The Sensitivity of Cash Savings to the Cost of Capital*

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Abstract

We theoretically and empirically show that in the presence of a time-varying cost of capital (COC), firms save cash from external capital when the COC is low to hedge against the risk of underinvestment in the *future* due to a higher COC. This hedging motive drives the sensitivity of cash savings to the COC in both financially constrained and currently unconstrained firms. This sensitivity is especially pronounced among firms with a greater correlation between their COC and financing needs for future investments. These results cannot be fully explained by either the precautionary motive or the market timing motive for cash.

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Abstract

We theoretically and empirically show that in the presence of a time-varying cost of capital (COC), firms save cash from external capital when the COC is low to hedge against the risk of underinvestment in the *future* due to a higher COC. This hedging motive drives the sensitivity of cash savings to the COC in both financially constrained and currently unconstrained firms. This sensitivity is especially pronounced among firms with a greater correlation between their COC and financing needs for future investments. These results cannot be fully explained by either the precautionary motive or the market timing motive for cash.

Key Words: Cash savings, Hedging, Precautionary motive, Market timing, Financial Constraint.

JEL Classification: G32 G35.

1. Introduction

Capital market frictions make external capital costlier than internally generated funds, which may lead to suboptimal investment decisions (Myers (1984)). The literature suggests that firms mitigate such external financing constraints by saving cash from internal cash flows.[1] However, we document that firms in the United States save 28 cents from each dollar of equity capital raised compared to 15 cents from each dollar of internal cash flows. Moreover, external equity issuance alone explains 9.4% of the variation in corporate cash savings, while internal cash flows explain only 1.3%. Despite this importance of external capital issuance for cash savings, the link between cash savings and external capital is not well understood.

Conceptually, it is important to consider variation over time in the cost of external capital to understand why firms save from external capital. Since cash is an important source of financing for future investment (Almeida et al. (2004), Almeida et al. (2014), and Denis and Sibilkov (2010)), firms should consider building cash reserves in a manner that lowers the overall cost of capital (COC) – averaged over time – for their investment opportunities.[2] We theoretically show that firms save cash from external capital issuance when the COC is relatively low to hedge against financing future investments at a higher cost and thereby reduce the overall COC. Under this hedging motive, both financially constrained and (currently) unconstrained firms' cash savings are sensitive to the COC. The need to hedge against raising external capital at a higher cost for future investments is the most pronounced in firms that tend to face a higher COC when having greater external capital needs. Saving cash by raising external capital is costly. Nonetheless, given the time-varying costs of external capital, firms choose their optimal savings to balance the current COC and the expected

[1]See Almeida, Campello, and Weisbach (2004), Acharya et al. (2007), Han and Qiu (2007), Bates et al. (2009), Chang et al. (2014), and Qiu and Wan (2015), etc.

[2]Although cash savings from external capital have been noted in previous studies (McLean (2011) and Darmouni and Siani (2021)), a formal analysis of the direct link between cash savings and the time-varying COC is absent in the literature.

COC for future investments. In summary, firms save more when (i) the current COC is low, and (ii) they face a high correlation between the COC and external financing needs.

To empirically test these predictions, we estimate a firm's COC by its weighted average cost of capital based on its debt to equity ratio and the cost of equity and debt. The cost of equity (COE) is estimated by the implied internal rate of return obtained by equating the stock price to the present value of future cash flow forecasts. The cost of debt (COD) is estimated as the actual yield on the debt carried by the firm.[3] We first show that the average cash holdings of firms are negatively associated with their average COC over the 39-year sample period (Figure 1). Moreover, firms save significantly more when the COC is lower relative to its historical average (Figure 2) and when their realized future investments are greater (Figure 3).

To empirically test our model's predictions, we measure a firm's "hedging motive" as the regression coefficient of the firm's external finance needs on the COC based on the standard proxies used in the literature for such needs. A high value of the coefficient indicates that the firm faces a higher COC when it needs more external capital. Consistent with the model, we find that firms' cash savings from external capital are more sensitive to the COC when their hedging needs are greater; such firms issue significantly more external capital in excess of their current financial needs when the COC is relatively low. We also show that future investment needs influence the sensitivity of cash savings to the COC, especially in firms with a strong hedging motive. These findings support our novel perspective on corporate hedging, i.e., firms save cash to hedge their future investments against a high cost of capital.

When comparing the relative importance of equity and debt as sources of external capital, we find that firms save significantly more cash from equity issues (28 cents from each dollar of equity

[3] Claus and Thomas (2001) and Fama and French (2002) use the implied cost of capital (ICC) to measure the equity premium; Li, Ng, and Swaminathan (2013) and Lee, So, and Wang (2020) use the ICC to predict stock market return; and Burgstahler, Hail, and Leuz (2006), Botosan and Plumlee (2005), Hughes, Liu, and Liu (2009) Frank and Shen (2016), Xu (2020), and Byoun and Wu (2020) use the ICC to estimate the COE. The COD is estimated using the same measure applied in Frank and Shen (2016) and Xu (2020).

raised) than from debt issues (6 cents from each dollar of debt raised). Moreover, firms' cash savings are much more sensitive to the COE than to the COD.

To address the endogeneity concern that cash savings may themselves affect the COC, we adopt an identification strategy that uses the Regulation Fair Disclosure (Reg FD) in 2000 as a plausibly exogenous shock to the COC and conduct a generalized triple difference analysis. Reg FD reduced the COC by leveling the information playing field, especially among firms that are more prone to selective disclosure prior to the regulation, as shown in Chen et al. (2010). By exploiting the cross-sectional variation in the impact of Reg FD on the firm-level COC, we show that following Reg FD, firms experiencing a larger decline in the COC exhibit an increased sensitivity of cash savings to external capital compared to firms with a smaller decline in the COC. We also conduct placebo tests to minimize the possibility that our results are driven by some omitted factors rather than changes in the COC. Our results are also robust to alternative COC measures and to adjustments for potential measurement errors.

Then, we investigate whether financial constraints explain the sensitivity of cash savings to the COC. We find that financially constrained and (currently) unconstrained firms *both* save more in response to a low COC and save more from external capital than internal cash flows. Almeida et al. (2004) suggest that financially constrained firms save from internal cash flows to mitigate underinvestment due to financial constraints. Our findings suggest that firms save from not only internal cash flows to mitigate the effect of financial constraints, but also external capital to hedge against higher financing costs for future investments, as saving from external capital when the COC is relatively low reduces underinvestment due to a higher future COC.

We also explore alternative motives that might explain the sensitivity of cash savings to the COC. One alternative is the market timing motive, which suggests that firms save from equity issue proceeds to take advantage of overvalued stock (Alti (2006), Kim and Weisbach (2008), Bates, Kahle, and Stulz

(2009), and Hertzel and Li (2010)). To test this alternative motive, we examine whether firms with high market timing motives are more likely to save cash and issue excess external capital when the COC is low than firms with low market timing motives. Using three market timing measures, we find that our result are not driven by such motives.

Second, Keynes (1936) suggests that the purpose of precautionary cash savings is to insulate firms from external finance by saving from internal cash flows. This precautionary motive does not predict that firms save cash out of external capital issuance when the COC is low as we document. However, McLean (2011) shows that a firm's precautionary motive, as measured by the level of R&D, cash flow volatility, dividend payout, and their principal component, explains its cash savings from equity issue proceeds. Accordingly, we examine whether firms with greater precautionary motives save more from external capital when the COC is relatively low. Although the precautionary motive has an overall positive effect on cash savings, it does not explain the sensitivity of cash savings from external capital to the COC.

Finally, we examine whether our results can be explained by the model proposed by Bolton et al. (2013), who showed that the dynamics of cash and financing decisions are related to the *relative* importance of the market timing and precautionary savings motives, which varies with the firm's cash holdings. Their model predicts that firms with low cash holdings will time favorable market conditions to shield against crises, while firms with high cash holdings do not time the market. However, we find that our results of saving cash from external capital at a low COC for future investments are not driven by the difference in the level of firms' cash holdings. Overall, our analyses show that the sensitivity of cash savings to the COC is best explained by firms' hedging needs stemming from the time variation in the COC and its correlation with their future financing needs for investments.

2. Related Literature

The literature has offered several explanations for firms' cash holdings, including agency conflicts (Dittmar et al. (2003); Dittmar and Mahrt-Smith (2007), Harford et al. (2008), Gao et al. (2013), and Nikoloo and Whited (2014)), tax considerations (Foley et al. (2007), and Harford et al. (2017), Faulkender et al. (2019)), product market competition (Fresard (2010)), refinancing risk (Harford et al. (2014)), and leverage (DeAngelo et al. (2021)). Our study focuses on explaining firms' cash saving behavior in the presence of time-varying cost of capital and contributes to the literature by demonstrating the importance of a hedging motive for corporate cash savings from external capital.

In the related empirical literature, DeAngelo, DeAngelo, and Stulz (2010) raise questions concerning the economic significance of the existing theories for cash saving from equity issuance: market timing motive (Kim and Weisbach (2008)) and precautionary motive (McLean (2011)). They find that most firms with attractive market timing opportunities fail to issue stocks and that many mature firms issue stocks without apparent financial difficulties. Moreover, Dittmar et al. (2019) maintain that the existing theories fail to explain most within-firm variation in cash savings and that the precautionary savings theory does not explain the cash holdings of cash-rich firms. Contributing to this literature, we show that firms save to reduce the overall COC by transferring financial resources to future states with a higher COC. Accordingly, the market timing (to take advantage of overvalued stocks) and the precautionary (to prepare for uncertain contingencies) motives are not sufficient conditions for firms to save from external capital because firms will not issue external capital to save if they have no expected capital needs or if they can meet their future capital needs at a low COC.

We also extend the literature on the effects of financial constraints on cash savings. Almeida et al. (2004) suggest that the cash flow sensitivity of cash captures the effect of financial constraints. Riddick and Whited (2009) challenge this interpretation by showing that financially constrained firms' cash savings and cash flows can be negatively related because firms reduce cash to increase investment after receiving positive cash flow shocks. In the financial constraint models, constrained firms trade off between current and future investments to save from internal cash flows. In our model, firms trade off between not only current and future investments but also the current COC and the future COC in accessing external capital so as to hedge against higher financing costs for future investments. This hedging motive drives the sensitivity of cash savings to the COC in *both* financially constrained and (currently) unconstrained firms. Our empirical results show that the cash savings of *both* financially constrained and unconstrained firms increase as the COC decreases.

The Bolton et al. (2013) continuous-time model shows that firms respond to fluctuations in financing conditions such as a probability of a crisis by adjusting cash, payout and investment decisions, and by timing the market to raise funds, even without immediate funding needs. Our model is complementary to their model and focuses on identifying the cash-saving motive of individual firms to reduce the overall external financing cost with consideration of future investment needs. In particular, we introduce a novel hedging motive for cash-saving decisions that is reflected in the correlation between the firm's cost of capital and funding needs. Moreover, we provide empirical evidence supporting the theoretically implied sensitivity of cash savings to the COC and the impact of hedging needs in driving this sensitivity.

Acharya, Almeida, and Campello (2007) show that financially constrained firms' preference for cash savings from internal funds over preserving debt capacity depends on their need to hedge investment opportunities against income shortfalls. Our hedging motive is distinct from that in their study because we consider cash savings from *both* internal cash flows and external capital (especially equity) in response to the COC. More importantly, *both* financially constrained and unconstrained firms save from external capital obtained with a relatively low COC to hedge against a higher COC for future investment.

Finally, our study is also related to Azar, Kagy, and Schmalz (2016) who suggest that the cost of carry for cash holdings, which depends on the risk-free interest rate, is an important factor explaining the trend in corporate cash holdings over time. However, Gao, Whited, and Zhang (2021) find a hump-shaped relationship between cash holdings and interest rates. They rationalize this relationship in a model in which firms' precautionary cash demand is correlated with interest rates nonmonotonically. They suggest that interest rates are unlikely to explain the recent rise in corporate cash holdings.[4] We contribute to the literature by showing that corporate cash savings are closely related to the time-varying COC, particularly the COE, which fluctuates over time due to changes in the risk premium in addition to the level of the risk-free interest rate.

3. Hypothesis Development

3.1 A Model of Cash Savings with Time-Varying Costs of External Finance

We develop a three-date model to illustrate how cash savings are affected by the time-varying cost of external finance.[5] A firm, initially endowed with W_t, faces a two-period investment and financing decisions with a zero discount rate. The investment at t produces $\pi(I_t) + z_{t+1}$, where I_t is the investment at the beginning of t, $\pi(I_t)$ is the expected cash flows at the end of t (or $t+1$) with a homogeneous of degree 1, $\pi_I > 0$ and $\pi_{II} < 0$, and z_{t+1} is a cash flow shock to the investment. We assume that z_{t+1} is i.i.d. normal with a zero mean and a variance of σ^2.[6] At $t+1$, after observing a random cash flow shock, the firm chooses investment, I_{t+1} and external finance, X_{t+1} for

[4] Differing from Azar, Kagy, and Schmalz (2016), who estimate a weighted regression with the sum of each firm's total assets as weights, Gao, Whited, and Zhang (2021) estimate an unweighted regression that includes a squared interest rate term to account for the hump-shaped relationship between cash and theinterest rate.

[5] The intuition from the analytical solution to the three-date model can also apply to a dynamic model, as shown in Appendix 5.

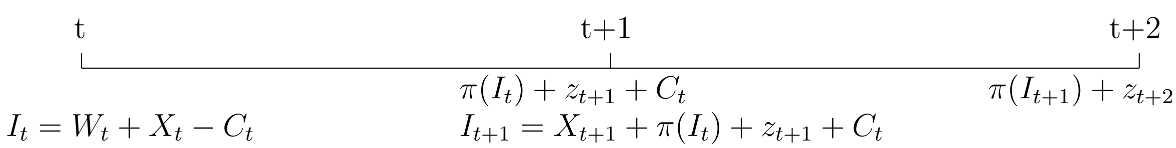
[6] f_x and f_{xx} denote the first and second partial derivatives, respectively, of $f(x, y)$ with respect to x, and "*i.i.d*" stands for independent and identically distributed across firms and over time.

its investment opportunity.

The firm maximizes the current shareholder wealth which is given as follows:

$$
\begin{aligned}
V_t \;&=\; \max_{(I_t, C_t, X_t)} E_t\{\pi(I_t) + z_{t+1} - I_t - C_t - \lambda(\delta_t, X_t) + V_{t+1}\} \qquad (1)\\
&\quad \text{subject to} \quad I_t = W_t + X_t - C_t \quad \text{and} \quad C_t \geq 0,\\
&\text{where} \quad V_{t+1} = \max_{(I_{t+1}, X_{t+1})} E_{t+1}\{\pi(I_{t+1}) + z_{t+2} - I_{t+1} - \lambda(\delta_{t+1}, X_{t+1})\}, \quad \text{and}\\
&\qquad I_{t+1} = X_{t+1} + \pi(I_t) + z_{t+1} + C_t,
\end{aligned}
$$

where C_t is cash saving at the beginning of t which returns the same amount at $t+1$, E_t is the expectation over z given the information at t, and X_t is external finance (or dividend if negative). The external financing decision is made at the beginning of each period. The firm's need for external capital at t is determined by the sum of investment and cash savings minus the initial endowment. The firm pays out funds without costs if X_t is negative. The external finance cost is represented by $\lambda(\delta, X)$ for $X > 0$ with $0 < \lambda_X(\delta, X) < 1$. The external finance cost function implies that the marginal external finance cost increases with the amount of external capital raised and cannot be greater than its proceeds. The external finance cost is also an increasing function of δ ($\lambda_\delta(\delta, X) > 0$), which is the time-varying component of the external financing cost related to market frictions such as agency problems, limited intermediation,[7] investor preferences that drive fluctuation in the risk premium, and/or market sentiment. Here, we assume that δ is deterministic and independent of z but we relax this assumption in Section 3.2. The following time line shows the firm's cash flows and decisions.



[7] According to Baker (2009), limited intermediation refers to intermediaries' inability to reinforce fundamental value due to the lack of competition or efficiency.

To explore the optimal cash savings, financing, and investment decisions in equation (1), we solve the model backwards, starting with the second-period financing and investment decisions as follows:

$$\begin{aligned} V_{t+1} &= \max_{(I_{t+1},X_{t+1})} E_{t+1}\{\pi(I_{t+1}) + z_{t+2} - I_{t+1} - \lambda(\delta_{t+1}, X_{t+1})\} \\ &\qquad \text{subject to} \quad I_{t+1} = X_{t+1} + \pi(I_t) + z_{t+1} + C_t. \end{aligned} \tag{2}$$

The external capital raised by the firm at $t+1$ depends on the cash flow generated from investment and cash saved at t. The first-order conditions with respect to the firm's optimal decisions regarding I_{t+1} and X_{t+1} are as follows:

$$\pi_I(I_{t+1}) = \mu_{t+1} \quad \text{and} \quad \mu_{t+1} = 1 + \lambda_X(\delta_{t+1}, X_{t+1}), \tag{3}$$

where μ_{t+1} is the Lagrangian for the constraint on X_{t+1}. These conditions imply that the optimal level of investment is below the first-best level (I^*_{t+1}), satisfying $\pi_I(I^*_{t+1}) = 1$, if the firm raises external capital with financing costs. Notably, cash at $t+1$ is the sum of the cash flow from its initial investment and cash savings at t as follows: $C_{t+1} = \pi(I_t) + z_{t+1} + C_t$. The first-best level of investment can be achieved if the firm has sufficient cash at $t+1$ ($I^*_{t+1} \leq C_{t+1}$). If C_{t+1} is insufficient to cover the investment, the firm must rely on external finance, and its investment will be determined to satisfy $\pi_I(\hat{I}_{t+1}) = 1 + \lambda_X(\delta_{t+1}, \hat{X}_{t+1}) > 1$. Thus, the firm may invest below the first-best level in the presence of the cost of external capital ($\hat{I}_{t+1} < I^*_{t+1}$).

Based on the above observations, we obtain the following:

$$\begin{aligned} E_t[V_{t+1}] &= \int_{I^*_{t+1}-C_t-\pi(I_t)}^{\infty} \left\{\pi(I^*_{t+1}) - I^*_{t+1}\right\} g(z)dz \\ &\quad + \int_{-\infty}^{I^*_{t+1}-C_t-\pi(I_t)} \{\pi(X_{t+1} + C_t + \pi(I_t) + z_{t+1}) - I_{t+1} - \lambda(\delta_{t+1}, X_{t+1})\} g(z)dz, \end{aligned} \tag{4}$$

where $g(z)$ is the probability density function (PDF) of z_{t+1}.

Moving back to the first period, the first-order conditions (FOCs) are derived in Appendix 1. The FOCs suggest that the expected marginal benefit of cash due to the cost of external finance at $t+1$ (denoted by H in Appendix 1) is an important consideration for investment and cash savings decisions at t. In particular, when the firm relies on external finance, it will choose the optimal investment where the marginal benefit of the investment is equal to its marginal cost. Similarly, the optimal cash savings decision with external finance is made where the marginal benefit of cash savings is equal to the marginal cost. If the firm is unconstrained at t because it has a sufficient initial endowment to make initial investment and cash savings, the optimal cash savings will be set where its marginal benefit is equal to the marginal cost without incurring an external financing cost.

To examine how the firm reacts when the firm expects a higher external finance cost, we make the following additional assumptions regarding the second-order derivatives of $\lambda(\delta, X)$:

Assumption 1 *The external finance cost function, λ, satisfies:*

for $X > 0$,

(i) $\lambda_{XX}(\delta, X) > 0;$

(ii) $\lambda_{X\delta}(\delta, X) > 0;$

(iii) $\lambda_{\delta\delta}(\delta, X) > 0;$

for $X \leq 0$,

(iv) $\lambda_{XX}(\delta, X) = \lambda_{\delta\delta}(\delta, X) = \lambda_{X\delta}(\delta, X) = 0.$

Assumptions (i) - (iii) require that λ is a convex function, such as that obtained under the costly-state-verification approach used by Froot et al. (1993). Assumption (ii) also implies that the marginal cost of external finance increases as δ increases. Assumption (iv) regarding $X \leq 0$ reiterates that there is no cost when the firm does not raise external capital. These assumptions imply that a lower cost of external capital at t will increase optimal cash savings, external finance, and investment at t

(See Appendix 2).

As the cost of capital varies over time, the firm's optimal decisions at t are also affected by the time-varying component of the external financing cost δ_{t+1} as shown in the following proposition:

Proposition 1 *The optimal investment, $\hat{I}_t$, external finance, $\hat{X}_t$, and cash savings, $\hat{C}_t$, at t exhibit the following properties:*

For $\hat{X}_t > 0$,

$$\frac{\partial \hat{C}_t}{\partial \delta_{t+1}} > 0, \quad \frac{\partial \hat{X}_t}{\partial \delta_{t+1}} > 0, \quad \text{and} \quad \frac{\partial \hat{I}_t}{\partial \delta_{t+1}} < 0.$$

For $\hat{X}_t \leq 0$,

$$\frac{\partial \hat{X}_t}{\partial \delta_{t+1}} > 0, \quad \frac{\partial \hat{C}_t}{\partial \delta_{t+1}} > 0, \quad \text{and} \quad \frac{\partial \hat{I}_t}{\partial \delta_{t+1}} = 0.$$

Proof: See Appendix 2.

Proposition 1 suggests that when the firm expects a higher δ_{t+1} and, hence, a higher COC at $t+1$, the value of cash available at $t+1$ increases, which increases the firm's incentives to save by raising external capital. Thus, the firm will raise additional external capital to increase its savings at t. However, increasing investment at t to generate more cash at $t+1$ is less attractive because of diminishing returns on investment as suggested by the concave production function. When the firm is presently unconstrained in that it has enough cash to make its optimal investment and savings decisions at t, it will not change its investment but will increase cash by reducing payout (given $X_t \leq 0$) in response to a higher δ_{t+1}. In this case, the optimal investment at t is not affected by the expected COC at $t+1$ because the marginal return on cash remains constant while that on investment is decreasing. Consequently, when the firm expects a higher cost of external finance at $t+1$, it is more beneficial to save cash than to increase investment at t, since cash savings help the firm hedge against the higher future cost of external finance at a lower cost. If the firm does not save at t and faces a low internal cash flow at $t+1$, it will face an increase in the amount of external capital at a higher cost and a reduction in the amount of investment at $t+1$.

The effects of expected investment I_{t+1} on the firm's optimal decisions at t are similar to those of δ_{t+1} (Appendix 2), leading to the following corollary:

Corollary 1 *The optimal investment, $\hat{I}_t$, external finance, $\hat{X}_t$, and cash savings, $\hat{C}_t$, at t exhibit the following properties:*

For $\hat{X}_t > 0$,

$$\frac{\partial \hat{C}_t}{\partial I_{t+1}} > 0, \quad \frac{\partial \hat{X}_t}{\partial I_{t+1}} > 0, \quad \text{and} \quad \frac{\partial \hat{I}_t}{\partial I_{t+1}} < 0.$$

For $\hat{X}_t \leq 0$,

$$\frac{\partial \hat{X}_t}{\partial I_{t+1}} > 0, \quad \frac{\partial \hat{C}_t}{\partial I_{t+1}} > 0, \quad \text{and} \quad \frac{\partial \hat{I}_t}{\partial I_{t+1}} = 0.$$

Thus, when expecting profitable future investment opportunities, the firm will increase cash savings and external finance at t. The firm will also reduce investment at t by trading off between the marginal return on the current investment and that on the future investment. Together with the FOCs at t, the proposition and the corollary suggest that firms expecting higher external finance costs or greater investment are likely to increase cash savings by raising external capital beyond the current investment, i.e., they issue excess capital. The firm will save more when it faces a lower COC at t relative to the COC at $t+1$ while expecting greater investment at $t+1$. The cash saved at the lower COC at t reduces the amount of external capital that must be raised under the higher COC at $t+1$, reducing the overall COC of the firm over time. This inter-temporal smoothing of the COC is a key insight of the model.

3.2 Hedging Motive

In this section, we extend our analysis to incorporate uncertainty in external finance costs and investment opportunities. In the discussion above, we assume that the time-varying cost component of external finance stemming from market frictions and investor preferences, δ, is nonstochastic, and thus independent of the cash flows from its assets in place. However, cash flow shock z due to aggregate economic uncertainty may affect both δ and investment opportunities, resulting in a correlation between financing costs and external capital. Such a correlation induces an incentive to save more cash to hedge against costs for external capital needs. We refer to this incentive as the "hedging motive" of cash savings.

We redefine δ and $\pi(I)$ at $t+1$ to capture the changes in the external finance cost and investment opportunities correlated with cash flow shock z. For simplicity, we assume that $\delta^o = \delta + \frac{\alpha\sigma_\delta}{\sigma} z$ and $\pi^o(I) = \pi(I)(1+\beta z)$, where α and β measure the strength of the correlation between z and δ^o and the effect of z on investment opportunities, respectively.[8] For a given optimal investment I^o, the optimal external finance is given by $X^o = I^o - \pi(I_t) - C - z$.

As shown in Appendix 3, δ^o can be rewritten as follows:

$$\delta^o = \delta + \frac{\alpha\sigma_\delta}{\sigma} z = \delta + \gamma\left(X^o - \bar{X}\right), \tag{5}$$

where $\gamma = \frac{d\delta^o}{dX^o}$ measures the relative effects of z on δ^o and X^o. If a negative shock to z is expected to increase δ^o while reducing investment and consequently its external finance, the firm will have less incentive to hedge against the increasing costs for external capital needs. If a negative shock to z is expected to increase both X^o and δ^o, however, the firm will have a greater incentive to hedge against the increasing costs for external capital needs. Thus, a higher γ implies greater effects of z on the expected cost of external finance and the expected marginal value of cash.

[8] We assume that the external finance component follows a normal distribution with mean δ and variance σ_δ^2. Consequently, δ^o can be considered a conditional expectation given z. Variables without subscript are at $t+1$.

Since the expected external finance cost and the expected marginal value of cash are key considerations for cash saving at t, optimal decisions at t are also affected by γ. Proposition 2 establishes the properties of optimal decisions at t with respect to γ as follows:

Proposition 2 *The optimal levels of cash savings, C_t^o, external finance, X_t^o, and investment, I_t^o, exhibit the following dependence on γ:*

For $X_t^o > 0$,

$$\frac{\partial C_t^o}{\partial \gamma} = \frac{\partial C_t^o}{\partial \delta^o}\frac{\partial \delta^o}{\partial \gamma} > 0, \quad \frac{\partial X_t^o}{\partial \gamma} = \frac{\partial X_t^o}{\partial \delta^o}\frac{\partial \delta^o}{\partial \gamma} > 0 \quad \text{and} \quad \frac{\partial I_t^o}{\partial \gamma} = \frac{\partial I_t^o}{\partial \delta^o}\frac{\partial \delta^o}{\partial \gamma} < 0.$$

For $X_t^o \leq 0$,

$$\frac{\partial C_t^o}{\partial \gamma} > 0, \quad \frac{\partial X_t^o}{\partial \gamma} > 0, \quad \text{and} \quad \frac{\partial I_t^o}{\partial \gamma} = 0.$$

Proof: See Appendix 4.

Proposition 2 implies that the sensitivities of the optimal cash savings and external finance decisions to the COC are magnified by the correlation between the external capital needs and external finance cost as measured by γ. Firms with a high γ may have to reduce investments at $t + 1$ due to higher external finance costs when facing lower cash flows; these firms can issue external capital (or reduce payout if $X_t^o \leq 0$) at time t at a lower cost and save for future investment, thereby reducing their overall cost of external finance. Consequently, the amount of cash savings and excess capital issuance at t should be larger when firms expect greater investment and a higher COC in the future. The optimal investment at t, however, is less affected by γ because it is more beneficial to save cash (with a constant marginal rate of return) than to increase investment (with a decreasing marginal rate of return).

Given these results, we propose the following hedging motive hypotheses:

Hypothesis 1a Firms with a high correlation between external capital needs and the COC will save more when the COC is relatively low.

Hypothesis 1b Firms with a high correlation between external capital needs and the COC will issue more excess external capital when the COC is relatively low.

Hypothesis 1c Firms with greater future expected investments will save more when the COC is relatively low.

4. Data and Variables

4.1 Sample

The initial sample consists of all U.S. firms from the annual Compustat files during the 1981–2019 period. We require that firms have a value of assets greater than $5 million and positive values for equity, cash holdings and net sales. Financial firms (SIC codes 6000-6799) and regulated utilities (SIC codes 4900-4999) are excluded from the sample. Observations with missing net income and stock issuance proceeds are also excluded. The stock price information is obtained from the Center for Research in Security Prices (CRSP), the nominal GDP growth rates are obtained from the Bureau of Economic Analysis, and the interest rates are from the Federal Reserve Bank of St. Louis.

To estimate the cost of equity, we obtain analysts' earnings and growth forecasts from the Institutional Brokers Estimate System (I/B/E/S). We require non-missing data for the prior year's book value, earnings, and dividends. When explicit forecasts are unavailable, we obtain forecasts by applying the long-term growth rate to the prior year's earnings forecast.

4.2 Cost of Capital

It is challenging to estimate individual firms' cost of capital because the cost of equity and the cost of debt are not directly observable. We measure the COE using the implied cost of capital approach, which estimates the *ex ante* expected return implied by market prices (Gebhardt, Lee, and Swaminathan (2001) and Li, Ng, and Swaminathan (2013)). Specifically, the ICC is the discount rate that equates a stock's present value of expected cash flows to its current price. According to the discounted cash flow model, the stock price of a firm at time t is as follows:

$$P_t = \sum_{k=1}^{\infty} \frac{E_t(FE_{t+k})}{(1 + ICC_t)^k}, \tag{6}$$

where P_t is the market value of the stock at time t, $E_t(FE_{t+k})$ is the expected free cash flow to equity at time $t + k$, and ICC_t is the implied cost of equity capital.

To estimate the cost of equity, we use three different models proposed by Gebhardt, Lee, and Swaminathan (2001), Claus and Thomas (2001), and Li, Ng, and Swaminathan (2013). The detailed procedures of this estimation are provided in Appendix 7. The consensus analyst forecasts from I/B/E/S are used to predict future earnings per share. Given that firms are required to file their financial statements within 90 days of the fiscal year end, we estimate the COE using the earliest forecasts available after three months of the prior fiscal year end. The reported results are based on the Gebhardt, Lee, and Swaminathan (2001), approach. The results are robust to the alternative COE estimation methods.

We estimate the COC as follows:

$$COC_{i,t} = \frac{Debt_{i,t}}{MVA_{i,t}} COD_{i,t}(1 - TaxRate) + (1 - \frac{Debt_{i,t}}{MVA_{i,t}})COE_{i,t}, \tag{7}$$

where $COC_{i,t}$ is the weighted average cost of capital of firm i in year t. $\frac{Debt_{it}}{MVA_{it}}$ is the market leverage ratio. $COD_{i,t}$ is the cost of debt of firm i in year t measured as the actual yield of the debt carried by the firm as used in Frank and Shen (2016). The COC of each firm is estimated for each year.

4.3 Hedging Motive Measures

We measure the hedging motive by the regression coefficient of external capital needs on the COC.[9] The following three proxies are used to capture firms' needs for external capital: KZ index, external finance dependence, and financial deficit. Following Baker, Stein, and Wurgler (2003), we use the KZ index to measure external finance dependence as follows:

$$KZ = -1.002CF - 39.368DIV - 1.315CASH + 3.139LEV, \tag{8}$$

where CF is the operating income before depreciation and amortization (oibdp) divided by net property, plant and equipment at the beginning of the period (PPE); DIV is cash dividend divided by PPE; $CASH$ is cash and equivalents divided by PPE; and LEV is long-term debt divided by long-term debt plus total equity.

Following Rajan and Zingales (1998), external finance is measured as follows:

$$External = (CapEx - OCF)/CapEx, \tag{9}$$

where $CapEx$ is capital expenditures; and OCF is the operating income before depreciation and amortization (oibdp) .

We also follow Shyam-Sunder and Myers (1999), Frank and Goyal (2003), and Byoun (2008) and define financial deficit as follows:

$$Deficit = (Div + Acq + Inv - ICF1)/TA, \tag{10}$$

where Div is cash dividend; Acq is acquisitions; Inv is net investments; $ICF1$ is income before extraordinary (ibc) items plus depreciation and amortization (dpc) and TA is total assets at the beginning of the period.

We use the industry median $External$ based on the 2-digit SIC code and the firm-level $Deficit$

[9]The hedging motive measured by the regression coefficient is consistent with γ in our model. In an earlier version of the paper, we also measure the hedging motive based on the correlation coefficient between the COC and external capital needs. The results are similar.

and KZ as proxies for external capital needs. To measure hedging needs, we obtain annual external capital needs measures and compute their regression coefficients on individual firms' COCs over the sample period. Based on the coefficients, we define firms in the top 30 percent as high hedging needs firms and those in the bottom 30 percent as low hedging needs firms and remove the middle 40 percent.

5. Empirical Analysis

5.1 Univariate Analysis

The summary statistics of the firm characteristic variables and the COC are reported in Table 1 Panel A. The average cash holding is 11% of total assets and the cash savings rate is approximately 1.18% of total assets. The average COC is 8.49%, with an average COE of 9.62% and an average COD of 7.01%. Panel B shows the decomposition of the standard deviation of the COC across firms and over time. As expected, the COD exhibits less variation than the COE cross-sectionally and over time.

Figure 1 plots the average annual cash holdings relative to the average COC, COE, and COD over the sample period. The striking symmetry of the two series suggests that firms increase (decrease) cash when the COC is low (high). Thus, the COC appears to be an important driver of corporate cash holding behavior over time. Notably, the COC declined significantly until the early 2000s, which may help explain the increasing trend in cash holdings over the same period documented by Bates et al. (2009).

To further examine how a relatively low COC drives corporate cash savings, we obtain a firm's COC minus its historical average for firms with a minimum of 3 years of data. Figure 2 plots cash savings across deciles of the deviation of COC from the historical average for the sample period of 1981-2019 and the subsample periods of 1981-1999 and 2000-2019. The downward-sloping graphs indicate that firms save more when COC is below the historical average.

Figure 3 plots the current year cash savings across future investment (subsequent three-year average) deciles. The figure shows that firms with greater future investment save more cash in the current year, which is consistent with the prediction of the hedging motive for cash savings that firms save cash for future investments.

5.2 Sensitivities of Cash Savings to Cash Sources

Firms may save cash from internal or external capital. To examine how cash savings are associated with cash sources in a multivariate setting, we estimate the following regression:

$$\Delta Cash_{it} = \lambda_0 + \lambda_1 ExCapital_{it} + \lambda_2 ICF_{it} + \lambda_3 X_{it-1} + f_i + \gamma_t + \varepsilon_{it} \tag{11}$$

where $\Delta Cash_{it}$ is the change in cash and equivalents of firm i in year t; ICF_{it} is internal cash flow; and $ExCapital_{it}$ is the sum of the net equity issue and net debt issue. Each variable is divided by total assets at the beginning of the period. X_{it-1} is a vector of control variables and f_i is firm fixed effects. γ_t controls for year fixed effects. Following Opler et al. (1999) and Bates et al. (2009), we include the following control variables: M/B_{it-1}, market-to-book asset ratio; $Cash_{it-1}$, lagged cash-to-asset ratio; Vol, cash flow volatility; $Leverage_{it-1}$, leverage ratio;[10] $Size_{it-1}$, the logarithm of total assets; NWC_{it}, net working capital excluding cash and equivalents divided by total assets at $t-1$; $CapEx_{it}$, capital expenditures divided by total assets at $t-1$; $Acquisitions_{it}$, acquisitions divided by total assets at $t-1$; and $Divdend_{it}$, cash dividend divided by total assets at $t-1$. We winsorize all variables at the 2 and 98 percentiles to mitigate the effects of outliers.

We first estimate the model without firm and year fixed effects. The results are reported in Table 2. The coefficient estimate of external capital ($ExCapital$) is 0.2822 and significant, whereas

[10] Previous studies show that firms with more volatile cash flows tend to hold more cash (Bates et al. (2009) and McLean (2011)). The inclusion of cash flow volatility as an independent variable helps control for the effect of the precautionary motive of cash savings. We include leverage to control for the potential effects of capital structure. Although firms may hedge by altering their capital structure, this change will only enable firms to optimize debt and equity, but cannot neutralize the common component in the COE and the COD.

that of internal cash flows (ICF) is 0.2299 and significant. To evaluate the relative importance of external capital to internal cash flows, we estimate the standardized beta coefficients. Column 5 of Table 2 shows that the standardized beta coefficient of external capital is much larger than that of internal cash flow (0.6691 vs. 0.1806), indicating that external capital is a major source of firms' cash savings.

When we include firm fixed effects (Column 2), year fixed effects (Column 3), and firm and year fixed effects (Column 4), the coefficient estimates of the cash sources remain positive and significant. The estimates also show that M/B and cash flow volatility have positive effects on cash savings, while lagged cash, dividend, leverage, firm size, net working capital, capital expenditures, and acquisitions have negative effects.

5.3 Cost of Capital and Cash Savings

To test whether firms' cash savings are sensitive to the COC, we include the COC and its interactions with external capital ($ExCapital$) and internal cash flows (ICF) in equation (11). The estimation results are reported in Table 3. For brevity, we do not report the estimates of control variables. The negative and significant coefficient estimates of the COC suggest that firms save more when the COC is low. The economic magnitude of the impact is also significant. A one percentage point decrease in the COC is associated with an approximately 16% increase in cash savings. The negative coefficient estimates of its interaction with external capital indicate that firms save significantly more from external capital when the COC is lower.

6. Hedging Motive

Our model suggests that in the presence of the time-varying COC, firms with a high correlation between their COC and external financing needs (high hedging motive) have more incentives to raise external capital and save cash at a relatively low COC. Such cash savings should be more pronounced when firms expect greater future investments. We test these predictions in this section.

6.1 Hedging Needs and Cash Savings

To test hypothesis 1a that firms with high hedging motives save more when the COC is relatively low, we examine whether the sensitivity of cash savings to the COC is more pronounced among firms with high hedging needs. We divide the sample into high and low hedging needs firms based on the hedging motive measures and report the results in Table 4. Hedging Motives 1 to 3 represent the correlation coefficients between the COC and each of the three measures of external capital needs ($External$, $Deficit$, and KZ).

The coefficient estimates of the interaction terms between external finance proceeds and the COC ($ExCapital \times COC$) are significant and negative only among high hedging needs firms, indicating that firms with greater hedging motives save more from external capital when the COC is relatively low. These results are consistent with hypothesis 1a.

6.2 Hedging Needs and Excess Capital Issuance

Hypothesis 1b predicts that firms with greater hedging needs issue excess capital when the COC is relatively low. To test this prediction, we define excess capital issuance as the net external capital issue proceeds minus the financial deficit, which represents the portion of external capital that is saved as cash. Panel A of Table 5 reports the results of firms with high and low hedging needs based on the three hedging motive measures. The coefficient estimates of the COC are negative and significant only among firms with high hedging needs. These results are consistent with hypothesis 1b, indicating that firms with high hedging needs issue excess external capital to save as cash when the COC is lower.

6.3 Future Investment and Cash Savings

Subsequently, we test hypothesis 1c, which predicts that firms save cash to fund future investments, using the following regression:

$$\Delta Cash_{it} = \alpha_0 + \alpha_1 FInvest_{it} + \alpha_2 ICC_{it} + \alpha_3 FInvest_{it} \times ICC_{it} + \alpha_4 X_{it-1} + f_i + \gamma_t + \varepsilon_{it} \tag{12}$$

where $FInvest_{it}$ is the future investment at time t of firm i, defined as the average of investment scaled by lagged total assets in the subsequent three years.[11] The same set of control variables used in equation (11) are included. We expect firms to save more when they expect greater future investment ($\alpha_1 > 0$) because their realized future investment will be positively correlated with their managers' ex ante expected investment. We estimate equation (12) separately for firms with low and high hedging needs. Since the incentive to save cash for future expected investment will be greater when facing a relatively low COC, we expect α_3 to have a negative sign, especially among firms with greater hedging needs.

Panel B in Table 5 reports the results of the high and low hedging needs firms based on the three hedging motive measures. The coefficient estimates of future investment are positive and significant only among firms with high hedging needs. Moreover, the coefficient estimates of the interaction term between future investment and the COC are all negative and significant only among high hedging needs firms. These findings provide support for hypothesis 1c that firms with hedging needs save cash at a low cost for future investments.

6.4 Equity versus Debt

Thus far, our results show that firms save cash from external capital and that this saving behavior is affected by the COC. As equity and debt are the two main sources of external capital, we investigate

[11] The use of realized future investment is consistent with the use of future stock returns in previous studies (Baker et al. (2003) and DeAngelo et al. (2010)).

their relative importance for firms' cash savings. We first perform a simple regression for each cash sources and report the results in Table 6 Panel A. The coefficient estimate of net equity issues ($EIssue$) is 0.2804 and significant, with an adjusted R^2 of 9.4%. The coefficient estimate of debt issues ($DIssue$) is a mere 0.0556, and the adjusted R^2 is 0.71%. The estimated coefficient of internal cash flows (ICF) is 0.1503 and statistically significant, with an adjusted R^2 of 1.3%. When we include all cash sources along with the control variables (column 4) and firm fixed effects (column 5), the coefficient estimates of all cash sources remain positive and significant. Overall, equity is the most important source for cash savings.

Then. we examine the relative importance of the COE and the COD for firms' cash savings by including the interaction terms between the COE (COD) and net equity issue proceeds (net debt issue proceeds) and internal cash flows into our regression model. As shown in Table 6 Panel B, the coefficient estimates of COE are negative and significant among firms with high hedging motives, while the coefficient estimates of COD are mostly insignificant. For all firms in Column (1), the coefficient estimates of both $Eissue \times COE$ and $ICF \times COE$ are negative and significant. The coefficient estimate of $Dissue \times COD$ is also negative and significant but that of $ICF \times COD$ is insignificant. These results suggest that firms' cash savings from equity issuance and internal cash flows are both sensitive to the COE, whereas cash savings from internal cash flows show limited sensitivity to the COD.

When the sample is divided into low and high hedging needs firms in the remaining columns, we find that the coefficient estimates of both $Eissue \times COE$ and $ICF \times COE$ are significant and negative only among high hedging needs firms. Thus, COE appears to be an important consideration in firms' cash savings decisions, particularly in firms with high hedging needs.

6.5 Exogenous Shock to the Cost of Capital

An endogeneity concern may arise if firms' cash savings affect their COC or if other confounding factors drive the observed relationship. To ease this concern and buttress our results of the causal effects of the COC on cash savings, we exploit a plausibly exogenous event that affects firms' COC. In particular, we use Regulation Fair Disclosure (Reg FD) as a shock to the COC and investigate whether firms experiencing a greater reduction in their COC during the post-Reg FD period save more from external capital than firms experiencing a smaller reduction in COC. Reg FD, which was implemented on October 23, 2000, prohibits the selective disclosure of material information to a subset of market participants, such as analysts and institutional investors, without simultaneously disclosing such information to the public. By curtailing selective disclosure, the Securities and Exchange Commission (SEC) believed that Reg FD would encourage continued widespread investor participation in capital markets, thereby enhancing market efficiency and liquidity, and more effective capital raising. As a result, Reg FD lowers the COC for those firms with selective disclosure before Reg FD (Chen et al. (2010)).

Following Chen et al. (2010), we use market-to-book ratios (M/B) and R&D as firm characteristics indicative of selective disclosure and classify firms into treated and control groups. Specifically, the treatment and control firms are defined as the top and bottom 30% ranked by the M/B ratio or the top 50% ranked by the R&D-to-sales ratio among positive R&D firms and zero-R&D firms, respectively. M/B ratio and R&D-to-sales ratio are measured as of the end of September 2000 before Reg FD. We set the *Post* dummy as one for 2000-2003 and zero for 1997-1999.

Columns (1) and (2) in Table 7 show the results of the M/B- and R&D-based measures of selective disclosure, respectively. For both measures, the coefficient estimates of the triple interaction term $Treated \times ExCapital \times Post$ are positive and significant, indicating that cash savings from external capital have significantly increased among firms with a larger reduction in the COC relative to firms with a smaller reduction in the COC following the legislation.

To ease the concern that the results may be driven by some omitted variables that affect both the COC and cash savings, we also conduct placebo tests based on the fictitious event years of 2008 and 2011. The sample period is 6 years surrounding the fictitious event year. The results of the placebo tests reported in Columns (3)-(6) show that none of the coefficient estimates of $Treated \times ExCapital \times Post$ are significant. Thus, the results appear to be unique to Reg FD and are less likely due to other confounding factors. These findings boost our confidence that the COC has a causal impact on corporate cash savings from external capital.

It is also possible that the above results simply capture pre-existing divergent trends or differences between the treatment and control groups that are unrelated to the shock to the COC. To explore this possibility, we investigate the dynamics of firms' cash savings from external capital surrounding the shock. If this alternative explanation holds true, we should observe more cash savings from external capital by the treatment firms prior to Reg FD. To test this possibility, we replace *Post* with year indicator variables associated with the years surrounding Reg FD. Figure 4 presents the coefficient estimates of the triple interaction term $Treated \times ExCapital \times Year$ with the 90% confidence interval. As shown in Figure 4, the differences in the sensitivities of cash savings to external capital between the treated and control groups are close to zero before Reg FD. Firms experiencing a larger decline in the COC save significantly more cash from external capital than firms experiencing a smaller decline in the COC after Reg FD. Therefore, it is less likely that our results are driven by pre-existing divergent trends in the treated and control firms or reverse causality.

6.6 Robustness

Although we show that the COC has a significant impact on cash savings in a natural experimental setting, an endogeneity concern may exist due to measurement errors in the COC. As a remedy for measurement errors in the COC, we estimate the model using high-order cumulants as suggested by Erickson et al. (2014). Table A1 in Appendix 8 reports the estimation results. The coefficient estimates of the interaction between external capital and the COC in Columns (1) and (2) are negative and significant for high hedging motive firms, whereas they are insignificant among lower hedging motive firms. These results are consistent with our main estimations. We also examine whether our results are robust to alternative measures of the COC using the Claus and Thomas (2001) and Li, Ng, and Swaminathan (2013) approaches as specified in Appendix 7. The results shown in Columns (3)-(6) illustrate that our findings are robust to these alternative COC measures.

7. Financial Constraints and Alternative Hedging Measure

7.1 Financial Constraints

Since financial constraints are an important consideration for firms' cash savings decisions (Almeida et al. (2004)), it is possible that our results simply reflect financial constraints. To investigate this possibility, we examine whether financial constraints explain the cash savings behavior observed in Table 3. Following previous studies, we use credit ratings, the WW (Whited and Wu (2006)) index, and the HP (Hadlock and Pierce (2010)) index to define financially constrained and unconstrained firms. Financially constrained (unconstrained) firms are defined as firms without (with) credit ratings or firms in the top (bottom) 30 percent of the WW index or the HP index.

The results presented in Table 8 Panel A show that both financially constrained and unconstrained firms save more when the COC is relatively low. Regarding the economic magnitude, one standard deviation decrease in the COC is associated with an approximately 4.52% (6.11%) increase in cash savings among unconstrained (constrained) firms based on the HP index. The estimated coefficients of $ExCapital \times COC$ are negative and significant among both constrained and unconstrained firms. Firms' cash savings from external capital in response to the COC are also economically significant in both financially constrained and unconstrained firms. When $ExCapital \times COC$ decreases by one standard deviation, the cash savings of financially unconstrained (constrained) firms increase by 21% (10%) based on the HP index. The estimated coefficients of $ICF \times COC$ are also negative and significant among both constrained and financially constrained firms.

We further test whether financial constraints help explain firms' excess capital issuance in response to a low COC and the effects of future investments on cash savings. To this end, we partition firms with high (low) hedging motives into financially constrained and unconstrained firms. The unreported tables show that both financially constrained and unconstrained firms with high hedging motives raise external capital in excess of current financial needs when the COC is relatively low.[12] The estimated coefficients of $FInvest \times COC$ are negative and significant for both constrained and unconstrained firms with high hedging motives, while the coefficients are insignificant for both constrained and unconstrained firms with low hedging motives. Overall, these results suggest that financial constraints cannot fully explain the sensitivity of cash savings to the COC.

7.2 Acharya, Almeida, and Campello (2007) Hedging Measure

Acharya et al. (2007) (AAC, henceforth) suggest that financially constrained firms save cash to hedge investment opportunities against income shortfalls, while unconstrained firms do not have a propensity to save cash out of cash flows. They measure a firm's hedging needs by the correlation between the firm's cash flows from current operations and its industry-level median R&D expenditures. We investigate whether their hedging needs measure explains the sensitivity of cash savings to the COC.

[12] The tables are available upon request.

We conduct tests based on our hedging motive and AAC hedging needs measures for financially constrained and unconstrained firms. We report the results of high hedging motive firms in Panel B of Table 8. The coefficient estimates of $ExCapital \times COC$ are negative and significant for both constrained and unconstrained firms when our hedging motive measure is used. These results are consistent with the finding shown in Panel A that both financially constrained and unconstrained firms save from external capital when the COC is relatively low. When the AAC measure is used, however, the coefficient estimates of $ExCapital \times COC$ are insignificant among financially constrained firms, whereas the coefficient estimate of $ICF \times COC$ is negative and significant among constrained firms. The results are consistent with the finding reported by Acharya et al. (2007) that financially constrained firms save from internal funds when they have high hedging needs against a cash flow shortage. However, the AAC hedging measure does not fully capture firms' needs of saving cash from external capital in response to a lower COC.

8. Alternative Explanations

8.1 Market Timing Motive

The market timing hypothesis suggests that firms may time the market and issue equity when it is overvalued. Mispricing in the stock market may be driven by nonfundamental components of the stock price, such as investor sentiment, which directly affects the COC but not cash flows (Campbell, Polk, and Vuolteenaho, 2010). When such mispricing drives the current COC below the expected COC, the firm may see an opportunity to issue external capital and save. Such cash savings, however, are not motivated by future investments. If market timing drives firms' cash savings behavior, the sensitivity of excess capital to the COC should be larger among firms with a higher market timing motive. These arguments lead to the following market timing hypotheses:

Hypothesis 2a Firms with greater market timing motives save more from external capital when the COC is relatively low than do firms with lower market timing motives.

Hypothesis 2b Firms with greater market timing motives issue more excess external capital when the COC is relatively low than do firms with lower market timing motives.

Using three market timing measures, we conduct a series of tests to investigate whether the market timing motive can explain our results. The first market timing measures is yearly timing (Timing 1) constructed by Kayhan and Titman (2007), which is the sample covariance between external financing and the market-to-book ratio over a five-year period. This market timing measure captures the idea that a firm raises more external capital by taking advantage of short-term overvaluation determined by the firm's current M/B ratio relative to its M/B in surrounding years. The second market timing measure is the long-term timing (Timing 2) as defined in Kayhan and Titman (2007), which is the product of the average market-to-book ratio and the average external financing over a five-year period. This measure captures a firm's market timing incentive by its M/B ratio relative to all firms in general. The third market timing measure (Timing 3) is the mispricing proxy developed by Stambaugh et al. (2015). This measure is constructed as the average of a stock's ranking percentiles for each of 11 anomaly variables, and a higher rank is associated with a greater relative degree of overpricing based on the given anomaly variable. The most overpriced stocks have the highest composite rankings. For each measure of market timing, we define firms in the top 30 percent as firms with high market timing motives and those in the bottom 30 percent as firms with low market timing motives.

To test market timing hypothesis 2a, we estimate regression models for firms with high or low market timing motives based on the three market timing measures. As shown in Table 9 Panel A, the coefficient estimates of $ExCapital \times COC$ are negative and significant for both firms with high market timing motives and firms with low market timing motives. The results are inconsistent with market timing hypothesis 2a that firms with greater market timing motives save more from external capital when the COC is relatively low.

In Panel C, we test market timing hypothesis 2b regarding excess external capital. The results show that the coefficient estimates of the COC are negative and significant for both low and high market timing motive firms, which is inconsistent with the hypothesis that excess capital issues are mainly driven by the market timing motive. Both low and high market timing motive firms issue excess external capital to save when the COC is lower.

Furthermore, we examine whether the market timing motive explains the effects of future investment on cash savings by estimating model (12) separately for high and low market timing firms. As shown in Panel D, the coefficient estimates of $FInvest \times COC$ are negative and significant among both firms with high market timing motives and firms with low market timing motives. Thus, the market timing motive does not fully explain the sensitivity of firms' cash savings to the COC.

8.2 Precautionary Motive

According to the precautionary motive, firms can avoid external financing by saving cash from internal cash flows (Fazzari et al. (1998), Almeida et al. (2004), Opler et al. (1999), and Bates et al. (2009)). Taking advantage of a relatively low COC to save cash from external capital is not considered the main reason for precautionary cash savings. In particular, Keynes (1936) argues that the quantity of cash demanded for precautionary purposes is not sensitive to changes in the COC because it is mainly determined by the general activity of the economic system and the level of income. Nevertheless, given the recent finding that the precautionary motive drives firms to save from equity issuance (McLean (2011)), we examine whether the cash savings of firms with stronger precautionary motives are more sensitive to the COC. Specifically, we test the following precautionary motive hypotheses:

Hypothesis 3a Firms with greater precautionary motives save more from external capital when the COC is relatively low than do firms with lower precautionary motives.

Hypothesis 3b Firms with greater precautionary motives issue more excess external capital when the COC is relatively low than firms with lower precautionary motives.

To test these hypotheses, we follow previous studies and use R&D spending, cash flow volatility, and nondividend payout as measures of precautionary motives that represent unforeseen opportunities and contingencies requiring sudden expenditures. Cash flow volatility is the 10-year standard deviation of the average industry cash flow based on the 2-digit SIC code. We pay particular attention to the precautionary measure used by McLean (2011) based on the first principal component of R&D spending and cash flow volatility. For R&D spending, cash flow volatility and their first principal component, we define the top 30% of firms as high precautionary firms and the bottom 30% as low precautionary firms. We also treat nondividend-paying firms as high precautionary firms and dividend-paying firms as low precautionary firms.

Table 9 Panel B shows that the estimated coefficients of $ExCapital \times COC$ are mostly negative and significant for both low and high precautionary firms. These results are not consistent with precautionary hypothesis 3a that firms with greater precautionary motives save more when the COC is relatively low. In Panel C, we test precautionary hypothesis 3b regarding excess external capital and find that the coefficient estimates of the COC are negative and significant for both low and high precautionary motive firms. These results are inconsistent with hypothesis 3b that firms with greater precautionary motives issue more capital in excess of the current financial needs than firms with lower precautionary motives when the COC is relatively low.

We also examine whether the precautionary motive explains the effects of future investment on cash savings. As shown in Panel D, the coefficient estimate of $FInvest \times COC$ is insignificant among firms with high precautionary motives, but significant among firms with low precautionary motive. Thus, there is no supporting evidence that the precautionary motive fully explains the sensitivity of firms' cash savings to the COC.

8.3 Market Timing and Precautionary Motives

Bolton et al. (2013) develop a dynamic model in which firms have both a precautionary-savings motive and a market timing motive for external financing. Under stochastic financing conditions, the dynamics of cash and financing decisions depend on the relative importance of the market timing and precautionary savings motives, which varies with the firm's cash holdings. They show that firms with a considerable amount of cash do not time the market because the market timing option is out of the money. In contrast, firms with low cash holdings have incentives to raise external capital when relatively cheap financing opportunities are available. Firms time favorable market conditions to shield against crises through precautionary cash holdings. Accordingly, we test the following hypotheses:

Hypothesis 4a Firms with low cash holdings save more from external capital when the COC is relatively low than do firms with high cash holdings.

Hypothesis 4b Firms with low cash holdings issue more excess external capital when the COC is relatively low than do firms with high cash holdings.

To test these hypotheses, we define firms with high (low) cash holdings as firms in the top (bottom) 30 percent based on their cash ratio or cash balance. As shown in Table 9 Panel B, the coefficient of $ExCapital \times COC$ is negative and significant among firms with high cash ratios, while it is positive among firms with low cash ratios. The coefficients are insignificant among firms with high cash balances and firms with low cash balances. These results are inconsistent with hypothesis 4a that firms with low cash holdings tend to time favorable market conditions to save cash more than firms with high cash holdings. These results indicate that our finding that firms with high hedging motive save more from external capital when the COC is relatively low is not explained by the model developed by Bolton et al. (2013).

We test hypothesis 4b by investigating excess capital issuance in response to the varying COC among firms with high cash holdings and firms with low cash holding. Since the results based on the cash ratio and cash balance are similar, Panel D presents the estimations based on the cash ratio. As shown in Columns (5) and (6), both cash-rich firms and cash-poor firms issue more excess capital when the COC is relatively low. The results provide no support for hypothesis 4b and indicate that raising excess capital at a low cost to save as cash is not driven by the dominating market timing motive among cash-poor firms as predicted by the Bolton et al. (2013) model.

We further examine whether our finding that firms save more for future expected investment when facing a lower COC is due to firms' cash holdings instead of the hedging motive. Columns (5) and (6) of Table 9 Panel E show that the coefficients of $FInvest \times COC$ are insignificant among both firms with high cash holdings and firms with low cash holdings. These results further indicate that the dynamic model proposed by Bolton et al. (2013) cannot fully explain our findings.

9. Conclusions and Discussions

We develop a theoretical model showing that in the presence of a time-varying COC, firms channel funds into future states with a high COC by saving cash from external capital when the current COC is relatively low. In particular, when a firm expects a higher COC for future investments, it will increase cash savings from external capital at a low cost to lower the *overall* cost of capital. Cash savings and excess external financing show greater sensitivities to the COC among firms with greater hedging needs.

Consistent with the theoretical predictions, we find that both financially constrained and unconstrained firms save more cash from external capital than they save from internal cash flows. The cash savings of firms with greater hedging needs are particularly sensitive to their COC. Moreover, firms with greater hedging needs tend to issue excess external capital when the COC is relatively low. Our findings cannot be fully explained either by the precautionary motive or by the market timing motive.

In summary, our study illustrates that firms' hedging motive to transfer funds from a low COC state to a higher COC state through cash savings is an important consideration for corporate cash savings policies. Previous studies show that credit lines also play an important role in firms' liquidity and risk management (Sufi (2009) and Acharya et al. (2014)). How the time-varying COC affects firms' choice between cash and credit lines is an interesting question. Extending our theoretical framework and empirical results to answer this question seems a fruitful area for future research.

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Figure 1: Cash Holdings versus Cost of Capital

This figure plots firms' average cash holdings relative to the level of the cost of capital (COC, COE, COD) from 1981 to 2019. Cash is cash and equivalents divided by total assets.

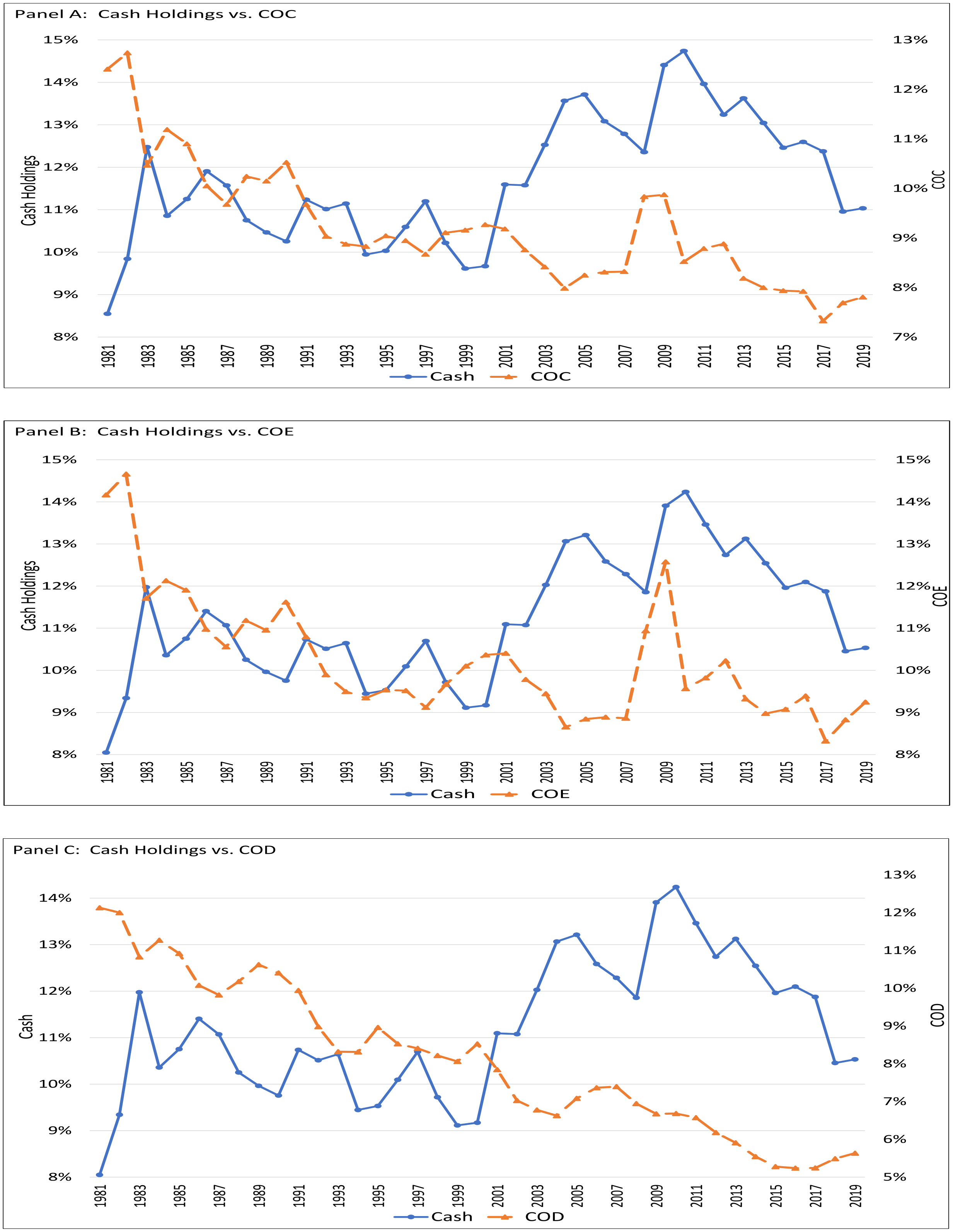

Figure 2: Cost of Capital and Cash Savings

The figure presents firms' cash savings across deciles of the deviation of the cost of capital (COC) from its historical average for firms with a minimum of three-year observations during the 1981-2019 sample period and the1981-1999 and 2000-2019 subsample periods. Cash savings is the changes in cash and equivalents divided by total assets at the beginning of the year.

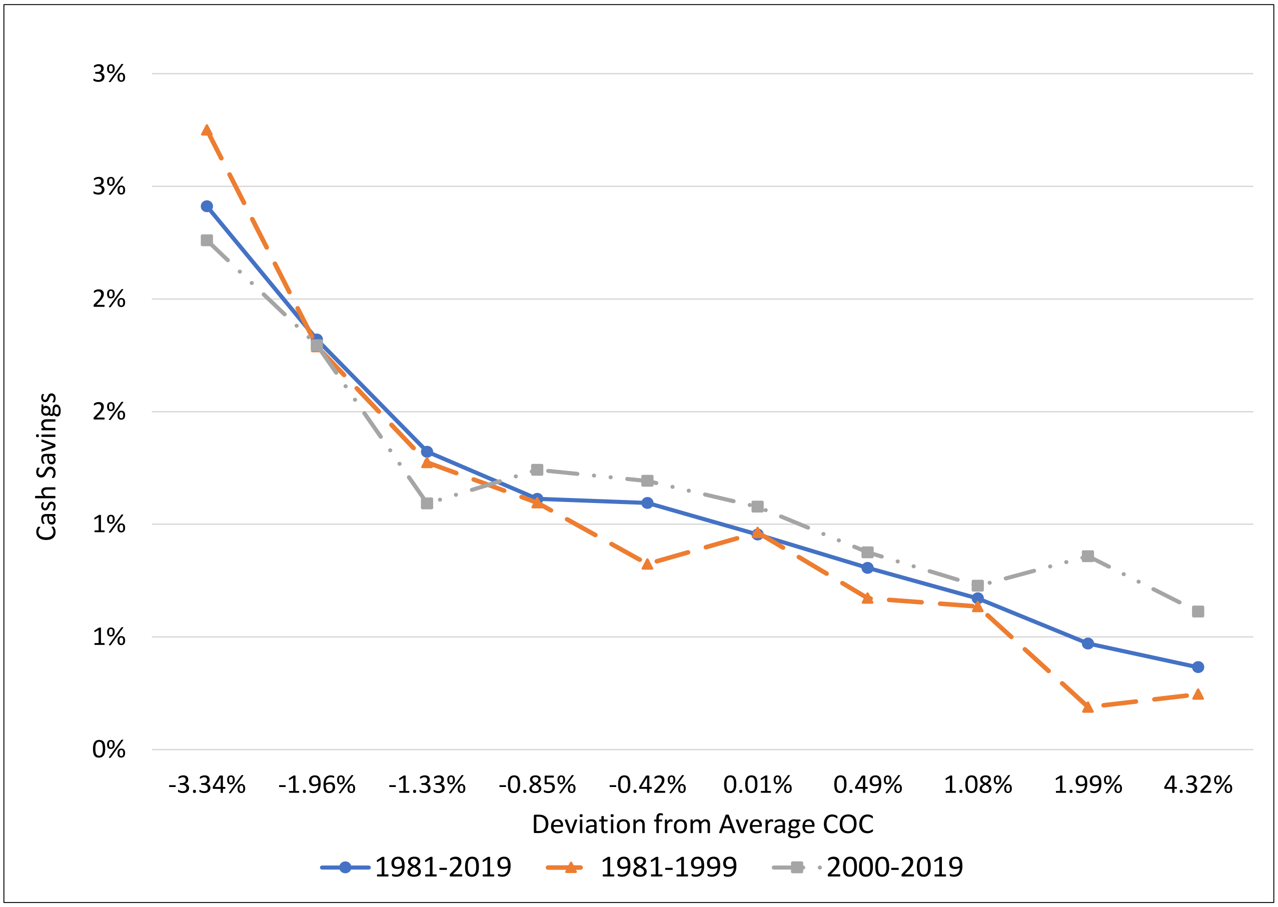

Figure 3: Cash Savings versus Future Investment

This figure plots firms' cash savings relative to future investment deciles. Future investment is defined as the three subsequent year average of net investment. Cash saving is the current year change in cash and equivalents divided by lagged total assets.

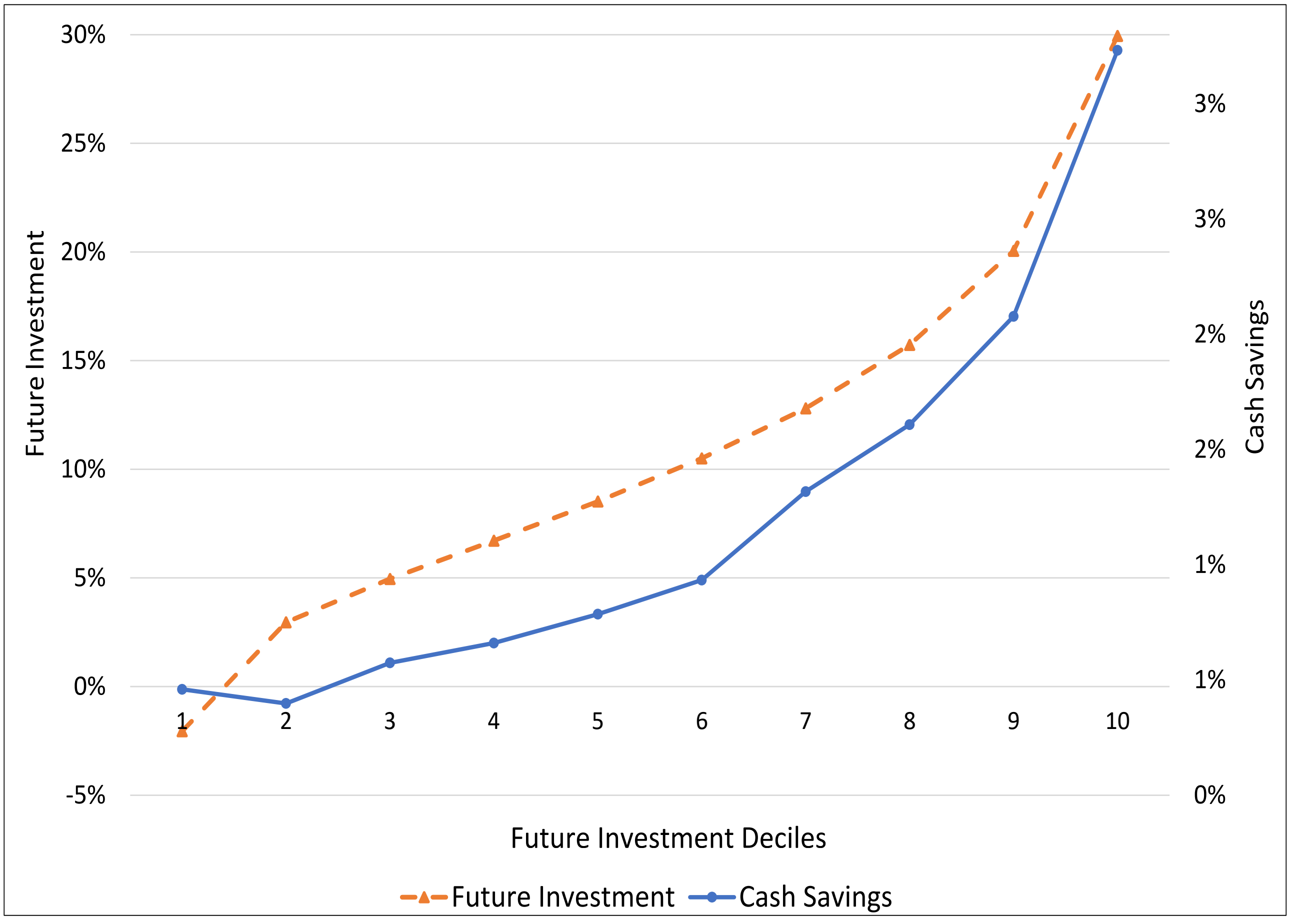

Figure 4: Dynamics of the Effects

This figure plots the differences in the sensitivities of cash savings to external capital around the adoption of Reg FD in October 2000 between the treated and control firms. The treatment firms are the top 50% of R&D-to-Sales ratio among positive R&D firms and the control firms are zero-R&D firms. The partition variables are measured as of the end of September 2000 before Reg FD.

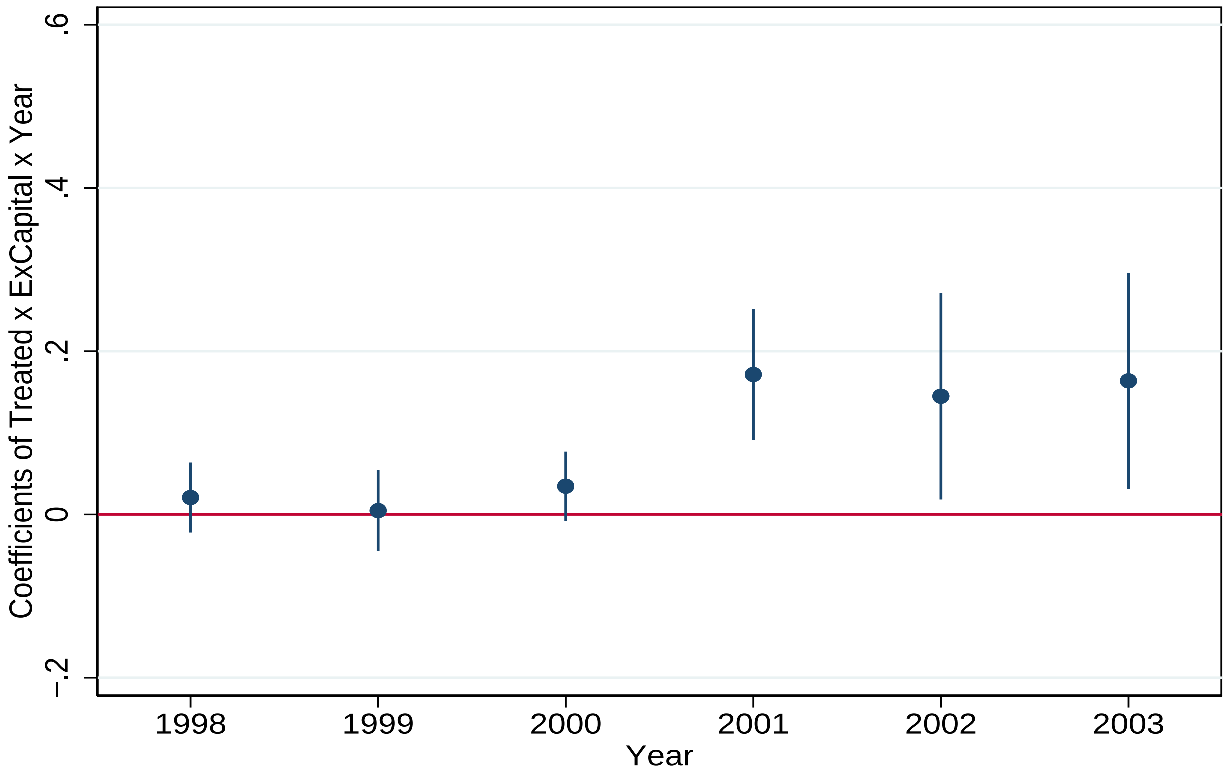

Table 1: Summary Statistics

This table reports the summary statistics of firm characteristics (Panel A) and standard deviation of the cost of capital cross firms and over time (Panel B). ΔCash is the change in cash and equivalents (*Cash*) divided by total assets at the beginning of the year. *ExCapital* and *ICF* are external capital and internal cash flow, respectively. *NWC* is net working capital excluding cash and equivalents. *M/B* is market-to-book asset ratio. *Vol* is cash flow volatility. *CapEx* is capital expenditures. *COE* is cost of equity. *COD* is cost of debt. *COC* is weighted average of cost of capital. The detailed variable definitions are provided in Appendix 6.

	Panel A: Summary Statistics		
	Mean	Median	Standard Deviation
ΔCash	0.0118	0.0020	0.0808
Cash	0.1106	0.0644	0.1214
ExCapital	0.0330	-0.0109	0.1943
ICF	0.0221	0.0257	0.0613
Size	6.7279	6.6094	1.9510
M/B	1.7310	1.4398	0.9405
Vol	0.0108	0.0075	0.0102
Dividend	0.0141	0.0058	0.0200
Leverage	0.2456	0.2323	0.1625
NWC	0.1042	0.0866	0.1709
CapEx	0.0854	0.0602	0.1070
Acquisitions	0.0449	0.0000	0.1079
R&D	0.0258	0.0000	0.0479
COE	0.0962	0.0920	0.0328
COD	0.0701	0.0671	0.0292
COC	0.0849	0.0822	0.0249

	Panel B: Decomposition of Standard Deviation	
	Cross-section	Time-series
COE	0.0256	0.0239
COD	0.0255	0.0200
COC	0.0199	0.0180

Table 2: Sensitivities of Cash Savings to Cash Sources

This table reports the sensitivities of cash savings to external capital and internal cash flows. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. *ExCapital* and *ICF* are external capital and internal cash flow, respectively. Control variables include *Leverage*, leverage ratio; *Size*; *NWC*, net working capital excluding cash and equivalents; *M/B*, market-to-book asset ratio; *Vol*, cash flow volatility, *CapEx*, capital expenditures; *Acquisitions*; *Divdend*; *lagged Cash*. Firm fixed effects are included in Column (2). Year fixed effects are included in Column (3). Firm and year fixed effects are included in Column (4). Standardized beta coefficients are reported in Column (5). The detailed variable definitions are provided in Appendix 6. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)
ExCapital	0.2822***	0.2999***	0.2826***	0.2962***	0.6691
	[0.0060]	[0.0065]	[0.0059]	[0.0065]	
ICF	0.2299***	0.2212***	0.2356***	0.2189***	0.1806
	[0.0071]	[0.0079]	[0.0072]	[0.0080]	
Cash	-0.0894***	-0.2324***	-0.0897***	-0.2395***	-0.1419
	[0.0043]	[0.0068]	[0.0043]	[0.0070]	
M/B	0.0111***	0.0102***	0.0127***	0.0116***	0.14
	[0.0005]	[0.0007]	[0.0005]	[0.0007]	
Vol	0.1469***	0.3378***	0.1890***	0.1064**	0.0192
	[0.0319]	[0.0508]	[0.0338]	[0.0518]	
Dividend	-0.0038	0.0417	-0.0513***	0.03	-0.001
	[0.0192]	[0.0332]	[0.0196]	[0.0338]	
Leverage	-0.0348***	-0.0314***	-0.0338***	-0.0267***	-0.0718
	[0.0021]	[0.0038]	[0.0021]	[0.0038]	
Size	-0.0023***	-0.0100***	-0.0017***	-0.0139***	-0.0565
	[0.0002]	[0.0006]	[0.0002]	[0.0009]	
NWC	-0.0330***	0.0310***	-0.0373***	0.0310***	-0.0689
	[0.0025]	[0.0054]	[0.0025]	[0.0054]	
CapEx	-0.2756***	-0.3607***	-0.2882***	-0.3616***	-0.3626
	[0.0070]	[0.0086]	[0.0071]	[0.0087]	
Acquisitions	-0.3401***	-0.3528***	-0.3359***	-0.3475***	-0.4607
	[0.0079]	[0.0086]	[0.0079]	[0.0086]	
R&D	0.0925***	-0.1667***	0.0870***	-0.1637***	0.0564
	[0.0091]	[0.0324]	[0.0092]	[0.0322]	
Firm FEs	No	Yes	No	Yes	No
Year FEs	No	No	Yes	Yes	No
Observations	59,564	59,507	59,564	59,507	59,564
Adj. R^2	0.2685	0.3474	0.2826	0.3599	0.2685

Table 3: The Cost of Capital and Cash Savings

This table reports the sensitivities of cash savings to the cost of capital and sources of cash. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. *COC* is weighted average cost of capital. *ExCapital* and *ICF* are external capital and internal cash flow, respectively, divided by total assets at the beginning of the year. The detailed variable definitions are provided in Appendix 6. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
COC	-0.0196	-0.0177	0.0005	-0.1742***	-0.1685***	-0.1551***
	[0.0152]	[0.0156]	[0.0151]	[0.0218]	[0.0224]	[0.0219]
ExCapital	0.3299***	0.2826***	0.3339***	0.3380***	0.2960***	0.3409***
	[0.0128]	[0.0060]	[0.0130]	[0.0136]	[0.0065]	[0.0137]
ICF	0.2289***	0.3080***	0.3265***	0.2125***	0.2997***	0.3121***
	[0.0072]	[0.0249]	[0.0252]	[0.0080]	[0.0263]	[0.0264]
ExCapital×COC	-0.5985***		-0.6399***	-0.5314***		-0.5605***
	[0.1356]		[0.1371]	[0.1432]		[0.1440]
ICF×COC		-0.8380***	-1.0227***		-0.9151***	-1.0344***
		[0.2376]	[0.2400]		[0.2509]	[0.2515]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	No	No	No	Yes	Yes	Yes
Year FEs	No	No	No	Yes	Yes	Yes
Observations	59,564	59,564	59,564	59,507	59,507	59,507
Adj. R^2	0.2697	0.2689	0.2702	0.3620	0.3615	0.3625

Table 4: Hedging Motive

This table compares the impacts of the cost of capital on the sensitivities of cash savings to external capital between firms with high and low hedging motives. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. *ExCapital* and *ICF* are external capital and internal cash flow, respectively, divided by total assets at the beginning of the year. High and low hedging-need firms are defined as those in the top 30 percent and those in the bottom 30 percent, respectively based on the correlation between industry-level external finance and the COC (Hedging Motive 1), the correlation between financial deficit and the COC (Hedging Motive 2), and the correlation between the *KZ* index and the COC (Hedging Motive 3). The detailed variable definitions are provided in Appendix 6. Firm and year fixed effects are controlled. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	Hedging Motive 1		Hedging Motive 2		Hedging Motive 3	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
COC	-0.1905***	-0.0733*	-0.3746***	0.1614***	-0.3583***	0.1211***
	[0.0389]	[0.0405]	[0.0363]	[0.0380]	[0.0381]	[0.0341]
ExCapital	0.3409***	0.3137***	0.4783***	0.3104***	0.3806***	0.2392***
	[0.0260]	[0.0222]	[0.0314]	[0.0246]	[0.0247]	[0.0237]
ICF	0.2941***	0.2884***	0.3994***	0.1932***	0.3538***	0.1670***
	[0.0453]	[0.0502]	[0.0405]	[0.0492]	[0.0413]	[0.0435]
ExCapital×COC	-0.9302***	-0.276	-1.7274***	0.0857	-1.1970***	-0.2543
	[0.2609]	[0.2439]	[0.2872]	[0.2812]	[0.2491]	[0.2412]
ICF×COC	-1.0880***	-0.7474	-1.7938***	-0.0104	-1.6359***	0.2709
	[0.4000]	[0.5212]	[0.3573]	[0.4624]	[0.3727]	[0.4489]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,770	17,633	17,795	17,660	17,710	17,945
Adj. R^2	0.3561	0.3748	0.3736	0.3816	0.3691	0.3015

Table 5: Excess Capital Issuance and Future Investment

This table compares the sensitivities of excess capital issuance to the cost of capital (Panel A) and the sensitivities of cash savings to future investment (Panel B) between firms with high and low hedging motives. The dependent variable in Panel A is excess capital issues. COC is weighted average cost of capital. The dependent variable in Panel B is the change in cash and equivalents divided by total assets at the beginning of the year. $FInvest$ is future investment defined as the average of three subsequent years of capital expenditures plus acquisitions plus R&D divided by lagged total assets. High and low hedging-need firms are defined as those in the top 30 percent and those in the bottom 30 percent, respectively based on the correlation between industry-level external finance and the COC (Hedging Motive 1), the correlation between financial deficit and the COC (Hedging Motive 2), and the correlation between KZ index and the COC (Hedging Motive 3). Firm and year fixed effects are controlled. The detailed variable definitions are provided in Appendix 6. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

Panel A: Excess Issuance

	Hedging Motive 1		Hedging Motive 2		Hedging Motive 3	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
COC	-1.0103***	0.4535***	-0.4472***	-0.084	-0.5884***	0.0526
	[0.0583]	[0.0598]	[0.0632]	[0.0665]	[0.0622]	[0.0597]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,795	17,660	17,770	17,633	17,710	17,945
Adj. R^2	0.2653	0.2185	0.2147	0.2143	0.1997	0.2038

Panel B: Future Investment

	Hedging Motive 1		Hedging Motive 2		Hedging Motive 3	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
FInvestment	0.0924**	0.0530	0.1324***	-0.0137	0.1588***	-0.0453
	[0.0382]	[0.0444]	[0.0418]	[0.0431]	[0.0416]	[0.0355]
FInvest× COC	-0.9929**	-0.4774	-1.3847***	0.0291	-1.8154***	0.6280
	[0.4208]	[0.4975]	[0.4429]	[0.4734]	[0.4538]	[0.4009]
COC	-0.2252***	-0.1303*	-0.2984***	-0.0799	-0.4068***	0.0409
	[0.0608]	[0.0693]	[0.0557]	[0.0675]	[0.0644]	[0.0553]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,908	13,474	14,025	13,540	13,410	14,139
Adj. R^2	0.2035	0.1773	0.1939	0.1682	0.2006	0.1713

Table 6: Cash Savings: Equity vs Debt

This table compares cash savings from equity issues versus debt issues versus internal cash flows (Panel A) and the sensitivities of cash savings to sources of cash and the cost of capital between firms with high and low hedging motives (Panel B). The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. High and low hedging-need firms are defined as those in the top 30 percent and those in the bottom 30 percent, respectively based on the correlation between industry-level external finance and the COC (Hedging Motive 1), the correlation between financial deficit and the COC (Hedging Motive 2), and the correlation between KZ index and the COC (Hedging Motive 3). The detailed variable definitions are provided in Appendix 6. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	Panel A: Equity vs Debt				
	(1)	(2)	(3)	(4)	(5)
Eissue	0.2804***			0.4741***	0.5001***
	[0.0069]			[0.0090]	[0.0099]
Dissue		0.0556***		0.2658***	0.2953***
		[0.0043]		[0.0077]	[0.0083]
ICF			0.1503***	0.2291***	0.2122***
			[0.0061]	[0.0072]	[0.0081]
Controls	No	No	No	Yes	Yes
Firm FEs	No	No	No	No	Yes
Year FEs	No	No	No	No	Yes
Observations	65,398	65,398	65,398	59,564	59,507
Adj. R^2	0.0940	0.0071	0.0130	0.2663	0.359

	Panel B: Cost of Equity vs Cost of Debt						
		Hedging Motive 1		Hedging Motive 2		Hedging Motive 3	
	All	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
COE	0.011	-0.1238***	0.0142	-0.1998***	0.1204***	-0.1905***	0.0793***
	[0.0148]	[0.0278]	[0.0299]	[0.0271]	[0.0278]	[0.0264]	[0.0247]
COD	-0.1427***	0.0591	-0.0009	-0.0514	0.0709	-0.0483	0.0493
	[0.0245]	[0.0794]	[0.0842]	[0.0784]	[0.0805]	[0.0790]	[0.0672]
Eissue	0.5601***	0.5488***	0.5143***	0.6164***	0.5688***	0.5863***	0.3284***
	[0.0245]	[0.0474]	[0.0432]	[0.0446]	[0.0415]	[0.0424]	[0.0489]
Dissue	0.3621***	0.3131***	0.3590***	0.3611***	0.3705***	0.3542***	0.2961***
	[0.0147]	[0.0258]	[0.0261]	[0.0279]	[0.0294]	[0.0272]	[0.0223]
ICF	0.3866***	0.2888***	0.3291***	0.4264***	0.2575***	0.3684***	0.1971***
	[0.0275]	[0.0469]	[0.0505]	[0.0457]	[0.0501]	[0.0420]	[0.0438]
Eissue×COE	-0.6070**	-1.1583**	-0.4279	-0.9207**	-0.6645	-1.6044***	0.2512
	[0.2591]	[0.4766]	[0.4619]	[0.4620]	[0.4355]	[0.4446]	[0.4997]
Dissue×COD	-0.9277***	-0.7475**	-0.9972***	-1.1978***	-1.0199***	-0.9228***	-0.7881***
	[0.1614]	[0.2925]	[0.3010]	[0.3182]	[0.3484]	[0.3014]	[0.2311]
ICF×COE	-1.5180***	-1.2391***	-1.3521***	-1.9480***	-0.5869*	-1.7244***	-0.3131
	[0.1795]	[0.2837]	[0.3363]	[0.2677]	[0.3249]	[0.2607]	[0.2981]
ICF×COD	-0.1019	0.5764	0.4394	0.3588	-0.1956	0.325	0.4758
	[0.2445]	[0.4340]	[0.4808]	[0.4237]	[0.4346]	[0.3566]	[0.4250]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	59,507	17,770	17,633	17,795	17,660	17,710	17,945
Adj. R^2	0.3518	0.3616	0.3568	0.3756	0.3677	0.373	0.3021

Table 7: The Effect of Exogenous Shocks to the Cost of Capital on Cash Savings
This table reports the effects of exogenous shocks to the cost of capital on cash savings. We use Regulation Fair Disclosure of 2000 (Reg FD) (Columns 1 and 2) as a shock to the cost of capital. We set the *Post* dummy as zero for 1997-1999 and one for 2000-2003. The remaining columns report the results of placebo tests based on fictitious event years 2008 (Columns 3 and 4) and 2011 (Columns 5 and 6). In Columns 1, 3, and 5, the treated firms are the top 50% of R&D-to-Sales ratio among positive R&D firms and control firms are zero-R&D firms. In Columns 2, 4, and 6, the treatment and control firms are defined as top and bottom 30% of market-to-book ratio, respectively. All partition variables are measured as of the end of September 2000 before Reg FD. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. Firm and year fixed effects are controlled. The detailed variable definitions are provided in Appendix 6. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	Panel A: Exogenous Shock to Cost of Capital					
	Reg FD		Placebo 1		Placebo 2	
	(1)	(2)	(3)	(4)	(5)	(6)
Treated×Post	0.0011	0.0083**	0.0080	0.0030	0.0003	0.0042
	[0.0063]	[0.0040]	[0.0049]	[0.0036]	[0.0051]	[0.0034]
ExCapital×Post	0.0769***	0.0674**	0.0588**	0.0146	-0.0123	0.0237
	[0.0170]	[0.0272]	[0.0282]	[0.0213]	[0.0267]	[0.0214]
ICF×Post	0.0090	0.0708	-0.0002	0.0034*	0.0010	0.0042
	[0.0349]	[0.0541]	[0.0023]	[0.0018]	[0.0031]	[0.0030]
Treated×ExCapital×Post	0.1197***	0.0982**	-0.0505	-0.0012	-0.0133	-0.0044
	[0.0410]	[0.0408]	[0.0415]	[0.0345]	[0.0443]	[0.0393]
Treated×ICF×Post	0.2430**	-0.0039	-0.0013	-0.0064**	-0.0003	-0.0052
	[0.1148]	[0.0939]	[0.0035]	[0.0030]	[0.0044]	[0.0034]
Treated×ExCapital	-0.0617*	0.0105	0.0737***	0.0455**	0.0506	0.0751**
	[0.0337]	[0.0134]	[0.0261]	[0.0200]	[0.0377]	[0.0305]
Treated×ICF	0.0536	0.1254**	0.0079**	0.0065**	0.0029	0.0061**
	[0.1064]	[0.0543]	[0.0039]	[0.0030]	[0.0041]	[0.0030]
ExCapital	0.2635***	0.0952***	0.3760***	0.3717***	0.4312***	0.3941***
	[0.0143]	[0.0104]	[0.0309]	[0.0253]	[0.0289]	[0.0286]
ICF	0.1507***	0.1164***	0.0038**	0.0051***	0.0074***	0.0053***
	[0.0260]	[0.0287]	[0.0016]	[0.0018]	[0.0023]	[0.0020]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,317	11,249	6,099	8,538	6,177	7,825
Adj. R^2	0.3821	0.2437	0.5164	0.4705	0.4727	0.4805

Table 8: Constrained vs Unconstrained Firms

This table compares the sensitivities of cash savings to the cost of capital and sources of cash between financially constrained and unconstrained firms (Panel A). Constrained and unconstrained firms are defined as firms that do not have a credit rating and firms that have a credit rating (Columns 1 and 2), firms at the top and bottom 30% of the WW index (Whited and Wu (2006)) (Columns 3 and 4), and firms at the top and bottom 30% of the HP index (Hadlock and Pierce (2010)) (Columns 5 and 6), respectively. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. *ExCapital* and *ICF* are external capital and internal cash flow, respectively, divided by total assets at the beginning of the year. Panel B compares cash savings from external capital and internal capital for financially constrained and unconstrained firms with a high hedging motive using our hedging measure and using the Acharya et al. (2007) measure. The reported results are based on the WW index and Hedging Motive 1 measure. Firm and year fixed effects are controlled. The detailed variable definitions are provided in Appendix 6. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

Panel A: Cash Savings and the Cost of Capital						
	Rating		WW Index		HP Index	
	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained	Constrained
	(1)	(2)	(3)	(4)	(5)	(6)
COC	-0.0729***	-0.2982***	-0.1645***	-0.3488***	-0.1194***	-0.2116***
	[0.0243]	[0.0461]	[0.0378]	[0.0521]	[0.0431]	[0.0496]
ExCapital	0.3149***	0.3722***	0.3590***	0.3709***	0.3641***	0.3505***
	[0.0181]	[0.0223]	[0.0280]	[0.0232]	[0.0364]	[0.0246]
ICF	0.2910***	0.3750***	0.2988***	0.3697***	0.3852***	0.3569***
	[0.0311]	[0.0485]	[0.0553]	[0.0457]	[0.0579]	[0.0485]
ExCapital×COC	-0.4020**	-0.6819***	-0.8258***	-0.4541*	-1.0842***	-0.5147**
	[0.1911]	[0.2405]	[0.2891]	[0.2520]	[0.3394]	[0.2554]
ICF×COC	-1.1879***	-1.2552***	-1.1266**	-1.3089***	-1.9377***	-1.4170***
	[0.3005]	[0.4571]	[0.5168]	[0.4397]	[0.5536]	[0.4550]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	37,889	20,197	17,418	17,746	11,755	17,564
Adj. R^2	0.3342	0.419	0.3431	0.4331	0.3043	0.4001

	Panel B: Compare with AAC Measure			
	High Hedging Motive		High AAC Measure	
	Unconstrained	Constrained	Unconstrained	Constrained
	(1)	(2)	(3)	(4)
COC	-0.1862***	-0.4688***	-0.0814*	-0.3491***
	[0.0710]	[0.1123]	[0.0473]	[0.0655]
ExCapital	0.3692***	0.4344***	0.3026***	0.3541***
	[0.0454]	[0.0442]	[0.0336]	[0.0298]
ICF	0.3685***	0.4285***	0.2362***	0.3379***
	[0.0850]	[0.0988]	[0.0669]	[0.0590]
ExCapital×COC	-1.4010***	-1.2916***	-0.5579*	-0.3939
	[0.4499]	[0.4695]	[0.3282]	[0.3244]
ICF×COC	-1.6097**	-2.0681**	-0.6756	-1.0523*
	[0.7943]	[0.8692]	[0.6305]	[0.5711]
Controls	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	4,850	3,808	10,693	10,909
Adj. R^2	0.3282	0.4540	0.3118	0.4106

Table 9: Alternative Motives

This table reports the test results of the following alternative motives for cash saving: market timing and precautionary motive. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. Panel A compares the impacts of the cost of capital on the sensitivities of cash savings to external capital between firms with high and low market timing motives. We measure market timing by the yearly timing (Timing 1), long-term timing (Timing 2) following Kayhan and Titman (2007), and mispricing proxy (Timing 3) developed by Stambaugh et al. (2015). For each measure, we define firms in the top 30 percent as firms with high market timing motive and those in the bottom 30 percent as firms with a low market timing motive while removing the middle 40 percent. Panel B compares the impacts of the cost of capital on the sensitivities of cash savings to external capital issues between firms with high and low precautionary motives. Firms with high (low) precautionary motives are defined as firms without (with) dividend payments, firms in the top 30 percent (bottom 30 percent) based on R&D expenditures, the industry-level median cash flow volatility (*CF Risk*), and a precautionary motive measure (*Precaution*), respectively. In Panel C, we test the predictions of model developed by Bolton et al. (2013) that considers both the market timing and precautionary motives. We compare the impacts of the cost of capital on the sensitivities of cash savings to external capital issues between firms with high and low cash holdings. Firms with high (low) cash holdings are classified as those in the top 30 percent (bottom 30 percent) based on cash ratios (che/at) or the cash balance (che). *ExCapital* and *ICF* are external capital and internal cash flow, respectively, divided by total assets at the beginning of the year. Panel C and D test whether the market timing or precautionary motive explains the sensitivities of excess capital issuance to the cost of capital and the sensitivities of cash savings to future investment. For brevity, the results based on the Timing 1 measure and *Precaution* are reported. Firm and year fixed effects are controlled. The detailed variable definitions are provided in Appendix 6. The coefficient estimates of the control variables are not reported for brevity. The The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	Panel A: Market Timing Motive					
	Timing 1		Timing 2		Timing 3	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
COC	-0.2591***	-0.1276***	-0.2522***	-0.1680***	-0.1913***	-0.1518***
	[0.0531]	[0.0477]	[0.0577]	[0.0516]	[0.0512]	[0.0414]
ExCapital	0.3782***	0.3695***	0.3612***	0.3296***	0.3628***	0.3497***
	[0.0374]	[0.0343]	[0.0335]	[0.0398]	[0.0304]	[0.0253]
ICF	0.3200***	0.3632***	0.3456***	0.1986***	0.4029***	0.2637***
	[0.0547]	[0.0655]	[0.0642]	[0.0614]	[0.0639]	[0.0455]
ExCapital×COC	-0.7202*	-1.0525***	-0.8110**	-0.7619*	-0.6172*	-0.6422**
	[0.4128]	[0.3497]	[0.3611]	[0.4125]	[0.3302]	[0.2761]
ICF×COC	-1.3467***	-1.7534**	-1.8003***	-0.2250	-1.5796**	-0.9183**
	[0.5103]	[0.6830]	[0.6551]	[0.5757]	[0.6544]	[0.4260]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,407	11,401	11,509	11,627	14,245	14,159
Adj. R^2	0.3539	0.3339	0.3494	0.2987	0.3961	0.3624

	Panel B: Precautionary Motive							
	Dividend		R&D		CFSD		Precaution	
	High	Low	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
COC	-0.1241***	-0.2778***	-0.2152***	-0.1186***	-0.1018***	-0.3678***	-0.0772**	-0.2655***
	[0.0252]	[0.0440]	[0.0357]	[0.0278]	[0.0374]	[0.0470]	[0.0393]	[0.0468]
ExCapital	0.2520***	0.3840***	0.4110***	0.2533***	0.3942***	0.3263***	0.3927***	0.3376***
	[0.0194]	[0.0192]	[0.0204]	[0.0188]	[0.0232]	[0.0270]	[0.0263]	[0.0265]
ICF	0.1302***	0.4224***	0.3946***	0.2082***	0.3530***	0.0356	0.4185***	0.2210***
	[0.0345]	[0.0406]	[0.0380]	[0.0358]	[0.0365]	[0.0747]	[0.0431]	[0.0603]
ExCapital×COC	-0.1966	-0.6165***	-0.6676***	-0.2602	-0.5542**	-0.6472**	-0.6750**	-0.6999***
	[0.1927]	[0.2100]	[0.2308]	[0.1905]	[0.2483]	[0.2694]	[0.2886]	[0.2677]
ICF×COC	0.1453	-1.8812***	-1.4409***	-0.4854	-1.3951***	1.2313*	-2.0530***	-0.3904
	[0.3304]	[0.3933]	[0.3642]	[0.3427]	[0.3729]	[0.6590]	[0.4382]	[0.5530]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	34,489	24,367	27,766	31,572	17,703	17,111	17,228	17,154
Adj. R^2	0.2862	0.4124	0.4280	0.2978	0.4322	0.3674	0.4015	0.3797

	Panel C: Market Timing and Precautionary Motives			
	Cash Ratio		Cash Balance	
	High	Low	High	Low
	(1)	(2)	(3)	(4)
COC	0.0088	-0.2922***	-0.1217***	-0.0904**
	[0.0106]	[0.0520]	[0.0312]	[0.0392]
ExCapital	0.0408***	0.4002***	0.1318***	0.3270***
	[0.0079]	[0.0249]	[0.0190]	[0.0280]
ICF	0.0283**	0.4402***	0.1202***	0.3061***
	[0.0123]	[0.0489]	[0.0373]	[0.0569]
ExCapital×COC	-0.2336***	0.5528*	-0.2529	0.0028
	[0.0668]	[0.2873]	[0.1908]	[0.3211]
ICF×COC	-0.1558	-0.9357**	-0.2350	-0.7987
	[0.1242]	[0.4756]	[0.3577]	[0.5255]
Controls	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Observations	17,308	16,862	17,297	17,322
Adj. R^2	0.7595	0.5612	0.4463	0.4519

	Panel D: Excess Issuance					
	Market Timing		Precautionary		Market Timing and Precautionary	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
COC	-0.5057***	-0.3341***	-0.3738***	-0.3482***	-0.1303**	-0.6246***
	[0.0986]	[0.0864]	[0.0673]	[0.0803]	[0.0633]	[0.0839]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,407	11,401	17,228	17,154	17,308	16,862
Adj. R^2	0.1750	0.2086	0.2094	0.2446	0.2666	0.2328

	Panel E: Future Investment					
	Market Timing		Precautionary		Market Timing and Precautionary	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
Finvest	0.0629	0.0814	0.0363	0.0721	-0.0033	-0.0128
	[0.0556]	[0.0523]	[0.0456]	[0.0470]	[0.0090]	[0.0531]
FInvest× COC	-1.1302*	-1.2347*	-0.1439	-0.8619*	0.0204	-0.5270
	[0.6232]	[0.6437]	[0.5521]	[0.4952]	[0.0988]	[0.5859]
COC	-0.3101***	-0.1396*	-0.2410***	-0.3518***	0.0017	-0.5543***
	[0.0881]	[0.0797]	[0.0699]	[0.0784]	[0.0155]	[0.1003]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,867	9,011	13,309	13,960	13,471	13,341
Adj. R^2	0.1477	0.17	0.1785	0.2106	0.7523	0.2748

Appendix 1: First-order conditions

For $X_t > 0$, the Lagrangian for the maximization problem in equation (1) at t can be written as follows:

$$
\begin{aligned}
L_t(I_t, C_t, X_t) &= E_t[\pi(I_t) + z_{t+1} - I_t - C_t - \lambda(\delta_t, X_t)] + \mu_t[X_t - I_t - C_t + W_t] + \psi_t C_t \\
&+ \int\limits_{I^*_{t+1} - C_t - \pi(I_t)}^{\infty} \left\{\pi(I^*_{t+1}) - I^*_{t+1}\right\} g(z)dz \qquad \text{(A.1)} \\
&+ \int\limits_{-\infty}^{I^*_{t+1} - C_t - \pi(I_t)} \left\{\pi(X_{t+1} + C_t + \pi(I_t) + z_{t+1}) - I_{t+1} - \lambda(\delta_{t+1}, X_{t+1})\right\} g(z)dz.
\end{aligned}
$$

where μ_t and ψ are Lagrange multipliers for the constraints in equation (1). Applying the Leibnitz integral rule, the first-order conditions for I_t, C_t, X_t, and μ_t, respectively, are as follows:

$$
\begin{aligned}
\frac{\partial L_t}{\partial I_t} &= \pi_I(I_t) - 1 - \mu_t + \pi_I(I_t)\left[\pi(I^*_{t+1}) - I^*_{t+1}\right] g[I^*_{t+1} - C_t - \pi(I_t)] \\
&\quad + \pi_I(I_t)\left(\int\limits_{-\infty}^{I^*_{t+1} - C_t - \pi(I_t)} \left\{\pi_I(X_{t+1} + C_t + \pi(I_t) + z_{t+1}) - 1 + \lambda_X(\delta_{t+1}, X_{t+1})\right\} g(z) \right. \\
&\quad \left. - \left[\pi(I^*_{t+1}) - I^*_{t+1}\right] g[I^*_{t+1} - C_t - \pi(I_t)] \right) \\
&= \pi_I(I_t) - 1 - \mu_t \\
&\quad + \pi_I(I_t)\left(\int\limits_{-\infty}^{I^*_{t+1} - C_t - \pi(I_t)} \left\{\pi_I(X_{t+1} + C_t + \pi(I_t) + z_{t+1}) - 1 + \lambda_X(\delta_{t+1}, X_{t+1})\right\} g(z)dz \right) \\
&= [1 + H]\pi_I(I_t) - 1 - \mu_t = 0 \qquad \text{(A.2)} \\
\frac{\partial L_t}{\partial C_t} &= H - 1 - \mu_t + \psi_t = 0 \qquad \text{(A.3)} \\
\frac{\partial L_t}{\partial X_t} &= -\lambda_X(\delta_t, X_t) + \mu_t = 0 \qquad \text{(A.4)} \\
\frac{\partial L_t}{\partial \mu_t} &= X_t - I_t - C_t + W_t = 0, \qquad \text{(A.5)}
\end{aligned}
$$

where

$$
H = \int\limits_{-\infty}^{I^*_{t+1} - C_t - \pi(I_t)} \left\{\pi_I(X_{t+1} + C_t + \pi(I_t) + z_{t+1}) - 1 + \lambda_X(\delta_{t+1}, X_{t+1})\right\} g(z)dz. \qquad \text{(A.6)}
$$

Thus, when the firm relies on external finance ($X_t > 0$), it will choose the optimal investment where the marginal benefit of investment, $[1+H]\pi_I(I_t)$, is equal to its marginal cost, $1+\mu_t = 1+\lambda_X(\delta_t, X_t)$. Similarly, the optimal cash savings decision with external finance is made where the marginal benefit of cash savings, $H+\psi_t$, is equal to the marginal cost, $1+\mu_t = 1+\lambda_X(\delta_t, X_t)$.

If the firm is financially unconstrained with sufficient initial endowment to make the initial investment and cash savings decisions ($W_t \geq C_t + I_t$ or $X_t \leq 0$), we have $\lambda(\delta_t, X_t) = 0$ and the first-order conditions are as follows:

$$\begin{aligned}
\frac{\partial L_t}{\partial I_t} &= (1+H)\pi_I(I_t) - 1 = 0 && \text{(A.7)}\\
\frac{\partial L_t}{\partial C_t} &= H - 1 + \psi_t = 0 && \text{(A.8)}\\
\frac{\partial L_t}{\partial X_t} &= \mu_t = 0 && \text{(A.9)}\\
\frac{\partial L_t}{\partial \mu_t} &= X_t - I_t - C_t + W_t = 0. && \text{(A.10)}
\end{aligned}$$

In this case, the optimal cash savings will be set such that its marginal benefit is equal to the marginal cost ($H + \psi_t = 1$) without incurring external financing cost ($\lambda(\delta_t, X_t) = 0$ and $\mu_t = 0$). In this case, the firm's optimal investment is set at $(1+H)\pi_I(I_t) = 1$

Given $\pi_{II} < 0$ and Assumption 1, the second-order condition is also satisfied as the Hessian matrix of the Lagrangian is negative definite.

Appendix 2: Comparative Statistics and Proof of Proposition 1

To examine how the optimal investment, $\hat{I}_t$, cash savings, $\hat{C}_t$, and external finance $\hat{X}_t$ are affected by the COC at t, we rearrange the FOCs in equations (A.2) to (A.5) as follows:

$$\begin{aligned}
[1+H]\pi_I(\hat{I}_t) - 1 - \lambda_X(\delta_t, \hat{X}_t) &= 0 && \text{(A.11)}\\
H - 1 - \lambda_X(\delta_t, \hat{X}_t) &= 0 && \text{(A.12)}\\
\hat{X}_t - \hat{I}_t - \hat{C}_t + W_t &= 0, && \text{(A.13)}
\end{aligned}$$

From the FOCs we obtain $\pi_I(\hat{I}_t) = \frac{H}{1+H}$, implying that $\pi_I(\hat{I}_t) - 1 = \frac{-1}{1+H} < 0$. We also assume that the second-order condition with respect to I_t is satisfied: i.e., $\pi_{II}(\hat{I}_t) - \frac{H_I}{(1+H)^2} < 0$. These conditions imply that $\pi_{II}(\hat{I}_t)(1+H) + H_I[\pi_I(\hat{I}_t) - 1] < 0$.

We differentiate each FOCs in equations (A.11) to (A.13) w.r.t. δ_t as follows:

$$\begin{aligned}
\{H_I\pi_I(\hat{I}_t) + (1+H)\pi_{II}(\hat{I}_t)\}\frac{d\hat{I}_t}{d\delta_t} + H_C\pi_I(\hat{I}_t)\frac{d\hat{C}_t}{d\delta_t} - \lambda_{XX}\frac{d\hat{X}_t}{d\delta_t} - \lambda_{X\delta} &= 0 & \text{(A.14)}\\
H_I\frac{d\hat{I}_t}{d\delta_t} + H_C\frac{d\hat{C}_t}{d\delta_t} - \lambda_{XX}\frac{d\hat{X}_t}{d\delta_t} - \lambda_{X\delta} &= 0 & \text{(A.15)}\\
-\frac{d\hat{I}_t}{d\delta_t} - \frac{d\hat{C}_t}{d\delta_t} + \frac{d\hat{X}_t}{d\delta_t} &= 0 & \text{(A.16)}
\end{aligned}$$

where

$$\begin{aligned}
H_C &= \int_{-\infty}^{I^*_{t+1}-\hat{C}_t-\pi(\hat{I}_t)} \left[\pi_{II}(\hat{X}_{t+1} + \hat{C}_t + \pi(\hat{I}_t) + z_{t+1}) - \lambda_{XX}(\delta_{t+1}, \hat{X}_{t+1})\right] g(z)dz < 0,\\
H_I &= \pi_I(\hat{I}_t)H_C < 0. & \text{(A.17)}
\end{aligned}$$

H_I and H_C represent the rate of change in the marginal benefit of cash due to increased investment and cash savings at time t, respectively.

After subtracting $\pi_I(\hat{I})$ times (A.15) from (A.14), the determinant of the Jacobian matrix of the derivatives is as follows:

$$\begin{aligned}
D &= \begin{vmatrix} (1+H)\pi_{II}(\hat{I}_t) & 0 & (\pi_I - 1)\lambda_{XX} \\ H_I & H_C & -\lambda_{XX} \\ -1 & -1 & 1 \end{vmatrix}\\
&= (1+H)\pi_{II}(\hat{I}_t)[H_C - \lambda_{XX}(\delta_t, \hat{X}_t)] - \lambda_{XX}(\delta_t, \hat{X}_t)H_C[\pi_I(\hat{I}_t) - 1]^2 > 0. & \text{(A.18)}
\end{aligned}$$

By the implicit function theorem and Crammer's rule, we obtain the following:

$$\frac{\partial \hat{I}_t}{\partial \delta_t} = \frac{\begin{vmatrix} (1-\pi_I)\lambda_{X\delta} & 0 & (\pi_I - 1)\lambda_{XX} \\ \lambda_{X\delta} & H_C & -\lambda_{XX} \\ 0 & -1 & 1 \end{vmatrix}}{D} = \frac{\lambda_{X\delta}(\delta_t, \hat{X}_t)H_C[1 - \pi_I(\hat{I}_t)]}{D} < 0, \quad \text{(A.19)}$$

$$\begin{aligned}
\frac{\partial \hat{C}_t}{\partial \delta_t} &= \frac{\begin{vmatrix} (1+H)\pi_{II}(\hat{I}_t) & (1-\pi_I)\lambda_{X\delta} & (\pi_I - 1)\lambda_{XX} \\ H_I & \lambda_{X\delta} & -\lambda_{XX} \\ -1 & 0 & 1 \end{vmatrix}}{D} & \text{(A.20)}\\
&= \frac{\lambda_{X\delta}(\delta_t, \hat{X}_t)\left\{[H_I[\pi_I(\hat{I}_t) - 1] + (1+H)\pi_{II}(\hat{I}_t)\right\}}{D} < 0,
\end{aligned}$$

$$\frac{\partial \hat{X}_t}{\partial \delta_t} = \frac{\begin{vmatrix} (1+H)\pi_{II}(\hat{I}_t) & 0 & (1-\pi_I)\lambda_{X\delta} \\ H_I & H_C & \lambda_{X\delta} \\ -1 & -1 & 0 \end{vmatrix}}{D} = \frac{\lambda_{X\delta}(\delta_t, \hat{X}_t)\left\{[H_C[\pi_I(\hat{I}_t)-1]^2 + (1+H)\pi_{II}(\hat{I}_t)\right\}}{D} < 0. \tag{A.21}$$

These results suggest that the firm decreases investment, cash savings, and external finance when facing a higher external finance cost at time t.

To prove Proposition 1, we differentiate each FOC w.r.t. δ_{t+1} as follows:

$$\{H_I\pi_I(\hat{I}_t) + (1+H)\pi_{II}(\hat{I}_t)\}\frac{d\hat{I}_t}{d\delta_{t+1}} + H_C\pi_I(\hat{I}_t)\frac{d\hat{C}_t}{d\delta_{t+1}} - \lambda_{XX}(\delta_t, \hat{X}_t)\frac{d\hat{X}_t}{d\delta_{t+1}} + H_\delta\pi_I(\hat{I}_t) = 0 \tag{A.22}$$

$$H_I\frac{d\hat{I}_t}{d\delta_{t+1}} + H_C\frac{d\hat{C}_t}{d\delta_{t+1}} - \lambda_{XX}(\delta_t, \hat{X}_t)\frac{d\hat{X}_t}{d\delta_{t+1}} + H_\delta = 0 \tag{A.23}$$

$$-\frac{d\hat{I}_t}{d\delta_{t+1}} - \frac{d\hat{C}_t}{d\delta_{t+1}} + \frac{d\hat{X}_t}{d\delta_{t+1}} = 0 \tag{A.24}$$

where

$$H_\delta = \int_{-\infty}^{I^*_{t+1}-\hat{C}_t-\pi(\hat{I}_t)} \lambda_{X\delta}(\delta_{t+1}, \hat{X}_{t+1})g(z)dz > 0. \tag{A.25}$$

H_δ represents the rate of change in the marginal benefit of cash due to an increase in the external finance cost at $t+1$.

After subtracting $\pi_I(\hat{I})$ times (A.23) from (A.22), the determinant of the Jacobian matrix of the derivatives remains the same as D. Thus, we obtain the following:

$$\frac{\partial \hat{I}_t}{\partial \delta_{t+1}} = \frac{\begin{vmatrix} 0 & 0 & (\pi_I-1)\lambda_{XX} \\ -H_\delta & H_C & -\lambda_{XX} \\ 0 & -1 & 1 \end{vmatrix}}{D} = \frac{\lambda_{XX}(\delta_t, \hat{X}_t)H_\delta[\pi_I(\hat{I}_t)-1]}{D} < 0, \tag{A.26}$$

$$\frac{\partial \hat{C}_t}{\partial \delta_{t+1}} = \frac{\begin{vmatrix} (1+H)\pi_{II}(\hat{I}_t) & 0 & (\pi_I-1)\lambda_{XX} \\ H_I & -H_\delta & -\lambda_{XX} \\ -1 & 0 & 1 \end{vmatrix}}{D} = \frac{-H_\delta\left\{\lambda_{XX}(\delta_t, \hat{X}_t)[\pi_I(\hat{I}_t)-1] + (1+H)\pi_{II}(\hat{I}_t)\right\}}{D} > 0, \tag{A.27}$$

$$\frac{\partial \hat{X}_t}{\partial \delta_{t+1}} = \frac{\begin{vmatrix} (1+H)\pi_{II}(\hat{I}_t) & 0 & 0 \\ H_I & H_C & -H_\delta \\ -1 & -1 & 0 \end{vmatrix}}{D} = \frac{-H_\delta (1+H)\pi_{II}(\hat{I}_t)}{D} > 0. \tag{A.28}$$

The result of $X_t \leq 0$ follows by noting $\lambda_{XX}(\delta_t, \hat{X}_t) = 0$. These results suggest that both the optimal cash saving and the optimal external finance at t increase, while the optimal investment does not increase, when expecting a higher COC at $t+1$.

We also note that differentiating the FOCs w.r.t. I_{t+1} yields the same results as the above with δ replaced by I_{t+1} as follows:

$$\{H_I \pi_I(\hat{I}_t) + (1+H)\pi_{II}(\hat{I}_t)\}\frac{d\hat{I}_t}{dI_{t+1}} + H_C \pi_I(\hat{I}_t)\frac{d\hat{C}_t}{dI_{t+1}} - \lambda_{XX}(\delta_t, \hat{X}_t)\frac{d\hat{X}_t}{dI_{t+1}} + H_{I_{t+1}}\pi_I(\hat{I}_t) = 0 \tag{A.29}$$

$$H_I \frac{d\hat{I}_t}{dI_{t+1}} + H_C \frac{d\hat{C}_t}{dI_{t+1}} - \lambda_{XX}(\delta_t, \hat{X}_t)\frac{d\hat{X}_t}{dI_{t+1}} + H_{I_{t+1}} = 0 \tag{A.30}$$

$$-\frac{d\hat{I}_t}{dI_{t+1}} - \frac{d\hat{C}_t}{dI_{t+1}} + \frac{d\hat{X}_t}{dI_{t+1}} = 0 \tag{A.31}$$

where

$$H_{I_{t+1}} = \int_{-\infty}^{I^*_{t+1} - \hat{C}_t - \pi(\hat{I}_t)} \lambda_{XX}(\delta_{t+1}, \hat{X}_{t+1}) g(z) dz > 0. \tag{A.32}$$

Thus, we obtain the following as in equations A.26 - A.28

$$\frac{\partial \hat{I}_t}{\partial I_{t+1}} = \frac{\lambda_{XX}(\delta_t, \hat{X}_t) H_I [\pi_I(\hat{I}_t) - 1]}{D} < 0, \tag{A.33}$$

$$\frac{\partial \hat{C}_t}{\partial I_{t+1}} = \frac{-H_{I_{t+1}} \left\{\lambda_{XX}(\delta_t, \hat{X}_t)[\pi_I(\hat{I}_t) - 1] + (1+H)\pi_{II}(\hat{I}_t)\right\}}{D} > 0,$$

$$\frac{\partial \hat{X}_t}{\partial I_{t+1}} = \frac{-H_{I_{t+1}}(1+H)\pi_{II}(\hat{I}_t)}{D} > 0. \tag{A.34}$$

The result of $X_t \leq 0$ follows by noting $\lambda_{XX}(\delta_t, \hat{X}_t) = 0$.

Appendix 3: External Finance Cost and Investment Decisions Conditional on Cash Flow

Consider a production function $\pi^o(I) = \pi(I)(1+\beta z)$, where β measures the effect of z on investment opportunities. Given that π is homogeneous of degree one, $\pi_I^o(I) = \pi_I(I)(1+\beta z) = \pi_I[I(1+\beta z)](1+\beta z)$; thus, the expected and marginal profits of production remain the same. Thus, for a given z, the optimal investment and external finance stemming from $\pi^o(I)$ should be given by $I^o = \bar{I} + \beta\bar{I}z$ and $X^o = I^o - \pi(I_t) - C - z = \bar{X} + (\beta\bar{I} - 1)z$, where $\bar{I}$ and $\bar{X}$ are the expected values of I^o and X^o, respectively. Thus, we obtain $\frac{dX^o}{dz} = \beta\bar{I} - 1$.

To examine the effect of z on the expected cost of external finance at $t+1$, we apply a Taylor expansion to $\lambda(\delta^o, X^o)$ around $\delta^o = E(\delta^o) = \bar{\delta}$ and $X^o = E(X^o) = \bar{X}$ as follows:

$$E[\lambda(\delta^o, X^o)] \approx \lambda(\bar{\delta}, \bar{X}) + \frac{1}{2}\left\{\lambda_{\delta\delta}(\bar{\delta}, \bar{X})Var(\delta^o) + 2\lambda_{\delta X}(\bar{\delta}, \bar{X})Cov(\delta^o, X^o) + \lambda_{XX}(\bar{\delta}, \bar{X})Var(X^o)\right\}. \quad (A.35)$$

The second term on the right-hand side of equation (A.35) measures the curvature of external finance costs. A positive value of this term indicates that the external finance costs associated with low cash flow (large external finance) states are higher than those incurred in high cash flow (small external finance) states. Thus, the hedging motive increases as the firm attempts to reduce the variation in the expected external finance cost captured by the second term. The benefit of hedging is determined by the convexity of the external finance cost function and the effects of z on δ^o and X^o. For the given convexity of λ, the covariance term is crucial for the hedging motive. For example, if a negative shock to z is expected to increase δ^o, while reducing investment and consequently its external finance, the firm will have a less incentive to hedge against the increasing costs for external capital needs. If a negative shock to z is expected to increase both X^o and δ^o, the firm will have a greater incentive to hedge against the increasing costs for external capital needs.

Given $\delta^o = \delta + \frac{\alpha\sigma_\delta}{\sigma}z$, we also have $\frac{d\delta^o}{dz} = \frac{\alpha\sigma_\delta}{\sigma}$. Based on the above results, we measure the relative effects of z on δ^o and X^o as follows:

$$\gamma = \frac{d\delta^o}{dX^o} = \frac{\left[\frac{d\delta^o}{dz}\right]}{\left[\frac{dX^o}{dz}\right]} = \frac{\alpha\sigma_\delta}{(\beta I - 1)\sigma}. \quad (A.36)$$

Noting $X^o - \bar{X} = (I\beta - 1)z$, we obtain

$$\delta^o = \delta + \frac{\alpha\sigma_\delta}{\sigma}z = \delta + \frac{\alpha\sigma_\delta}{(I\beta - 1)\sigma}(X^o - \bar{X}) = \delta + \gamma\left(X^o - \bar{X}\right). \quad (A.37)$$

We also note that conditional on z, $\frac{d\delta^o}{dX^o} = \frac{\rho\sigma_\delta}{\sigma_X}$, where σ_X and ρ are the standard deviation of

X^o and the correlation between X^o and δ^o, respectively. Thus, the correlation between X^o and δ^o is critical for determining the relative effects of z on δ^o and X^o.

Similar to equation (A.6), we obtain the expected marginal value of cash at $t+1$ as follows:

$$H^o = E_t \left[\pi_I^o(I_{t+1}^o) - 1 + \lambda_X(\delta^o, X^o) + \gamma\lambda_\delta(\delta^o, X^o) \,\middle|\, X^o \geq 0 \right]. \tag{A.38}$$

Equation (A.38) indicates that the expected marginal value of cash at $t+1$ stemming from additional investment without external finance increases with γ. The derivative of H^o with respect to C_t is expressed as follows:

$$H_C^o = E_t \left[\pi_{II}^o(I^o) - \lambda_{XX}(\delta^o, X^o) - 2\gamma\lambda_{X\delta}(\delta^o, X^o) - \gamma^2\lambda_{\delta\delta}(\delta^o, X^o) \,\middle|\, X^o \geq 0 \right]. \tag{A.39}$$

Equations (A.38) and (A.39) suggest that the marginal value of cash and its rate of change (the concavity of cash value) are greater when the cost of external capital is highly correlated with external capital needs.[13] The concavity of the cash value implies that the firm incurs greater loss from reduced investment due to the external finance cost when there is a negative cash flow shock and that cash savings at t increase the firm value by reducing the variation in external finance. Thus, the greater concavity of the cash value with higher γ implies a greater hedging incentive because the effect of cash savings at t on the firm value is greater among firms with high correlation between δ^o and X^o.

Appendix 4: Proof of Proposition 2

Using $\lambda(\delta_{t+1}^o, X_{t+1}^o)$, π^o, and H^o, we obtain results similar to Proposition 1 in terms of the optimal decisions at t, I_t^o, C_t^o, and X_t^o by solving the maximization program in equation (A.1). However, γ only affects H^o and its derivatives through $\lambda(\delta^o, X^o)$ at $t+1$. Consequently, we obtain the following:

$$H^o = \int_{-\infty}^{I^* - C_t - \pi(I_t)} \left\{ \pi_I^o(I^o) - 1 + \lambda_X(\delta^o, X^o) + \gamma\lambda_\delta(\delta^o, X^o) \right\} g(z) dz > 0. \tag{A.40}$$

[13] Froot et al. (1993) also show that when financing opportunities vary with the return on risky assets, firms have a greater hedging incentive and such hedging incentive arises from the concavity of a profit function.

Thus, we obtain the following:

$$
\begin{aligned}
H_C^o &= \int_{-\infty}^{I_{t+1}^*-C_t-\pi(I_t)} \{\pi_{II}^o(I^o) - \lambda_{XX}(\delta^o, X^o) - 2\gamma\lambda_{X\delta}(\delta^o, X^o) \\
&\quad -\gamma^2\lambda_{\delta\delta}(\delta^o, X^o)\Big\} g(z)dz < 0, \\
H_\delta^o &= \int_{-\infty}^{I_{t+1}^*-C_t-\pi(I_t)} \{\lambda_{X\delta}(\delta^o, X^o) + \gamma\lambda_{\delta\delta}(\delta^o, X^o)\} g(z)dz > 0, \\
H_\gamma^o &= \int_{-\infty}^{I_{t+1}^*-C_t-\pi(I_t)} \left\{\lambda_{X\delta}(\delta^o, X^o)(X^o - \bar{X}) + \gamma\lambda_{\delta\delta}(\delta^o, X^o)(X^o - \bar{X})\right\} g(z)dz > 0,
\end{aligned}
$$

given $X^o > \bar{X}$ for $z < I_{t+1}^* - C_t - \pi(I_t)$. We also have $H_I^o = \pi_I(\hat{I}_t)H_C^o < 0$ and $H_\gamma^o = H_\delta^o\left(\frac{d\delta^o}{d\gamma}\right)$.

After differentiating the FOCs with respect to γ, the determinant of the Jacobian matrix of the derivatives on the FOCs is as follows:

$$
D^o\left(\frac{d\delta^o}{d\gamma}\right) = \left\{(1+H)\pi_{II}(\hat{I}_t)[H_C - \lambda_{XX}(\delta_t, \hat{X}_t)] - \lambda_{XX}(\delta_t, \hat{X}_t)H_C[\pi_I(\hat{I}_t) - 1]^2\right\}\left(\frac{d\delta^o}{d\gamma}\right).
$$

Then, we derive the following:

$$
\frac{\partial I_t^o}{\partial \gamma} = \frac{\partial I_t^o}{\partial \delta^o}\frac{\partial \delta^o}{\partial \gamma} = \frac{\lambda_{XX}(\delta_t^o, X_t^o)H_\delta^o[\pi_I(I_t^o) - 1]}{D^o} < 0, \tag{A.41}
$$

$$
\frac{\partial C_t^o}{\partial \gamma} = \frac{\partial C_t^o}{\partial \delta^o}\frac{\partial \delta^o}{\partial \gamma} = \frac{-H_\delta^o\{\lambda_{XX}(\delta_t^o, X_t^o)[\pi_I(I_t^o) - 1] + (1+H^o)\pi_{II}(I_t^o)\}}{D^o} > 0, \tag{A.42}
$$

$$
\frac{\partial X_t^o}{\partial \gamma} = \frac{\partial X_t^o}{\partial \delta^o}\frac{\partial \delta^o}{\partial \gamma} = \frac{-H_\delta^o(1+H^o)\pi_{II}(I_t^o)}{D^o} > 0, \tag{A.43}
$$

The result of $X_t^o \leq 0$ follows by noting $\lambda_{XX}(\delta_t^o, X_t^o) = 0$.

Appendix 5: A Dynamic Model

We build upon the models developed by Whited (1992), Whited and Wu (2006) and Gomes et al. (2006) to consider the effects of the time-varying cost of external capital on cash savings in a dynamic setting. The firm maximizes the expected discounted value of future cash flows as follows:

$$
V_t = \max_{(I_t, K_{t+j}, C_{t+j})_{j=0}^{\infty}} E_t \sum_{j=0}^{\infty} M_{t,t+j}\{d_{t+j} - \lambda_t(X_t, \gamma)\}, \tag{A.44}
$$

where E_t is the expectation operator conditional on information at time t, $M_{t,t+j}$ is the discount factor at time t for cash flows at $t+j$, and d_{t+j} is cash flow at time $t+j$ as follows:

$$
d_t = \pi(K_t, S_t) - \phi(K_t, I_t) - I_t + X_t + C_t - C_{t+1}, \tag{A.45}
$$

where K_t is the capital stock at time t; I_t is the investment between t and $t+1$; X_t is the amount of external finance at t; $\pi(K_t, S_t)$ is the cash flow at time t from production with the first partial derivative with regard to K given as $\pi_K > 0$; S_t is an exogenous state variable; $\phi(K_t, I_t)$ is the cost of adjustment, with the partial derivatives satisfying $\phi_I > 0, \phi_{II} > 0$ and $\phi_K < 0$;[14] and C_t is the liquid asset called "cash" at time t.

Thus, the model allows firms to invest in the following two distinctive assets with possibly different returns: capital stock K_t and cash C_t. The external finance cost function, $\lambda_t(X_t, \gamma)$, varies over time, which may be due to market frictions such as asymmetric information. γ is a measure of the strength of the correlation between the external capital needs and the cost of external capital. We also assume that $\lambda_t(X_t) > 0$ and $\lambda_t'(X_t) > 0$ for $X_t > 0$ whereas $\lambda_t(X_t) = 0$ for $X_t \leq 0$, implying that the marginal external financing cost increases as the amount of external capital increases (see Gomes (2001)).

Capital accumulation follows the following rule:

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{A.46}$$

where δ is the depreciation rate, $\delta \in (0,1)$. The dividend constraint is as follows

$$d_t \geq d^*, \tag{A.47}$$

This constraint on d has the same effect as a restriction on external capital as shown in financial constraint models.

The Lagrangian function conditional on the information set at time t is as follows

$$\begin{aligned} V_t = \max_{(I_{t+j}, K_{t+j}, C_{t+j}, X_{t+j})_{j=0}^{\infty}} E_t \sum_{j=0}^{\infty} M_{t,t+j} \{ & (1+\mu_{t+j})d_{t+j} - \lambda_{t+j}(X_{t+j}, \gamma) \\ & -q_{t+j}[K_{t+1+j} - (1-\delta)K_{t+j} - I_{t+j}] \} \end{aligned} \tag{A.48}$$

where q_t and μ_t are the Lagrange multipliers for constraints (A.46) and (A.47), respectively. The first-order conditions for maximizing the firm value at t with respect to I_t, K_{t+1}, C_{t+1}, and X_{t+1} are

[14] These conditions imply a convex adjustment cost with economies of scale. $f_x = f'$ and $f_{xx} = f''$ denote the first and second derivatives, respectively, of $f(x)$ with respect to x.

as follows:

$$\frac{\partial V_t}{\partial I_t} = -(1+\mu_t)\left[\phi_I(K_t, I_t)+1\right]+q_t = 0; \tag{A.49}$$

$$\frac{\partial V_t}{\partial K_{t+1}} = E_t\left(M_{t,t+1}\left\{(1+\mu_{t+1})\left[\pi_K(K_{t+1}, S_{t+1})-\phi_K(K_{t+1}, I_{t+1})\right]+(1-\delta)q_{t+1}\right\}\right)$$
$$-q_t = 0; \tag{A.50}$$

$$\frac{\partial V_t}{\partial C_{t+1}} = E_t\left\{M_{t,t+1}\left(1+\mu_{t+1}\right)\right\}-(1+\mu_t) = 0; \quad \text{and} \tag{A.51}$$

$$\frac{\partial V_t}{\partial X_t} = 1+\mu_t-\lambda_t'(X_t, \gamma) = 0. \tag{A.52}$$

Equation (A.49) suggests that a firm's optimal investment is determined to be where the product of the opportunity cost of external financing and the marginal cost of adjustment is equal to the marginal rate of return on the investment at t. Clearly, the firm's investment in the presence of external financing costs will be less than optimal.

Without time-varying external financing costs ($\lambda_t' = \lambda_{t+1}'$), condition (A.51) also implies that saving cash today does not affect firm value. In the presence of the time-varying costs of external capital, however, the firm's investment and cash savings decisions depend on the relative (in an intertemporal sense) costs of external capital. For illustration, we obtain the following equations from equations (A.49) - (A.51):

$$\phi_I(K_t, I_t)+1 = E_t\left\{M_{t,t+1}\left(\frac{1+\lambda_{t+1}'(X_t,\gamma)}{1+\lambda_t'(X_t,\gamma)}\right)\left[1+\pi_K(K_{t+1}, S_{t+1})\right.\right. \tag{A.53}$$
$$\left.\left.-\phi_K(K_{t+1}, I_{t+1})+(1-\delta)\left[\phi_I(K_{t+1}, I_{t+1})+1\right]\right]\right\}; \quad \text{and}$$

$$E_t\left\{M_{t,t+1}\left(\frac{1+\lambda_{t+1}'(X_t,\gamma)}{1+\lambda_t'(X_t,\gamma)}\right)\right\} = 1. \tag{A.54}$$

The relative costs of external finance, $\Lambda_t(\gamma) = (1+\lambda_{t+1}'(X_t,\gamma))/(1+\lambda_t'(X_t,\gamma))$, in equations (A.53) and (A.54) represent the effect on the investment and savings decisions from the intertemporal variation in the costs of external finance and the correlation between the expected cost of external capital and future capital needs.

Given Assumption 1 for the two-period model regarding the external finance cost function, it is straightforward to observe that $\Lambda_t(\gamma)$ is an increasing function of γ for $\lambda_t' < \lambda_{t+1}'$:, i.e., the effect of the intertemporal costs of external capital is magnified in firms with a greater correlation between the expected COC and future external capital needs.

Appendix 6: Definitions of Variables

The following are variable definitions used in this study. Items in parentheses are variable names as used in the Compustat annual database.

Acquisitions = acquisitions (aqc) / lagged total assets (at)

Cash = cash and cash Equivalents (che) / total assets (at)

Cost of Capital (**COC**) = weighted average cost of capital

ΔCash = change in cash and cash equivalents (chech) / lagged total assets (at)

Cost of Debt (**COD**) = whichever is the greater: interest expense (xint) divided by the average of total debt at the beginning and the end of the year ; or AAA-rated bond yield (also winsorized at 6 and 94 percent)

Cost of Equity (**ICC**) = Implied Cost of capital

Credit Spread (**$Spread$**) = difference in yield between maturity matched Treasury yield and AAA-rated corporate bonds

Dividend = cash dividend (dv) / lagged total assets (at)

External Capital (**$ExCapital$**) =Net Equity Issuance ($EIssue$) + Net Debt Issuance ($DIssue$)

External Finance (**$External$**) = [capital expenditures (capx) - operating cash flow (oibdp)]/capx

External Finance Dependence (**KZ**) = $-1.002CF - 39.368DIV - 1.315CASH + 3.139LEV$, where CF = operating cash flow (oibdp)/ lagged plant and equipment (ppent)

Excess Issuance = Net Equity Issuance ($EIssue$) + Net Debt Issuance ($DIssue$) $-$ Financial Deficit ($Deficit$)

Financial Deficit (**$Deficit$**) = [dividends + acquisitions + net investment - internal cash flow]/ lagged total assets (at)[15]

Future Investment (**$FInvest$**) = the average of three subsequent years of [capital expenditures (capx) + acquisitions (acq) + R&D]/ lagged total assets (at)

HP index = $-0.737Size + 0.043Size^2 - 0.04Age$, where $Size$ is the natural logarithm of total assets capped by \$4.65 billion and Age is the number of years since the firm's initial offering capped by 37

Internal Cash Flow (**ICF**) = [income before extraordinary items (ibc) + depreciation and amortization (dpc)] / lagged plant and equipment (ppent)

Leverage = [short-term debt (dlc) + long-term debt (dltt)] / total assets (at)

M/B = market value of assets / total assets (at), where market value of assets is given by total assets (at) - common equity (ceq) + market value of common equity (common shares outstanding (csho) $\times$ share price (prcc))

[15] We follow Rajan and Zingales (1998) to include the change in the non-financial components of net working capital as part of funds from operations in defining the financial deficit and external finance dependence.

Net Debt Issuance ($DIssue$) = [long-term debt issues (dltis) - long-term debt reduction (dltr) + change in current debt (dlcch)] / lagged total assets (at)

Net Equity Issuance ($EIssue$) = [sale of common and preferred stock (sstk) - purchase of common and preferred stock (prstkc)] / lagged total assets (at)

Net Investment (INV) = [increase in investment (invch) + capital expenditures (capx) + other use of funds (fuseo)- sales of property and plants (sppe) - sales of investment (siv) - short-term investment change (ivstch) -other investment activities (ivaco)]/lagged total assets (at)

Net Working Capital NWC = [current assets (act) - Current Liabilities (lct) - Cash (che)] / total assets

Precaution = the first principal component of firm-level R&D and 2-digit industry cash flow volatility ($CFRisk$).

R&D = research and development expense (xrdq) / Sales

Size = logarithm of total assets (at)

Tax Rate ($Taxr$) =whichever is the lower: tax payment (txt) divided by pretax income (pi) or the statutory maximum tax rate

Timing 1 = $\hat{cov}(ExCapital, M/B)$

Timing 2 = $\overline{M/B} * \overline{ExCapital}$

Timing 3 = mispricing proxy based on the average of a stock's ranking percentiles for each of 11 anomaly variables

Vol (Cash Flow Volatility)] = standard deviation of 2-digit SIC industry average cash flow (ICF) for the prior ten years

WW index = -0.091ICF-0.062 Div+0.021LTD-0.044Size+0.102ISG-0.035SG, where Div is an indicator for dividend; LTD is long-term debt ratio; ISG is industry sales growth rate; and SG is the firm's sales growth rate

Appendix 7: Estimation procedure for the COE

The Li, Ng, and Swaminathan (2013) model is as follows:

$$P_t = \sum_{k=1}^{15} \frac{FE_{t+k} \times [1 - b_{t+1} + \frac{(b_{t+1} - \frac{g_t}{ICC_t})}{15} \times (k-1)]}{(1+ICC_t)^k} + \frac{FE_{t+15} \times (1-b_t)}{(ICC_t - g_t)(1+ICC_t)^{15}}. \tag{A.55}$$

The model has the following two aspects: 1) the present value of cash flows up to year $(t+15)$; and 2) the present value of cash flows beyond year $t+15$. For the first two years' earnings, we use the median forecasts by analysts and forecast earnings FE_{t+k} from year $t+3$ to year $t+T+1$ as $FE_{t+k} = FE_{t+2} \times (1 + g_{t+3} \exp\{g_t^g \times (k-2)\})$. We assume that the earnings growth rate g_{t+3} will mean-revert exponentially to steady-state values by year $t+T+2$. The assumption implies that $g_{t+3} \exp\{g_t^g \times 15\} = g_t$ with g_t^g being the growth rate of growth rate g_{t+2}, which yields $g_t^g =$

$\ln\left(\frac{g_t}{g_{t+2}}\right)/15$. For g_{t+3}, we use the median long-term growth rate forecast by analysts. If the long-term growth rate forecast is not available, we estimate it using the first two years' forecast earnings as follows: $g_{t+3} = \frac{FE_{t+2}}{FE_{t+1}} - 1$. The steady-state earning growth rate (g_t) is assumed to be a rolling average of the annual GDP growth rate.

We construct the stream of dividends as $D_{t+k} = FE_{t+k} \times (1 - b_{t+k})$ for $1 \leq k \leq 15$. The initial retention ratio is estimated as $b_{t+1} =$ [1- Cash Dividend$_t$ /Net Income$_t$]. For years $t+2$ to $t+T+1$, we estimate the retention rate as $b_{t+k} = b_{t+1} - \frac{(b_{t+1} - \frac{g_t}{ICC_t})}{15} \times (k-1)$. The retention rate is assumed to revert linearly to a steady-state rate $b_t = \frac{g_t}{ICC_t}$ by year $t+T+1$. After the terminal year, we estimate the terminal value of the remaining cash flows using the Gordon growth model as follows: $FE_{t+15} \times (1 - b_t)/(ICC_t - g_t)$.

The Gebhardt, Lee, and Swaminathan (2001) model is based on the following equation:

$$P_t = BE_t + \sum_{k=1}^{12} \frac{(ROE_{t+k} - ICC_t)BE_{t+k-1}}{(1 + ICC_t)^k} + \frac{(ROE_{t+12} - ICC_t)BE_{t+11}}{ICC_t(1 + ICC_t)^{12}} \tag{A.56}$$

where ROE_{t+k} is the return on equity at $t+k$ which is assumed to revert linearly to the median industry ROE by year $t+12$ starting with $ROEt+3$. The industry median ROE is the past 10-year average of the industry median based on the 2-digit SIC code after excluding firms with losses. For the first three years' earnings, we use the median forecasts by analysts FE_{t+k} and the book value of equity is estimated by $BE_{t+k} = BE_{t+k-1} + FE_{t+k} \times b_{t+1}$, where b_{t+1} is the retention ratio at $t+1$. Beyond the third year, we use the linear interpolation to the industry median ROE to forecast the firm ROE. We assume that economic profits ($ROE - ICC$) after year 12 are zero.

The Claus and Thomas (2001) model is based on the economic profit of shareholders as expressed in the following equation:

$$P_t = BE_t + \sum_{k=1}^{5} \frac{FE_{t+k} - ICC_t \times BE_{t+k-1}}{(1 + ICC_t)^k} + \frac{(FE_{t+5} - ICC_t \times BE_{t+4})(1 + g_t)}{(ICC_t - g_t)(1 + ICC_t)^5} \tag{A.57}$$

where P_t is the current stock price and the growth rate after 5 years, g_t, is estimated by the inflation rate. We obtain the initial forecast value of equity as $BE_{t+1} = BE_t + FE_{t+1} \times b_{t+1}$, where BE_t is the book equity value per share at t; FE_{t+1} is the forecast earnings per share at $t+1$; and b_{t+1} is the retention ratio as defined above.

Appendix 8: Robustness Check

Table A1: Hedging Motive: Robustness

This table reports the robustness of the impacts of cost of capital on the sensitivities of cash savings to external capital between firms with high and low hedging motives. The dependent variable is the change in cash and equivalents divided by total assets at the beginning of the year. *ExCapital* and *ICF* are external capital and internal cash flow, respectively, divided by total assets at the beginning of the year. High and low hedging-need firms are defined as those in the top 30 percent and those in the bottom 30 percent, respectively based on the correlation between industry-level external finance and COC. We use high order linear cumulants (Erickson et al. (2014)) to account for measurement errors in the cost of capital measure (Columns 1 and 2). Li et al. (2013) (Columns 3 and 4) and Claus and Thomas (2001) (Columns 5 and 6) are used as alternative COE measures. The detailed variable definitions are provided in Appendix 6. Firm and year fixed effects are controlled. The coefficient estimates of the control variables are not reported for brevity. The standard errors are clustered at the firm level and corrected for heteroscedasticity. ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively.

	High-Order Cumulants		Li et al. (2013)		Claus and Thomas (2001)	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
COC	-0.0605	0.2412***	-0.0517	-0.014	-0.0074	0.0229
	[0.0776]	[0.0925]	[0.0352]	[0.0389]	[0.0258]	[0.0352]
ExCapital	0.5079***	0.4404***	0.4415***	0.3675***	0.2771***	0.2621***
	[0.0400]	[0.0457]	[0.0256]	[0.0231]	[0.0154]	[0.0180]
ICF	0.5218***	0.3772***	0.4449***	0.2971***	0.2942***	0.2090***
	[0.1037]	[0.1271]	[0.0412]	[0.0499]	[0.0237]	[0.0292]
ExCapital×COC	-1.6390***	-0.2357	-0.6815***	-0.1061	-0.2388**	-0.0713
	[0.4344]	[0.5328]	[0.2600]	[0.2459]	[0.1133]	[0.1288]
ICF×COC	-1.7179	0.1469	-2.0530***	-0.0654	-0.7654***	-0.1023
	[1.1031]	[1.4293]	[0.4030]	[0.5616]	[0.1296]	[0.2407]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	No	No	Yes	Yes	Yes	Yes
Year FEs	No	No	Yes	Yes	Yes	Yes
Observations	18,394	18,135	13,926	14,094	17,206	17,294
Adj. R^2			0.4390	0.3917	0.3507	0.3525