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

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Abstract

This paper establishes a link between firms' capital investment decisions, the quality of the information they provide to a competitive market for their shares, and their cost of capital. We show that, if firms select projects to maximize share price, higher information quality reduces the cost of capital. The intuition is that better information improves the coordination between firms and investors with respect to capital investment decisions. Anticipating this effect, risk-averse investors demand a lower risk premium, i.e., they discount expected cash flows of firms with higher quality reporting at a lower rate of return. We show that this effect persists when investors price portfolios involving many assets. Idiosyncratic reporting components matter because they affect firms' investment decisions and these real effects do not ``disappear'' when aggregating across firms.

JEL classification: G12, G14, G31, M41

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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 put differently, whether investors discount cash flows of firms with lower information quality at a higher rate of return.

Our analysis has two key features. The first feature is to directly link the firm's cash flows to information quality. To do so, we assume an economy in which a firm reports on its investment opportunities to the market. These 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 share price.[2] Consequently, managers select projects that maximize share price, given the firm's report to the market. That is, the quality of the report affects share price, which, in turn, affects investment choice and ultimately the firm's cost of capital.

In essence, we attempt to capture the notion that share 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

[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 and French, 1999; Gebhardt et al., 2000).

[2] There is an extensive literature on the use of share price in managerial compensation (e.g., Diamond and Verrecchia, 1982; Scholes, 1991; Paul, 1992). Our analysis does not explicitly model these contracts, but simply assumes their existence to focus on the link between information quality and the cost of capital.

respect to capital investment by the firm. 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* we observe empirically that firms' cost of capital decreases in information quality.

We show that, in our setting, higher information quality (or reporting precision) reduces the firm's cost of capital. The intuition is that higher information quality improves the coordination between firms and investors with respect to capital investment decisions. Anticipating this effect, investors demand a lower risk premium at the outset and discount the expected cash flows of firms with higher information quality at a lower rate of return. In short, investors price the misalignment risk that stems from poor reporting.

The second feature of our analysis is to explore whether this link persists when investors form portfolios involving many assets, which is important in terms of the paper's empirical implications. A common argument for why information quality is not reflected in firms' cost of capital is that information quality operates like an additional element of idiosyncratic noise, which is uncorrelated across firms. Hence, in portfolios involving many assets, the precision of individual firms' reports "averages out" and is diversified away. In our analysis this does not happen. Each individual firm makes an individual investment choice based on how that choice affects its individual share price. Individual share prices, in turn, rely on the quality of individual firm reports; hence, information quality affects both the firm's cash flows and its share price. Thus, idiosyncratic reporting components matter, i.e., they do not "disappear" when investors price portfolios comprised of many firms.[3] In short, we show that firms' cost of capital decreases in the information quality of individual firms' reports, and this result persists even in the presence of many firms.

The link between information quality and the cost of capital is one of the most fundamental tenets in finance and accounting. However, 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., 2003a; Hail, 2003). 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 firm risk. Our paper provides support for this presumption. It extends the literature in providing a direct link between the firm's primary activities, which is to select among and invest in projects, the information quality of its reports and its cost of capital in a competitive equilibrium.

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),

[3] They would "average out" in the context of our analysis if all firms in a portfolio made a single collective or identical individual investment choices based on a "consensus" report. In the consensus report, the idiosyncratic noise in firms' individual reports would "average out". In this case, there is obviously no link between the quality of the individual firm's report and its primary activities.

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 does not disappear in portfolios involving many firms.

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.[4] 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 a few liquidity-based models, however, 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. In their model, the clientele effects give rise to return differentials, i.e., expected returns are increasing in the spread (or the amount of in-

[4] 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.

formation 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 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, however, the link between disclosure and the firm's cost of capital arises due to information asymmetries between traders in secondary markets and there is no link between information asymmetry (or quality) and the firm's cash flows.

Our analysis is not built on liquidity effects. The model captures the interaction between firms and investors in equity markets, and the fundamental role of information in facilitating firms' capital allocation and investment decisions. Reporting quality has real effects, which, in turn, 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 approach 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., 2003a and 2003b; Hail, 2003).

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 and returns are negatively associated, suggesting that liquidity is priced in returns (e.g., Amihud and Mendelson, 1986; Chordia et al., 2001; Pastor and Stambaugh, 2003). Our paper simply suggests a competing explanation as to how information quality and the firm's cost of capital are linked.

The paper is organized as follows. Section 2 describes the model and analyzes the relation between information quality and a firm's cost of capital. Section 3 extends the model to a setting with many firms addressing the issue whether the effect is diversifiable. Section 4 concludes the paper.

2 Assumptions of the model

In this section we introduce the assumptions that underlie our model. Specifically, we consider an economy with a single firm, a perfectly competitive market for firm shares, a single period until the firm liquidates, and no discounting. In other words, the risk-free rate-of-return is 0: a dollar invested in a risk-free asset at the beginning of the period yields a dollar at the end of the period. While this setting is stylized, its purpose is to focus our attention on the conceptual issues surrounding the link among firms' capital allocation choices, information quality, and cost of capital. In Section 4, we expand the discussion to allow for an economy with many firms.

2.1 Firm cash flows

Firm net cash flows result from a process in which an investment of k results in net cash flows of $\tilde{c}$ per share of stock outstanding in the firm, where $\tilde{c} = k\tilde{\pi} - \frac{1}{2}k^2$. Per share of stock outstanding, we interpret $\tilde{\pi}$ as the firm's (uncertain) revenue per-unit-of-investment k. In the expression for net cash flows, the role of $-\frac{1}{2}k^2$ is to capture the notion that there are diminishing returns to investment.

Henceforth we refer to k as the firm's investment choice. This choice incorporates two decisions: 1) in which of two mutually exclusive projects or markets the firm invests, and 2) the level of investment in that project or market. There are many examples of situations in which a firm has to choose among mutually exclusive projects or markets and subsequently has to determine the level of investment in the chosen project or market. For convenience, we assume that there are two mutually exclusive markets and that revenue per-unit-of-investment in the first market is $\tilde{\pi}$, and revenue per-unit-of-investment in the second market is $-\tilde{\pi}$. We further assume that $\tilde{\pi}$ has a normal distribution with mean 0 and precision h, which represents the reciprocal of the variance in the revenue per-unit-of-investment. We refer to the latter as the firm's revenue (or fundamental) volatility.

In effect, revenue per-unit-of-investment, $\tilde{\pi}$, is perfectly negatively correlated in the two markets. That is, because realizations of $\tilde{\pi}$ can be either positive or negative, one of the markets will be profitable while the other will be unprofitable depending upon the sign of $\tilde{\pi}$, capturing the idea that the firm choose between two mutually exclusive projects. The firm implements its investment choice through its choice of an k, where the sign of k designates in which of the two markets the firm should invest and $|k|$ determines the level of investment in that market.

For example, if $k > 0$, then the firm invests an amount $|k|$ in the production of goods in the first market, where it anticipates net cash flows of $k\tilde{\pi}-\frac{1}{2}k^2$. Alternatively, if $k < 0$, then the firm invests an amount $|k|$ in the production of goods in the second market, where it anticipates net cash flows of $|k| \cdot -\tilde{\pi} - \frac{1}{2}k^2 = k\tilde{\pi} - \frac{1}{2}k^2$. In other words, irrespective of the sign of k, net cash flows are always $k\tilde{\pi} - \frac{1}{2}k^2$.

In short, this simple representation of net cash flows as $\tilde{c} = k\tilde{\pi} - \frac{1}{2}k^2$ allows us to characterize the firm's primary activities, which are to select among and to invest in projects. While the assumption that investment opportunities are perfectly negatively correlated is stylized, its role is fairly innocuous. It simply provides a context for interpreting negative realizations of $\tilde{\pi}$; this, in turn, makes the analysis very facile by allowing uncertainty to be characterized by a normal distribution.

2.2 Project selection

With regard to project selection, we make two assumptions. First, we assume that the firm provides the market with some information about $\tilde{\pi}$. Specifically, we assume that the firm reports $\tilde{r}$, where $\tilde{r} = \tilde{\pi} + \tilde{\varepsilon}$ and $\tilde{\varepsilon}$ has a normal distribution with mean 0 and precision n. This implies that the expected value of $\tilde{\pi}$ conditional on r is $E[\tilde{\pi}|r] = \frac{n}{h+n}r$, and the variance of $\tilde{\pi}$ conditional on r is $Var[\tilde{\pi}|r] = \frac{1}{h+n}$. We interpret n as the precision of the report $\tilde{r}$. That is, as n increases, the report is more precise, i.e., of higher quality, or perhaps involves more disclosure.

Second, we assume that the firm selects among projects based on which project maximizes firm share price. This assumption implies that managers and investors coordinate through share price and links reporting precision to firms' net cash flows. 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 share price. 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., Scholes, 1991). Specifically, we assume that incentives are a monotonically increasing function of share price. Consequently, irrespective of what information firm managers may have about $\tilde{\pi}$, they select the projects which maximize share price.

We realize that firms' incentives in practice are likely to be more complex and involve other performance measures (e.g., Paul, 1992, Bushman and Indjejikian, 1993). However, our analysis highlights in an albeit stylized fashion that reporting quality, investment decisions and the cost of capital are linked if firm managers care about share price. It is meant to capture the notion that share markets play a role in firms' capital allocation choices and that financial reporting affects the market's ability to perform this function.

2.3 Market investors

N investors make up the perfectly competitive market for firm shares, where N is large. Let $U(c)$ represent each investor's utility preference for an amount of cash c. We assume that each investor has a negative exponential utility function: that is, $U(c)$ is defined by

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

where $\rho > 0$ 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:

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

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

3 An economy with one firm

3.1 Firm net cash flows and share price

To understand how firm managers select among projects when the market's only knowledge of $\tilde{\pi}$ is through $\tilde{r} = r$, and its implication to CoC, first we need to understand how the market determines firm share price. Let P represent the firm's share price in a competitive market for its shares based on the firm making an investment choice k. In addition, let D_i represent investor i's demand for shares in the firm expressed as percentage of total firm; D_i^* represent her endowment in firm shares expressed as a percentage of the firm she owns; B_i her demand for a risk-free bond that returns one unit for each unit invested (i.e., the risk-free rate is 0); and B_i^* her endowment in bonds, respectively. This implies that each investor solves

$$\max_{D_i, B_i} E\left[\rho\left(1-\exp\left[-\frac{1}{\rho}\left(D_i\left(k\tilde{\pi}-\frac{1}{2}k^2\right)+B_i\right)\right]\right)|r\right] \quad (1)$$

subject to the budget constraint

$$D_i P + B_i = D_i^* P + B_i^*.$$

It is a straightforward exercise to show that eqn. (1) reduces to

$$\max_{D_i, B_i} \rho\left(1-\exp\left[-\frac{1}{\rho}\left(D_i\left(k\frac{n}{h+n}r-\frac{1}{2}k^2-P\right)+D_i^*P+B_i^*\right)+\frac{1}{2}\frac{D_i^2k^2}{\rho^2}\frac{1}{h+n}\right]\right),$$

where we substitute for B_i the expression $D_i^*P+B_i^*-D_iP$ from the budget constraint. Maximizing this expression with respect to D_i implies setting

$$D_i = \frac{\rho(h+n)}{k^2}\left(k\frac{n}{h+n}r-\frac{1}{2}k^2-P\right). \quad (2)$$

Because we assume a perfectly competitive market, we characterize elements of the economy on a "per-capita," or "per investor," basis. For example, we assume that on a per-capita basis the firm has S shares of stock outstanding. As such, S can be thought of as investors' per-capita, exogenous endowment of firm shares. Per-capita characterizations are a standard convention in the rational expectations trading literature (e.g., Admati, 1985) to accommodate the fact that perfect competition requires an economy with many investors, e.g., a countably infinite number of investors. It is important to emphasize that we treat the firm's investment choice, k, as unrelated to S. That is, we assume that the firm has already sufficient resources to invest at any level (i.e., for any value of $|k|$). Thus, investment choice is not dependent the number of per-capita shares outstanding , or the cash proceeds those shares raised when they were originally issued.

When per-capita demand for firm shares is aggregated across the market, it must equal the per-capita supply of S. This implies that if we average both sides of eqn. (2) by the number of investors in the economy (i.e., subject both sides to the averaging mechanism $\frac{1}{N}\sum_i$), the share price that equilibriates demand with supply is:

$$P = k\frac{n}{h+n}r - \frac{1}{2}k^2 - \frac{k^2}{\rho\left(h+n\right)}S. \tag{3}$$

Let k^* represent the investment choice that maximizes firm share price. From the expression for price in eqn. (3), conditional on a report r firm managers maximize share price by choosing $k^* = \frac{\rho n}{\rho(h+n)+2S}r$. This implies that conditional on r, and managers choosing k^*, (per share) firm net cash flows are

$$\begin{aligned} E\left[k\tilde{\pi} - \frac{1}{2}k^2|r\right] &= \frac{\rho n}{\rho\left(h+n\right)+2S}r \cdot \frac{n}{h+n}r - \frac{1}{2}\left(\frac{\rho n}{\rho\left(h+n\right)+2S}r\right)^2 \\ &= \frac{1}{2}\rho n^2 \frac{\rho h + n\rho + 4S}{\left(h+n\right)\left(\rho h + n\rho + 2S\right)^2}r^2, \end{aligned}$$

and expected firm net cash flows are

$$\begin{aligned} E\left[\tilde{k}\tilde{\pi} - \frac{1}{2}\tilde{k}^2\right] &= \frac{1}{2}\rho n^2 \frac{\rho h + n\rho + 4S}{\left(h+n\right)\left(\rho h + n\rho + 2S\right)^2}E\left[\tilde{r}^2\right] \\ &= \frac{1}{2}\rho n \frac{\rho h + n\rho + 4S}{h\left(\rho h + n\rho + 2S\right)^2}. \end{aligned} \tag{4}$$

Similarly, conditional on r and managers choosing k^*, firm share price is

$$P = \frac{1}{2}\rho n^2 \frac{1}{\left(h+n\right)\left(\rho h + n\rho + 2S\right)}r^2,$$

and expected firm share price is

$$E\left[\tilde{P}\right] = \frac{1}{2}\rho n \frac{1}{h\left(\rho h + n\rho + 2S\right)}. \tag{5}$$

3.2 Cost of capital

We characterize the firm's cost of capital (henceforth, CoC) as the rate of return R that results from the equating the firm's expected price per share to the firm's (per share) expected net cash flow in the relation

$$E\left[\tilde{P}\right] = \frac{E\left[\tilde{k}\tilde{\pi} - \frac{1}{2}\tilde{k}^2\right]}{1+R},$$

or, equivalently,

$$1 + R = \frac{E\left[\tilde{k}\tilde{\pi} - \frac{1}{2}\tilde{k}^2\right]}{E\left[\tilde{P}\right]}.$$

This representation of the cost of capital is frequently used, for instance, in valuing firms and capital budgeting (e.g., DCF models), and in estimating the implied cost of capital from analyst forecasts (e.g., Gebhardt et al., 2001).

To digress briefly, we define CoC in terms of *expected* net cash flows and *expected* price per share. We do this so as to define CoC in terms of an anticipated report $\tilde{r}$, not in terms of the report itself. The advantage of this approach is that it abstracts from the first moment effect of a report, namely, whether the report is "good news" versus "bad news," and instead allows us to place exclusive emphasis on the second moment effect, that is, whether the report is anticipated to be of high quality or low quality (i.e., high n or low n). This approach more appropriately captures the idea of an information risk premium.

As a benchmark, consider the firm's cost of capital when the market knows the realization $\tilde{\pi} = \pi$. Here, a report plays no role because $\tilde{\pi} = \pi$ is known or certain. When $\tilde{\pi} = \pi$ is known, $E\left[\tilde{P}\right]$ simply reflects the value of the firm's (certain) net cash flows based on the firm choosing k:

$$E\left[\tilde{P}\right] = k\pi - \frac{1}{2}k^2.$$

Here, irrespective of the choice of k, expected firm net cash flows and expected firm price per share both equal $k\pi - \frac{1}{2}k^2$. Consequently, $1 + R = \frac{k\pi - \frac{1}{2}k^2}{k\pi - \frac{1}{2}k^2} = 1$, which implies $R = 0$. This is what one would expect: if firm net cash flows are known with certainty, then CoC should be 0 and there is no risk premium.

Now consider the more general case in which $\tilde{\pi}$ is unknown or unobservable. We combine our expressions above for expected firm net cash flows with expected firm share price as determined in eqns. (4) and (5), respectively, to determine the firm's cost of capital:

$$
\begin{aligned}
1 + R &= \frac{E\left[\tilde{k}\tilde{\pi} - \frac{1}{2}\tilde{k}^2\right]}{E\left[\tilde{P}\right]} \\
&= \frac{\frac{1}{2}\rho n \frac{\rho h + n\rho + 4S}{h(\rho h + n\rho + 2S)^2}}{\frac{1}{2}\rho n \frac{1}{h(\rho h + n\rho + 2S)}} \\
&= 1 + \frac{2S}{\rho(h+n) + 2S}.
\end{aligned}
$$

In effect, when the firm invests so as to maximize its share price, then its CoC is $R = \frac{2S}{\rho(h+n)+2S}$. In this characterization, the relation between R and various elements of the problem are straightforward. R is bounded between 0 and 1, and unambiguously decreases toward 0 as either: the precision in reports of the firm's revenue per-unit-of-investment increases (i.e., n increases); the volatility in revenue per-unit-of-investment goes down (i.e., as h increases); or as the market becomes more risk tolerant (i.e., as ρ increases). In other words, improved reporting precision should manifest itself as a lower a lower cost of capital.

It is also interesting to note that CoC increases as the per-capita number of shares outstanding increases, S. This effect is an artifact of two modeling features: 1) the market must absorb all risk that results from the firm generating uncertain net cash flows; and 2) as S increases the amount of risk that needs to be absorbed increases.[5]

Put differently, this effect occurs because the market assumes unlimited liability for any risk, and as S increases, is forced to absorb more of it.

Finally, we note that while improved reporting results in lower misalignment risk, it does not lead to less volatility in firm net cash flows.[6] As established above, expected firm net cash flows are $E\left[\tilde{c}\right] = \frac{1}{2}\rho n \frac{\rho h + n\rho + 4S}{h(\rho h + n\rho + 2S)^2}$. It is a straightforward exercise to show that the variance of these net cash flows is $E\left[\left(\tilde{c} - \frac{1}{2}\rho n \frac{\rho h + n\rho + 4S}{h(\rho h + n\rho + 2S)^2}\right)^2\right] = \frac{1}{2}\rho^2 n^2 \frac{(\rho h + n\rho + 4S)^2}{h^2(\rho h + n\rho + 2S)^4}$. In addition, it is straightforward to show that both expected net cash flows *and* the variance in net cash flows increase as reporting precision increases. The reason for the former is that improved reporting precision allows better coordination between the firm and market, and this, in turn, results in higher expected net cash flows. The reason for the latter is that, as reporting precision improves, the firm's investment becomes more responsive to reports, and this, in turn, results in more cash flow volatility. This finding shows that the empirical relation between the firm's cash flow volatility and its cost of capital can be ambiguous, even though the CoC unambiguously decreases in the firm's reporting precision n and increases in the fundamental volatility of the firm's investment project h.

4 An economy with many firms

Now that we have established a link between the firm's information quality and its cost of capital via the firm's primary activities (i.e., firm net cash flows), the remaining question is whether this link survives in an economy with many firms. The standard argument for why firms' information quality is not reflected in the

[5] This feature is also present in other competitive equilibrium models, such as Hellwig (1980), Easley and O'Hara (2004), or the incomplete information model by Merton (1987).

[6] This volatility should be differentiated from the fundamental volatility of the firm's revenue per-unit-of-investment h.

cost of capital is that information quality is idiosyncratic and, hence, diversifiable in portfolios involving many assets. While this logic may be true if the firm's net cash flows are given and independent of reporting precision, it no longer holds when information quality has real effects, i.e., affects the coordination between the firm and its investors with respect to investment.

4.1 Cash flows and reports

To show this, we generalize our results to allow for an economy comprised of Q firms, where Q becomes large, and show that the link shown in the previous section does not disappear. Specifically, we assume that firm j's net cash flows, $j = 1, 2, ..., Q$, arise from a process in which an investment of an amount k_j results in per share net cash flows of $\tilde{c}_j = k_j\tilde{\pi}_j - \frac{1}{2}k_j^2$, where $\tilde{\pi}_j$ is firm j's (uncertain) revenue per-unit-of-investment k_j, and S_j are the number of firm j shares outstanding. In addition, we assume that firm j's revenue per-unit-of-investment, $\tilde{\pi}_j$, has common and idiosyncratic components: that is,

$$\tilde{\pi}_j = \beta_j\tilde{\theta} + \tilde{\xi}_j,$$

where $\tilde{\theta}$ is the common component across all firms, β_j is a fixed coefficient that relates firm j's revenue per-unit-of-investment to the common component, and $\tilde{\xi}_j$ is the idiosyncratic component unique to firm j. We also assume that $\tilde{\theta}$ and $\tilde{\xi}_j$ each have a normal distribution with mean 0 and precisions s and t, respectively. Finally, we assume that $\frac{1}{Q}\sum_{j=1}^{Q}\beta_j = \beta_0 > 0$ where β_0 is a known parameter: in effect, the average of all firms' coefficients on the common component converges to a known parameter β_0.

Suppose that each firm provides the market with a report $\tilde{r}_j$ of its revenue per-unit-of-investment: that is,

$$\tilde{r}_j = \beta_j \tilde{\theta} + \tilde{\xi}_j + \tilde{\varepsilon}_j.$$

Note that the noise component in reporting $\tilde{\varepsilon}_j$ is idiosyncratic, i.e., uncorrelated across firms. Let $\bar{r}$ represent the set of all realized firm reports, $\bar{r} = \{\tilde{r}_1 = r_1, \tilde{r}_2 = r_2, .., \tilde{r}_Q = r_Q\}$. Conditional on $\bar{r}$, as the number of firm reports in the economy becomes large (i.e., as Q becomes large), they reveal the common component of revenue per-unit-of-investment, θ. Specifically, the statistic $\frac{1}{Q}\sum_{j=1}^{Q} r_j$ reveals $\beta_0 \tilde{\theta} = \beta_0 \theta$ through the law of large numbers. Thus, henceforth we assume that when the market conditions its expectations on $\bar{r}$ it knows $\tilde{\theta} = \theta$. Despite the fact that θ is known, note that $\tilde{r}_j$ provides information about the idiosyncratic component of firm j's revenue per-unit-of-investment, $\tilde{\xi}_j$. For example, conditional on $\bar{r}$ and θ, $E[\tilde{\pi}_j | \bar{r}, \theta] = \beta_j \theta + \frac{n}{t+n}\left(r_j - \beta_j \theta\right)$ and $E\left[\left(\tilde{\pi}_j - \beta_j \theta - \frac{n}{t+n}\left(r_j - \beta_j \theta\right)\right)^2 | \bar{r}, \theta\right] = \frac{1}{t+n}$.

4.2 Firm j's share price

Now consider the market price per share that prevails in a perfectly competitive market. Let $\bar{D}_i = \{D_{i1}, D_{i2}, ..., D_{ij}, ..., D_{iQ}\}$ represent the $1 \times Q$ vector of investor i's demand for shares in firm j as percentage of total firm, where D_{ij} represents investor i's demand for firm j; $\bar{D}_i^* = \left\{D_{i1}^*, D_{i2}^*, ..., D_{ij}^*, ..., D_{iQ}^*\right\}$ represent her vector of endowment in firm j shares expressed as a percentage of the firm she owns, where D_{ij}^* represents her endowment in firm j; and $\bar{P} = \{P_1, P_2, ..., P_j, ..., P_Q\}$ the vector of firm share prices, where P_j represents firm j's share price. As before, let B_i and B_i^* represent investor i's demand for a risk-free bond and her endowment in bonds, respectively. Conditional on $\bar{r}$, θ, and levels of investment k_j, $j = 1, 2, ...$, each investor solves

$$\max_{\bar{D}_i, B_i} E[\rho(1 - \exp[-\frac{1}{\rho}(\bar{D}_i\{\tilde{c}_1, \tilde{c}_2, ..., \tilde{c}_Q\}' + B_i)])|\bar{r}, \theta] \tag{6}$$

subject to the budget constraint

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

Note that eqn. (6) reduces to

$$\max_{\bar{D}_i, B_i} \rho(1 - \exp[-\frac{1}{\rho}(\bar{D}_i\{k_1\left(\beta_1\theta + \frac{n}{t+n}\left(r_1 - \beta_1\theta\right)\right) - \frac{1}{2}k_1^2 - P_1,$$
$$..., k_Q\left(\beta_Q\theta + \frac{n}{t+n}\left(r_Q - \beta_Q\theta\right)\right) - \frac{1}{2}k_Q^2 - P_Q\}' + \bar{D}_i^*\bar{P}' + B_i^*) + \frac{1}{2}\frac{1}{\rho^2}\bar{D}_i M \bar{D}_i']|\bar{r}, \theta],$$

where M is an $Q \times Q$ matrix whose j-th diagonal term is $k_j^2 \frac{1}{t+n}$ and whose off-diagonal terms are 0. Maximizing this expression with respect to D_{ij} implies setting

$$D_{ij} = \frac{\rho\left(t+n\right)}{k_j^2}\left(k_j\left(\left(\beta_j\theta + \frac{n}{t+n}\left(r_j - \beta_j\theta\right)\right)\right) - \frac{1}{2}k_j^2 - P_j\right).$$

Because on a per-capita basis S_j shares of firm stock are outstanding, when demand for firm shares is aggregated across the market per-capita demand must equal the per-capita supply of S_j. This implies that share price as a function of k is

$$P_j = k_j\left(\beta_j\theta + \frac{n}{n+t}\left(r_j - \beta_j\theta\right)\right) - \frac{1}{2}k_j^2 - \frac{1}{\rho}k_j^2\left(\frac{1}{t+n}\right)S_j. \tag{7}$$

As an aside, note that firm j's share price, P_j, is independent of the attributes of all other firms because conditional on knowledge of common revenue per-unit-of-investment, θ, all other firm attributes are idiosyncratic, and hence uncorrelated.

4.3 Firm j's cost of capital

Let k_j^* represent the investment choice that maximizes firm j's share price. From the expression for price in eqn. (7), conditional on a report r firm managers maximize share price by choosing

$$k_j^* = \rho\frac{t\beta_j\theta + nr_j}{\rho\left(t+n\right) + 2S_j}.$$

This implies that firm j's expected net cash flows are:

$$\begin{aligned}
& E\left[\tilde{k}_j\left(\beta_j\tilde{\theta}+\frac{n}{n+t}\left(\tilde{r}_j-\beta_j\tilde{\theta}\right)\right)-\frac{1}{2}\tilde{k}_j^2\right] \\
= \; & \frac{1}{2}\rho\frac{n\rho+\rho t+4S_j}{\left(n\rho+\rho t+2S_j\right)^2(t+n)}E\left[\left(t\beta_j\tilde{\theta}+n\tilde{r}_j\right)^2\right] \\
= \; & \frac{1}{2}\rho\left(n\rho+\rho t+4S_j\right)\frac{t\left(t\beta_j+n\right)^2+sn(t+n)}{st(t+n)\left(n\rho+\rho t+2S_j\right)^2}. \qquad (8)
\end{aligned}$$

Similarly, firm j's expected share price is

$$\begin{aligned}
E\left[\tilde{P}_j\right] &= E\left[\tilde{k}_j\left(\beta_j\tilde{\theta}+\frac{n}{n+t}\left(r_j-\beta_j\tilde{\theta}\right)\right)-\frac{1}{2}\tilde{k}_j^2-\frac{1}{\rho}\tilde{k}_j^2\left(\frac{1}{t+n}\right)\right] \\
&= \rho\frac{1}{n\rho+\rho t+2S_j}\frac{1}{2(t+n)}E\left[\left(t\beta_j\tilde{\theta}+n\tilde{r}_j\right)^2\right] \\
&= \frac{1}{2}\rho\frac{t\left(t\beta_j+n\right)^2+sn(t+n)}{st(t+n)\left(n\rho+\rho t+2S_j\right)}. \qquad (9)
\end{aligned}$$

Combining eqns. (8) and (9) yields firm j's CoC:

$$1+R_j=1+\frac{2S_j}{\rho(t+n)+2S_j}.$$

In effect, our expression for firm j's CoC is nearly identical to the one for a single-firm economy. The only notable difference is that here CoC is related through t exclusively to the idiosyncratic component of firm j's revenue per-unit-of-investment, whereas before it was related through h to both the common and idiosyncratic components. The reason for this difference is that in our setting the common component across firms is revealed and hence no longer priced in the cost of capital. Firm j's report, however, nonetheless provides information about the idiosyncratic component of firm j's revenue per-unit-of-investment; this, in turn, affects firm j's CoC through the relation $R_j=\frac{2S_j}{\rho(t+n)+2S_j}$.

This result shows that idiosyncratic reporting components do not "disappear" when investors price portfolios of many firms. Each individual firm makes an investment choice considering how that choice affects its individual share price. Individual share prices, in turn, rely on the quality of individual firm reports. Thus, idiosyncratic reporting components matter because they affect firms' investment decisions. Thus, even in an economy with many firms and idiosyncratic reporting components, investors price the risk of poor coordination (or capital allocation) that stems from poor reporting.

5 Conclusion

In this paper, we analyze a simple model in which the managers of each firm select among projects to maximize their firm's share price. Firm reports affect firm share price, and coordinate firms and investors with respect to the type and level of capital investment. The model 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.

In this setting, higher information quality (or reporting precision) reduces the firm's cost of capital. Poor information quality leads to misaligned capital investment by the firm. Anticipating this effect, investors demand a higher risk premium at the outset, i.e., they discount the firm's expected net cash flows at a higher rate of return. We show that this effect does not disappear even if investors form and price portfolios of many firms. This result holds even in the stark case where information quality is idiosyncratic, i.e., uncorrelated across firms. The intuition for the latter result is that capital allocation, that is, the coordination between firms and investors with respect to investment, is impaired for each firm in the portfolio if reporting quality is less than perfect. Idiosyncratic reporting components matter in terms of the investment of each individual firm, and consequently are priced in the firm's cost of capital.

Our model extends the literature in providing a direct link between information quality and cost of capital that does not rely on liquidity or risk sharing. It is build on the idea that poor reporting manifests in poor capital allocation choices. It also provides a rationale for recent empirical studies suggesting that more disclosure and higher information quality are negatively associated with firms' cost of capital.

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