accounting and Economics 32, 3-87.

Leuz, C. and R. Verrecchia, 2000, The economic consequences of increased disclosure, Journal of Accounting Research 38, 91-124.

Lewellen, J., and J. Shanken, 2002, Learning, asset pricing tests, and market efficiency, Journal of Finance 57, 1113-1145.

Lintner, J., 1965, The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets, Review of Economics and Statistics 47, 13-37.

Merton, R., 1987, A simple model of capital market equilibrium with incomplete information, Journal of Finance 42, 483-510.

Pastor, L., and R. Stambaugh, 2003, Liquidity risk and expected stock returns, Journal of Political Economy 111, 642-685.

Paul, J., 1992, On the efficiency of stock-based compensation, Review of Financial Studies 5, 471-502.

Tobin, J., 1982, On the efficiency of the financial system. Lloyd's Banking Review 153, 1-15.

Verrecchia, R., 1982, Information acquisition in a noisy rational expectations economy, Econometrica 50, 1415-1430.

Verrecchia, R., 2001, Essays on disclosure, Journal of Accounting and Economics 32, 91-180.