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**The Influence of Investment Volatility on
Capital Structure and Cash Holdings**

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Abstract: This paper studies the relationship between investment volatility, capital structure, and cash levels. Our evidence suggests: i) firms with relatively high capital expenditure volatility hold relatively high levels of both debt and cash, while firms with relatively high acquisition volatility hold relatively high levels of debt and lower levels of cash. Firms with relatively high research and development volatility hold relatively high levels of debt and are not important to determine cash levels, ii) firms fund large capital expenditures, acquisitions and research and development by increasing debt or decreasing cash, iii) immediately after funding large investments firms reduce debt levels and increase cash holdings. Overall, our results are consistent with parts, but not all, of the DeAngelo, DeAngelo and Whited (2011) model. In particular, firm investment volatility is persistent and leads to high debt levels over long periods of time.

Keywords: Capital structure, cash holding and investment volatility

JEL Classifications: G32

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1 Introduction

The seminal academic literature on investment and financing emphasizes agency issues. (Myers and Majluf, 1984, Jensen, 1986). Several more recent studies examined the relationship between large investments (investment spikes) and capital structure (Denis and McKeon, 2012, Dudley, 2012, Elsas, Flannery and Garfinkel, 2014). However, these studies omit the relationship between large investments and cash holdings and further do not recognize the close relationship between investment spikes and investment volatility. In addition, the relationship between investment volatility and capital structure is unexplored. For example, Frank and Goyal (2009) do not test if investment volatility is an important factor that explain capital structure. Theory suggests investment volatility is important – DeAngelo et al. (2011) create a dynamic capital structure model, where investment opportunities are subject to shocks and not predictable. Firms subject to investment opportunity shocks exhibit relatively high levels of investment volatility.¹

Our study is distinguished by the number of investment measures we study. As our first measure, we follow DeAngelo et al. (2011) and define investment as capital expenditures plus acquisitions. However, because firms’ policies may differ by investment types, we unbundle their definition and define investment as either capital expenditures or acquisitions. We further include research and development as investment. To measure investment volatility, we estimate a conditional investment volatility using the method of De Veirman and Levin (2015) and then take the natural logarithm of the five year rolling average. In robustness tests, we use the method of Kim and Sorensen (1986) and estimate the rolling five year standard deviation of scaled investment. To construct an investment spike (large investment) variable, we adapt the method of De Veirman and Levin (2015). Specifically, an investment spike occurs when actual investment growth is greater than predicted investment growth and when investment volatility is in the top tercile. Because our investment spike variable is estimated from realizations used to estimate conditional volatility, our investment

¹Using model simulations, DeAngelo et al. (2011) advance that firms with high shock volatility (relative to low shock volatility firms) have lower levels of debt, higher cash balances, and higher average debt issuance.

spike is closely related to investment volatility. For example, the correlation coefficient between the five year rolling average of investment volatility and investment spikes is thirty four percent.²

In this paper, we examine the relationship between investment volatility and both capital structure and cash policies. Our evidence shows that i) firms with relatively high capital expenditure investment volatility hold relatively higher levels of both debt and cash, while firms with relatively high acquisition volatility hold relatively higher levels of debt and lower levels of cash. Research and development investment volatility is related to higher levels of debt and not important to determine cash levels, ii) firms fund large capital expenditures, acquisitions and research and development by increasing debt or decreasing cash, iii) immediately after funding large investments firms reduce debt levels and increase cash holdings. Many of these findings are novel. For example, the idea that investment volatility leads to higher debt levels runs counter to the model of DeAngelo et al. (2011). In robustness tests, we confirm that investment volatility (and thus investment shocks) are correlated, which leads to persistently high levels of debt as documented by DeAngelo and Roll (2015).³

The dependent variable is either the book debt ratio or cash to total assets ratio. As the dependent variables in this study are bounded between zero and one, we test using the GLM (Generalized Linear Model) with a logit link function proposed by Kieschnick and McCullough (2003) and used by Keefe and Yaghoubi (2016). In addition to cross sectional regressions, we follow Lemmon, Roberts and Zender (2008) and Flannery and Rangan (2006) and estimate panel GLM to control for time invariant firm heterogeneity in the robustness section.

The first hypothesis is about the relationship between the investment volatility and a firm's debt and cash levels. Relative to the relationship between investment volatility and debt levels, our evidence indicates that high capital expenditure, acquisition and research and development investment volatility leads to higher debt levels. Relative to the relationship between investment volatility and cash levels, our estimation results indicate that high acquisition volatility leads to

²DeAngelo et al. (2011) define investment spikes as investments that are two standard deviations from the two digit SIC code average.

³DeAngelo and Roll (2015) use the term *transitory* debt to refer to debt used to fund investment from a productivity shock. This debt is *transitory* in that the firm temporarily goes over its target capital structure and then pays down the debt. Our findings suggest correlated investment shocks lead to *persistent* debt.

lower levels of cash, but high capital expenditure volatility leads to higher levels of cash. Research and development volatility is not important in explaining cash levels. Our results are statistically significant and economically important. One standard deviation increase from the mean of capital expenditure plus acquisition investments volatility variable, leads to a 16.1% increase in the debt ratio and a 12.4% decrease in the cash level. All in all, our evidence does not support the DeAngelo et al. (2011) model prediction that firms with high investment volatility keep debt levels low, and supports the DeAngelo et al. (2011) model prediction that firms with high investment volatility keep cash levels high using capital expenditure volatility but not using acquisition volatility. To our knowledge, we are the first to empirically test the relationship between financing and investment volatility.

The second hypothesis relates to how firms use debt and cash to fund large investments. We find a positive relationship between large investments and use of debt, and a negative relationship between large investments and cash levels. Our variable of interest is the investment spike variable defined earlier. Our evidence supports the notion that firms use debt and cash to fund large investments. Our results are statistically significant and economically important - our evidence suggests a 27.1% increase in the debt ratio and a 28.9% decrease in the cash level as a result of an investment spike (large investment). This finding supports the DeAngelo et al. (2011) model prediction and empirical tests that firms issue debt and use cash to fund large capital expenditure and acquisition investments. Unlike the first hypothesis, which has not been previously tested, our contribution relative to the second hypothesis is the use of a firm-level measure of investment spikes, as well as using research and development as a proxy for investment.

The third hypothesis is whether, after funding large investments, firms decrease debt levels and increase cash levels. Although rebuilding cash levels is not explicit in the model of DeAngelo et al. (2011), a plausible implication of their model is that firms rebuild their stock of cash after using cash stocks to fund large investments. For both cash and debt levels, our evidence suggests that one year after making large investments firms rebuild their debt and cash capacity by decreasing their debt levels and increasing their cash stocks. Our results are statistically significant and economically important - our evidence suggests a 10% decrease in the debt ratio and a 19% increase in the cash

levels one year after the large investment. Overall, our findings support the DeAngelo et al. (2011) model prediction that firms decrease their debt level after the spike year. Our finding that firms increase cash levels after funding investments is novel.

We also evaluate if our findings are robust to an alternative estimation method, a different measure of debt ratio, cash ratio, investment volatility and investment spike measures. In particular, we test our hypotheses using the book total liabilities ratio, the ratio of cash over net assets, a variable representing two consecutive investment spikes (large investments), an investment volatility measure constructed following Kim and Sorensen (1986) and an investment spike variable constructed following DeAngelo et al. (2011). We also test our three hypothesis using a panel GLM model. Most of our main results remain unchanged using different estimation method and variables.

This paper proceeds as follows: Section 2 reviews the literature and develops our hypotheses of the study. Section 3 reviews the data, constructs the variables, and reports the univariate statistics of the variables. Section 4 tests the hypotheses and discusses the results. Section 5 tests for robustness to other specifications and econometric methods. Section 6 provides concluding remarks.

2 Literature review and Hypothesis development

DeAngelo et al. (2011) create a dynamic model of capital structure where optimal investment requirements are not predictable. Specifically, the marginal productivity of capital is modeled as an auto-regressive (AR1) process, where the error term represents shocks to marginal productivity. These shocks imply that optimal investment is uncertain. The model suggests a firm's debt structure and cash levels are influenced by the need to fund uncertain investments. Using a Simulated Method of Moments (SMM), DeAngelo et al. (2011) show their model predicts that firms with higher versus lower standard deviation of investment shocks tend to have higher (lower) standard deviation of investment outlays, lower (higher) debt ratios, higher (lower) cash holdings, and higher (lower) deviation from target debt ratio. Essentially, a firm with uncertain future investment maintains financing capacity by keeping its debt ratio low and its cash level high.

DeAngelo et al. (2011) advance their dynamic model which implies firms with high investment shock volatility hold less debt. Intuitively, a firm with high investment shocks maintains low debt ratios to preserve debt capacity in order to fund uncertain investments. Although we cannot observe marginal productivity shocks in the DeAngelo et al. (2011) model, we can observe firm level investment volatility. To the extent that investment volatility is a proxy for marginal productivity shocks, firms with high investment volatility maintain lower debt ratios than would be optimal under a static trade-off model.

Hypothesis 1a. *Firms with high investment volatility have lower debt ratios, caeteris paribus.*

Opler, Pinkowitz, Stulz and Williamson (1999) state that firms set cash holding levels where the marginal benefits of holding cash are equal or greater than the marginal cost of it.⁴ One of the benefits of cash holdings is having the option to finance investment opportunities using cash when other sources of financing are costly. Also, Kim, Kim and Woods (2011) find a positive relationship between a firm’s cash holding level and investment opportunities. The model DeAngelo et al. (2011) advances that a higher fraction of investments in firms with high investment shock volatility are funded from cash balances, which implies:

Hypothesis 1b. *Firms with high investment volatility hold more cash, caeteris paribus.*

The model of DeAngelo et al. (2011) implies that firms temporarily diverge from their target capital structure to finance investments, where the difference between the target capital structure and the actual capital structure is the “transitory debt.” DeAngelo et al. (2011) refer to large investments as investment spikes, and analyze debt issuances that associated with investment spikes for a sample of Compustat firms. Empirical tests show that investment spikes are accompanied by large debt issuances. In a related note, Denis and McKeon (2012) discuss how firms evaluate the financing of investment opportunities, and if there is a financing deficit they deviate from the target capital structure. They find that increases in the debt levels are primarily the result of the investment needs. In addition, Elsas et al. (2014) conclude that firms issue debt to fund large investments.

⁴Examples of the drawbacks of holding cash are incremental taxes on interest income and lower rates of return.

Hypothesis 2a. *Firms with large investments have higher debt ratios, caeteris paribus.*

The model of DeAngelo et al. (2011) implies firms with large uncertain investments have a higher beginning-of-year than end-of-year cash to assets ratio, indicating that such firms use cash to fund large uncertain investments. Therefore, investment spikes are financed by a decrease in a firm's cash level, which implies:

Hypothesis 2b. *Firms with large investments have lower cash levels, caeteris paribus.*

The DeAngelo et al. (2011) model predicts firms fund large uncertain investments by issuing debt, after which, firms decrease their debt level back toward their target capital structure. In a related study, Elsas et al. (2014) conclude that firms issue debt to fund large investments and subsequently pay off the debt with internal cash flows. Both studies advance:

Hypothesis 3a. *After making large investments, firms decrease debt, caeteris paribus.*

The DeAngelo et al. (2011) model advances that firms hold cash to fund uncertain investments. Although not explicit in their model, a plausible implication is that after depleting cash stocks to fund a large investment, the firm will rebuild their stock of cash, which implies:

Hypothesis 3b. *After making large investments, firms increase cash, caeteris paribus.*

These hypotheses test the relationship between the volatility of investments and large realization of investment on debt and cash levels. Prior literature uses several investment definitions including capital expenditures ($Capx$), acquisitions (Acq), and the sum of capital expenditures and acquisitions ($Capx + Acq$). This paper contributes to the literature both in terms of the hypotheses tested and the range of our definitions of investment. To our knowledge, Hypotheses 1a, 1b and 3b have not been tested for any of these four investment volatilities. For some investment types some hypotheses have been tested. Hypothesis 2a has been empirically tested by DeAngelo et al. (2011) for large $Capx + Acq$ and by Elsas et al. (2014) for large $Capx$ and Acq , Hypothesis 2b has been empirically tested by DeAngelo et al. (2011) for large $Capx + Acq$, and Hypothesis 3a has been empirically tested by DeAngelo et al. (2011) for large $Capx + Acq$. Lastly, research and development expenditures ($R\&D$) has not been used as a measure of investment.

3 Sample, variable construction, and univariate statistics

3.1 Sample

To test these hypotheses we obtain annual data from 1974 through 2015 of the US corporations from the Compustat-CRSP Merged database. Following Bates, Kahle and Stulz (2009), we exclude financial firms, utilities, non-US firms and firms with missing or negative total assets or sales. We also follow Denis and Sibilkov (2010) and exclude firms with missing or negative cash. Also, we think firms that do not have sufficient engagement in research and developments or acquisitions (e.g. they just engaged one time) should be dropped from the sample when we test the effect of these volatility measures on debt and cash. In Section 3.2.4 we construct *Intensity* variables and when testing the effect of these volatility variables (as well as Investment volatility variable) we test if *Intensity* > 0.2.⁵ In addition, following Kale and Shahrur (2007), all the variables are winsorized at 0.1% level in both tails of the distribution before calculating the summary statistics.

3.2 Variable Construction

3.2.1 Dependent variables

To test the relationship between investment volatility and capital structure, we construct two book debt ratios. In Section 4, we test using the short and long-term book debt ratio and in the robustness section, we test using the total liabilities book debt ratio. We use book debt ratios as this study debt measure because of possible simultaneity between market value and investment.⁶

In constructing our leverage measures, we address the Welch (2011) critique related to the treatment of non-financial liabilities. Welch (2011) states that by using financial debt over total assets ratio, researchers treat the non-financial liabilities as equity. To be consistent with DeAngelo et al. (2011), we use the total long plus short-term debt (financial-debt) in the numerator of our debt ratio measures, but we do not use the DeAngelo et al. (2011) debt ratio's denominator as they used the total assets. Following the Welch (2011) critique, we modify the denominator of our debt

⁵We also test using *Intensity* > 0.3, 0.4 and 0.5, and the results remain quantitatively unchanged

⁶Investment might affect both the market value of the equity and the need for the firm to issue more debt to fund the investment.

measures and use the below book debt ratio used by Rajan and Zingales (1995). For replication purposes, we use Compustat variable names in our definitions.

- i) The short and long-term book debt ratio is the sum of short and long-term debt over the sum of common shareholders' equity, the total long-term debt and the total short-term debt.

$$BDR = \frac{dltt + dlc}{ceq + dltt + dlc}. \quad (1)$$

- ii) We also follow Rajan and Zingales (1995) and Welch (2011) and construct the total liabilities debt ratio as the total liabilities divided by total assets.

$$BDR_lt = \frac{lt}{at}. \quad (2)$$

Note that in BDR both the numerator and the denominator exclude the non-financial liabilities, and in BDR_lt non-financial liabilities have been categorized as debt.

To test the relationship between investment volatility and cash holdings, we construct two cash ratios. In Section 4, we test using cash scaled by total assets, and in the robustness section we test using cash scaled by net assets.

- i) The ratio of cash and short-term investments over total assets (DeAngelo et al., 2011, Bates et al., 2009, Almeida, Campello and Weisbach, 2004, DeAngelo, DeAngelo and Stulz, 2006).

$$Cash_at = \frac{che}{at}. \quad (3)$$

- ii) The ratio of cash and short-term investments over net assets, where che is cash and marketable securities and at is total assets (Opler et al., 1999).

$$Cash = \frac{che}{at - che}. \quad (4)$$

3.2.2 Variables of Interest

We measure investment in four ways. First, we follow Guay (1999), Eisfeldt and Rampini (2006) and DeAngelo et al. (2011), who define a firm's investment as the sum of its capital expenditures plus acquisitions, $Inv = Capx + Acq$.⁷ Second, we use the components of the aforementioned investment definition which are capital expenditure $Capx$ and acquisitions Acq as the investment measures. Third, we use the research and development expenses Xrd as a measure of investment following Brown and Petersen (2011). We follow DeAngelo et al. (2011) and scale our investment measures by total assets.

To construct investment volatility measures, we follow the De Veirman and Levin (2015) volatility estimation method and used by Keefe and Yaghoubi (2016) and Keefe and Tate (2013). To construct the De Veirman and Levin (2015) investment volatility measure, we estimate

$$\omega_{i,t} = \alpha_i + Year\beta + \epsilon_{i,t} \quad (5)$$

where $\omega_{i,t}$ represents the first difference of an investment measure scaled by total assets from $t - 1$ to t for firm i and $Year$ is a matrix of year dummies. The residual $\hat{\epsilon}_{i,t}$ represents the difference between the observed and the estimated investment growth of firm i when controlling for time and firm fixed effects. De Veirman and Levin (2015) estimate conditional volatility as

$$\hat{\sigma}_{i,t} = \sqrt{\pi/2} * |\hat{\epsilon}_{i,t}|, \quad (6)$$

and show $\hat{\sigma}_{i,t}$ is an unbiased estimator of the true conditional volatility and where $\hat{\epsilon}_{i,t}$ is the estimated residual from Equation (5).

Because firms tend to slowly adjust capital structure, we construct the five year rolling average of $\hat{\sigma}_{i,t}$. To denote a five year window, we use the subscript $t - 5, t$ for each investment volatility measure. To closely match the normal distribution of the investment volatility measures, we take the natural logarithm of each volatility measure. For example, $CapxVol_DL_{t-5,t} = \ln(\frac{1}{5} \sum_{t-5}^t \hat{\sigma}_{i,t})$. In our main results, we report results using the five year rolling average.

⁷Note that Compustat item capital expenditure $Capx$ excludes the acquisitions Acq .

We construct our investment spike measure, using the volatility estimation method of De Veirman and Levin (2015). For investment to be defined as a spike, it must meet two conditions. First, $\hat{\epsilon}_{i,t}$, which is estimated from Equation (5) must be positive. This implies that actual investment growth is greater than predicted investment growth from Equation (5). Second, the De Veirman and Levin (2015) measure of volatility $\hat{\sigma}_{i,t}$ in Equation (6) must be in the top tercile for each year. In summary, an investment spike occurs for those observations where $\hat{\sigma}_{i,t}$ is in the top tercile and where the deviation from predicted investment is positive. For example, $CapxSpike_DL_t$ is set to one when actual capital expenditure growth is higher than predicted from Equation (5) and capital expenditure volatility from Equation (6) is in the highest tercile. This method of investment spike construction illustrates the relationship between an investment spike and investment volatility.

As an alternative measure of investment volatility, we use the volatility estimation method of Kim and Sorensen (1986) and used by Keefe and Yaghoubi (2016) to estimate cash flow volatility. We estimate the ratio of the five years rolling standard deviation of *Inv*, *Capx*, *Acq* and *RnD* to the five years rolling average of total assets and construct $InvVol_KS_{t-5,t}$, $CapxVol_KS_{t-5,t}$, $AcqVol_KS_{t-5,t}$ and $RnDVol_KS_{t-5,t}$ investment volatility measures; where, for example, $InvVol_KS_{t-5,t}$ is the investment volatility measure using *Inv* as the investment measure and the Kim and Sorensen (1986) estimation method. Once again, we take the natural logarithm of the volatility measures.⁸

In addition, we follow DeAngelo et al. (2011) and create an alternative investment spike measure. DeAngelo et al. (2011) define investment spikes as investment “that is two or more standard deviations above the mean for the firm’s two-digit SIC code.” We use this definition and create our *DDW* spike variables. We first compute the mean and standard deviation by forty nine industries by year. Then, the *DDW* spike variable is set to one if the investment measure for the firm is greater than the mean plus two standard deviations, and zero otherwise. For example, $CapxSpike_DDW_{i,t}$ is set to one when *Capx* for the firm is greater than the mean plus two standard deviation of its industry *Capx*.

⁸For example, before taking the natural logarithm the skewness and the kurtosis of $InvVol_KS_{t-5,t}$ are 2.33 and 9.37, respectively. After taking the natural logarithm the skewness and the kurtosis decrease to 0.28 and 2.5, respectively. Note that the skewness and the kurtosis of a normal distribution is 0 and 3, respectively.

3.2.3 Control Variables

To control for variables that influence a firm's debt ratio, we follow Frank and Goyal (2009) and use the following control variables.

- i) *MarketToBook* is the proxy for a firm's growth opportunities and is the ratio of market value of asset to total assets.
- ii) *Tangibility* is the asset tangibility. The assets tangibility of a firm is the ratio of net property, plant, and equipment over book value of total assets.
- iii) *FirmSize* is a proxy for firms' size. It is the natural logarithm of total assets.
- iv) *Profitability* is the firm's operating income before depreciation divided by total assets.
- v) *FirmAge* is the number of years a firm has been listed in the Compustat.
- vi) *LnRnD* is the natural log of (1+ research and development expenses divided by revenue).
- vii) *IndustLev* is the ratio of median industry leverage ratio by SIC code to the total market debt ratio in each year.
- viii) *CreditRating* is an indicator variable, equals to one if S&P rates the debt as investment grade (BBB) debt and zero otherwise.
- ix) *Inflation* is the expected variation of CPI over the coming year.

We also control for cash flow volatility and follow Keefe and Yaghoubi (2016) and use:

- x) $CFV_{t-5,t}$ is the natural log of a firm's cash flow volatility using a five-year window for years $t - 5$ to t .

To control for the investment variables that are used to construct our investment volatility measures.

- xi) *Acquisitions* is the natural logarithm of the ratio of acquisition spending to property, plant and equipment (ppeg).

- xii) *Capx* is the natural logarithm of the ratio of capital expenditure to property, plant and equipment (ppeg).

Because we already control for research and development using the Frank and Goyal (2009) measure, we do not add an additional control for research and development. To mitigate possible omitted variable bias we use all of the control variables in all tests.

3.2.4 Intensity Variables

As explained in Section 3.1, we construct *AcqIntensity* and *RnDIntensity* variables to only include firms with sufficient engagement in research and development and acquisitions in our sample. *AcqIntensity* equals the number of acquisitions a firm makes (non-zero acquisitions) divided by the number of observations by firm in the sample. Similarly, the *RnDIntensity* equals the number of non-zero research and development expenditures divided by the number of observations by firm in the sample.

3.3 Univariate Statistics

Table 2 reports summary statistics. The table reports that for most variables there are 146,668 firm-year observations. The mean of the book debt ratio *BDR* is greater than the mean of the market debt ratio. This is consistent with the mean of market to book ratio *MtB* being greater than one. In addition, Table 2 shows that on average the cash holding level of the sample firms is about 17.7% of the total assets, with a standard deviation of 0.22. The table also shows that on average firms spend 9% of their total assets on research and development and have been listed in Compustat for about 9 years.

insert Table 2

Table 3 reports the correlation coefficients between our volatility measures, *MarketToBook* and our four investment measures. All the investment measures are positively correlated and among all of them *Capx* and *Inv* are highly correlated, with a correlation coefficient of 0.91. However, the correlation coefficient between *Capx* and *Acq* is only 0.18. This suggests *Capx* dominates the combined measure of investment used by DeAngelo et al. (2011). The correlation coefficients between

MarketToBook and *Inv*, *Capx* and *Acq* are small and negative, while the correlation between *RnD* and *MarketToBook* ratio is small and positive. All the investment volatility measures as well as *MarketToBook* are positively correlated. Also, all investment volatility and investment spike variables are positively correlated. The highest correlation coefficients are between *InvVol_DL_{t-5,t}* and *AcqVol_DL_{t-5,t}*, 0.62 and *InvVol_DL_{t-5,t}* and *CapxVol_DL_{t-5,t}*, 0.61.

insert Table 3

4 Testing

4.1 Estimation approach

To test our hypotheses, we consider the fact that our dependent variables are proportional variables that are bounded between zero and one, which implies a nonlinear relationship between our dependent variables and explanatory variables. To address this issue, we follow Cook, Kieschnick and McCullough (2008) and use the following GLM (Generalized Linear Model):

$$E(Ratio_{i,t}|X_{i,t-1}, I) = G(\alpha_i + X_{i,t-1}\beta_1 + \beta_2 I + \epsilon_i) \quad (7)$$

where

- $G(\cdot)$ is the logistic link function,
- $Ratio_{i,t}$ is the book debt ratio *BDR* for Hypotheses 1a, 2a and 3a; and is the cash ratio *Cash* for Hypotheses 1b, 2b and 3b.
- $X_{i,t-1}$ is a matrix of lagged control variables listed in Section 3.2.3, and
- I is the variable of interest. For Hypotheses 1a and 1b, I is the lag of one of the investment volatility variables *InvVol_DL_{t-5,t}*, *CapxVol_DL_{t-5,t}*, *AcqVol_DL_{t-5,t}* and *RnDVol_DL_{t-5,t}*; for Hypotheses 2a and 2b, I is one of the the dummy spike variables *InvSpike_DL_t*, *CapxSpike_DL_t*, *AcqSpike_DL_t* and *RnDSpike_DL_t*; for Hypotheses 3a and 3b, I is the first lag and the first lead of one of the spike variables.

Table 4 through Table 6 report estimation results. In each table, Columns (1) to (4) report the estimation results of Equation (7) using book debt ratio *BDR* as the dependent variable and Columns (5) to (8) report the estimation results of Equation (7) using the ratio of cash over total assets *Cash* as the dependent variable. In addition, Table 4 through Table 6 report that all the control variables are statistically significant with signs predicted from the literature.

4.2 Hypotheses 1a and 1b - Effect of investment volatility on a firm's debt and cash levels.

Columns (1) to (4) of Table 4 report estimation results that test Hypothesis 1a, which posits that investment volatility implies low levels of debt. The intuition behind this hypothesis is that firms with high investment volatility keep debt levels low to maintain debt capacity to fund uncertain future investments.

Columns (1) to (4) of Table 4 show the coefficients associated with the four investment volatility variables are positive and statistically significant at less than the 1% level, which is opposite to the predicted relationship. Our evidence suggests that firms with high capital expenditures, acquisitions and research and development investment volatility do not keep debt levels low. Rather, high investment volatility appears to lead to higher debt levels. All in all, our evidence does not seem to support the DeAngelo et al. (2011) model prediction that firms with high investment volatility keep debt levels low.

Columns (5) to (8) of Table 4 report estimation results test Hypothesis 1b, which advances that investment volatility implies high levels of cash. The intuition behind this hypothesis is firms with high investment volatility keep cash levels high to fund uncertain future investments.

Columns (5) to (8) of Table 4 show consistent with the DeAngelo et al. (2011) model, the coefficient associated with capital expenditure volatility $CapxVol_DL_{t-5,t}$ is positive and statistically significant at less than the 5%. Whereas, inconsistent with the DeAngelo et al. (2011) model, the coefficients associated with investment volatility $InvVol_DL_{t-5,t}$ and acquisitions volatility $AcqVol_DL_{t-5,t}$ are negative and statistically significant at less than the 1% level. The coefficient associated with research and development volatility $RnDVol_DL_{t-5,t}$ is not statistically signif-

icant. Although the negative (and different from $CapxVol_DL_{t-5,t}$) coefficient associated with acquisitions volatility $AcqVol_DL_{t-5,t}$ is not consistent with the intuition behind Hypothesis 1b, it can be explained by studies like Bharadwaj and Shivdasani (2003) and Harford, Klasa and Walcott (2009). They discussed that most acquisitions are financed by debt. In addition, the positive effect of $CapxVol_DL_{t-5,t}$ is consistent with Pinkowitz and Williamson (2007) findings. They show the value of cash is greater for firms with more volatile capital expenditure. Therefore, firms with high capital expenditure volatility keep cash level high to fund uncertain capital expenditure.

insert Table 4

4.3 Testing Hypotheses 2a and 2b - Effect of investment spikes on a firm's debt and cash levels.

Columns (1) to (4) of Table 5 report estimation results that test Hypothesis 2a, which proposes that an investment spike leads to higher levels of debt. The intuition behind this hypothesis is a firm's issue debt to fund large investments.

Columns (1) to (4) of Table 5 show the coefficients associated with investment spike $InvSpike_DL_t$, capital expenditures spike $CapxSpike_DL_t$, acquisitions spike $AcqSpike_DL_t$, and research and development spike $RnDSpike_DL_t$ are positive and statistically significant at less than the 1% level, which is consistent with the predicted relationship. Our evidence supports using debt to fund large investments. All in all, our findings support the DeAngelo et al. (2011) model prediction that firms issue debt to fund large investments.

Columns (5) to (8) of Table 5 report estimation results that test Hypothesis 2b, which posits that an investment spike implies lower levels of cash. The intuition behind this hypothesis is that firms use cash to fund large investments. Columns (5) to (8) of Table 5 show the coefficients associated with investment spike $InvSpike_DL_t$, capital expenditures spike $CapxSpike_DL_t$, acquisitions spike $AcqSpike_DL_t$, and research and development spike $RnDSpike_DL_t$ are negative and statistically significant at less than the 1% level. Our evidence supports using cash to fund large investments. All in all, our findings support the DeAngelo et al. (2011) model prediction that firms use cash to fund large investments.

insert Table 5

4.4 Hypotheses 3a and 3b - The intertemporal effect of investment spikes on firm debt and cash levels.

Columns (1) to (4) of Table 6 report estimation results that test Hypothesis 3a, which advances that firms decrease debt levels after funding large investments. The intuition behind this hypothesis is that after large investments, firms decrease debt levels to maintain debt capacity to fund future investment. Columns (1) to (4) of Table 6 show the coefficients associated with the lead of investment spike $InvSpike_DL_{t+1}$, capital expenditures spike $CapxSpike_DL_{t+1}$, acquisitions spike $AcqSpike_DL_{t+1}$, and research and development spike $RnDSpike_DL_{t+1}$ are negative and statistically significant at less than the 1% level, which is consistent with the predicted relationship.

Our evidence suggests that after large investments firms decrease their debt levels. All in all, our findings seem to support the DeAngelo et al. (2011) model prediction that firms decrease their debt level after the spike year.

Columns (5) to (8) of Table 6 report estimation results that test Hypothesis 3b, which puts forward that firms increase cash levels after funding large investments. The intuition behind this hypothesis is that after large investments, firms rebuild cash stock to maintain cash capacity to fund future investment. Columns (5) to (8) of Table 6 show the coefficients associated with the lead of investment spike $InvSpike_DL_{t+1}$, capital expenditures spike $CapxSpike_DL_{t+1}$, acquisitions spike $AcqSpike_DL_{t+1}$, and research and development spike $RnDSpike_DL_{t+1}$ are positive and statistically significant at less than the 1% level, which is consistent with the predicted relationship.

Our evidence suggests that after large investments firms rebuild their cash stock. Although not explicit in the model of DeAngelo et al. (2011), our evidence supports the plausible implication of their model that firms rebuild their stock of cash after depleting cash stocks to fund large investments.

insert Table 6

5 Discussion and Robustness

In this section we discuss the economic importance of our results, investigate if our findings are robust to alternative measures, and delve into why our findings diverge from the model predictions of DeAngelo et al. (2011).

5.1 Economic Importance

Table 7 reports the predicted percentage change in dependent variables (*BDR* and *Cash*) of our three Hypotheses cross-sectional model. The predicted percentage changes for Hypotheses 1a and 1b are the result of one standard deviation increase from the mean of the investment volatility variables, where other control variables are evaluated at their means. For example, to obtain the economic importance of $InvVol_DL_{t-6,t-1}$, we estimate the change in the dependent variable (*BDR*) due to a one standard deviation increase in $InvVol_DL_{t-6,t-1}$ using Equation (7). Predicted *BDR* at the mean of $InvVol_DL_{t-6,t-1}$ is 0.30 and at the mean plus one standard deviation of $InvVol_DL_{t-6,t-1}$ is 0.35, implying a 16% increase in debt ratio as a result of one standard deviation increase in $InvVol_DL_{t-6,t-1}$.⁹ For Hypotheses 2a, 2b, 3a and 3b the predicted percentage changes are the result of the change in the dummy spike variables from zero to one, where other control variables are evaluated at their means. For example, the predicted *BDR* when $InvSpike = 0$ is 0.26 and when $InvSpike = 1$ is 0.33, implying a 27% increase in debt ratio as a result of a large investment spike.

The second part of Table 7 reports the predicted percentage change in *Cash* of Hypothesis 1b. For example, the table reports a 12.4% decrease in a firm's cash level as a result of a one standard deviation increase from the mean of $InvVol_DL_{t-6,t-1}$. Like *BDR* changes, the *Cash* changes are mainly derived by $AcqVol_DL_{t-6,t-1}$. Note that $Inv = Capx + Acq$.

insert Table 7

⁹ $PercentageChange = \frac{0.35-0.30}{0.30} = +16\%$.

5.2 Robustness to alternative estimation method

In addition to our cross-sectional regression, we follow Lemmon et al. (2008) and Flannery and Rangan (2006) and estimate a panel data model which controls for time invariant firm heterogeneity, implying identification comes through investment volatility variations within a firm over time. Because our dependent variables are proportional variables bounded between zero and one, we use the GLM panel data model as follows:

$$E(Ratio_{i,t}|X_{i,t-1}, I) = G(\alpha_i + X_{i,t-1}\beta_1 + \beta_2 I + \epsilon_{i,t}) \quad (8)$$

where

- $G(.)$ is the logistic link function,
- $Ratio_{i,t}$ is the book debt ratio BDR for Hypotheses 1a, 2a and 3a; and is cash ratio $Cash$ for Hypotheses 1b, 2b and 3b.
- $X_{i,t-1}$ is a matrix of lagged control variables listed in Section 3.2.3, and
- I is the variable of interest. For Hypotheses 1a and 1b, I is the lag of one of the investment volatility variables $InvVol_DL_{t-5,t}$, $CapxVol_DL_{t-5,t}$, $AcqVol_DL_{t-5,t}$ and $RnDVol_DL_{t-5,t}$; for Hypotheses 2a and 2b, I is one of the the dummy investment spike variables $InvSpike_DL_t$, $CapxSpike_DL_t$, $AcqSpike_DL_t$ and $RnDSpike_DL_t$; for Hypotheses 3a and 3b, I is the first lag and the first lead of one of the investment spike variables.

Panel A of Table 8 shows estimation results of Equation (8) using panel GLM. The table reports our results remain qualitatively unchanged, except for Hypothesis 1a using capital expenditure volatility.

5.3 Robustness to alternative measures of debt, cash and investment volatility

In this section, we test if our results are robust to alternative measures of debt ratio, cash ratio and investment volatility.

To evaluate if our findings are robust to different measures of debt and cash ratios, we re-test our hypotheses using total liabilities debt ratio BDR_{lt} and cash scaled by net assets $Cash_{na}$ variables constructed in Section 3.2.1. Re-testing our three debt hypotheses using BDR_{lt} our main results remain qualitatively unchanged. Re-testing our three cash hypothesis $Cash_{na}$, our main results remain qualitatively unchanged except for Hypotheses 1b and 3b using capital expenditure volatility variable.

We also test if our results are robust to alternative measures of investment volatility and investment spike. We re-test Hypothesis 1 using volatility measures constructed following Kim and Sorensen (1986) in Section 3.2.2, and re-test Hypotheses 2 and 3 using spike measures constructed following DeAngelo et al. (2011) in Section 3.2.2. Panel B of Table 8 summarizes these results. The table shows our results remain qualitatively unchanged except for Hypothesis 1a using research and development volatility variable and Hypothesis 1b using capital expenditure volatility variable.

insert Table 8

In addition to our main investment spike variable that represents firms with large investments, we construct a two consecutive investment spikes variable that represents firms with two consecutive large investments. Panel C of Table 8 tests Hypotheses 2a and 2b using two consecutive spike variables. The table shows our main results remain qualitatively unchanged. The use of two investment spikes increases the magnitude of the coefficients associated with the spike variables in Hypothesis 2a testing.

5.4 Robustness – A re-examination of results related to Hypothesis 1

Relative to Hypothesis 1, we find that firms with high investment volatility hold more debt and less cash. We expected the opposite results – firms with uncertain investment should maintain financing capacity by maintaining relatively low levels of debt and high levels of cash. This firm strategy is both intuitive and prudent. Why do we find the opposite result?

To further examine this question, we perform two robustness checks.

First, we investigate if our result is driven by correlated investment shocks. DeAngelo and Roll (2015) show that over long periods of time firm capital structure exhibits both high and low debt

levels over protracted periods. DeAngelo and Roll (2015) attribute these high levels of debt to the need to fund investment. Consistent with the need to fund high levels of investment over an extended period is that investment volatility is also persistent over an extended period. Correlated investment shocks require firms to fund investment, which leads to plausibly lead to persistently high levels of debt and low levels of cash. Table 9 shows the correlation coefficients between the 5 year lag and the 5 year lead of investment volatility. Table 9 provides evidence that investment volatility is correlated. For example, the correlations coefficient between non-overlapping five year capital expenditure volatility is about 0.50.

insert Table 9

The above evidence suggests our findings may be related to correlated investment shocks. To test if our results are in-part due to correlated investment shock, we re-estimate where the variable of interest is future investment volatility and the dependent variable is either the book debt ratio of cash holdings. Table 10 shows the results.

Overall, the results do not support Hypothesis 1. We find that firms with high *future* investment volatility hold more debt and less cash – firms with *future* uncertain investment should maintain financing capacity by maintaining relatively low levels of debt and high levels of cash.

insert Table 10

6 Conclusion

The empirical literature on the relationship between firms’ financing options and the volatility of investment is narrow. Prior literature uses several investment definitions including capital expenditures, acquisitions, and the sum of capital expenditures and acquisitions. Specifically, research and development expenditures have not been tested as a measure of investment. We also consider the non-linear relationship between our proportional dependent variables and the explanatory variables and use both a cross-sectional and panel GLM with a logit link function. Thus, the paper contributes to the literature both in terms of the hypotheses tested and the range of our definition of investments.

The first hypothesis investigates if firms with higher investment volatility have lower debt levels and higher cash levels. Our results indicate that firms with high capital expenditure, acquisition and research and development volatility have higher debt levels. In addition, our evidence suggests that firms with high acquisitions volatility hold less cash. Our results are economically important - we predict the percentage change in debt and cash ratios by one standard deviation increase from the mean of all four investment volatility variables. For example, our evidence suggests a 16.1% increase in the debt ratio and a 12.4% decrease in the cash level as a result of one standard deviation increase from the mean of capital expenditure plus acquisition volatility. All in all, our evidence does not support the model of DeAngelo et al. (2011) prediction that firms with high investment volatility have low debt levels and high cash levels.

The second hypothesis tests the effect of large investments on firms' debt and cash levels. The intuition behind this hypothesis is that firms issue debt and use their cash holdings to fund large investments. We construct investment spike variables using our four measures of investment. Our results are economically important - we predict the percentage change in debt and cash ratios by the change in the investment spike dummy variable from zero to one. For example, our evidence suggests a 27.1% increase in the debt ratio and a 28.9% decrease in the cash level as a result of an investment spike (large investment). Our evidence supports the prediction of the DeAngelo et al. (2011) model and the findings of Elsas et al. (2014) that firms finance their large investments by issuing debt and using their cash holdings.

The third hypothesis investigates if firms rebuild their debt capacity and cash stocks following the large investments. To test this hypothesis we use the first lead of the investment spike variables. Our results are economically important - we predict the percentage change in debt and cash ratios by the change in the lead of investment spike dummy variable from zero to one. For example, our evidence suggests a 10.0% decrease in the debt ratio and a 19.0% increase in the cash levels, one year after the large investment. Our evidence supports the prediction from the DeAngelo et al. (2011) model and findings of Elsas et al. (2014) that firms decrease their debt level a year after the spike year. In addition, these firms rebuild their cash stock one year after funding large investments. Our findings that firms increase cash levels after funding investments is novel.

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6.1 Variable Definitions

Variable Definitions

This table provides variable definitions. Column (1) provides the variable name. Column (2) defines the variable. Column (3) shows the variable construction using system variable names. Column (4) provides the data source.

Variable	Definition	Construction	Data Sources
<i>BDR</i>	The ratio of short plus long-term debt to the sum of common shareholders' equity, the total long-term debt and the total short-term debt, (Rajan and Zingales, 1995).	$\frac{dltt+dlc}{dltt+dlc+ceq}$	Compustat
<i>BDR_lt</i>	The ratio of total liabilities over total assets, (Rajan and Zingales, 1995, ?).	$\frac{lt}{at}$	Compustat
<i>Cash</i>	The ratio of cash and short-term investments over total assets, (DeAngelo et al., 2011, Bates et al., 2009, Almeida et al., 2004, DeAngelo et al., 2006).	$\frac{che}{at}$	Compustat
<i>Cash_na</i>	The ratio of cash and short-term investments over net assets, (Opler et al., 1999).	$\frac{che}{at-che}$	Compustat
<i>CFV_{t-5,t}</i>	Natural logarithm of cash flow volatility.	See the (Keefe and Yaghoubi, 2016) paper	Compustat
<i>Tangibility</i>	The assets tangibility of a firm is the ratio of(ppent) net property, plant, and equipment(at) to total assets, (Lemmon et al., 2008) and (Frank and Goyal, 2009).	$\frac{ppenb}{at}$	Compustat
<i>IndustLev</i>	The median industry leverage of the sector a firm is classified by four-digit SIC code, (Frank and Goyal, 2009).	The median of $\frac{LT}{MVA}^{10}$	Compustat
<i>FirmSize</i>	The proxy for a firm size.	$ln(at)$	Compustat
<i>Profitability</i>	Shows the profitability of a firm.	$\frac{oibdp}{at}$	Compustat
<i>MarketToBook</i>	The proxy for a firm's growth opportunities and is the ratio of market value of asset to total assets.	$\frac{MVA}{at}$	Compustat
<i>Inflation</i>	The expected change in the consumer price index (CPI) over the coming year, (Frank and Goyal, 2009).	$\frac{Forecast12Month-BasePeriod}{BasePeriod}$	Livingston Survey

¹⁰Market value of assets (MVA) = debt in current liabilities (dlc) + long-term debt ($dltt$) + preferred stock ($pstkl$) + market value of equity ($csho*prcc-f$) - balance sheet deferred taxes and investment tax credit ($txditc$).

Variable	Definition	Construction	Data Sources
<i>RnD</i>	The ratio of R&D expenses to sales of a firm, (Frank and Goyal, 2009).	$\ln(1 + \frac{rnd}{revt})$	Compustat
<i>CreditRating</i>	Indicator variable: One if a firm is listed as investment grade by S&P, and zero otherwise.	=1 if <i>SPLTICRM</i> or <i>SPSDRM</i> < 13	Compustat
<i>FirmAge</i>	The number of years a firm has had data in Compustat.	fyear-First year in Compustat	Compustat
<i>Acq</i>	The ratio of acquisitions spending to the total assets, (Bates et al., 2009)	$\ln(1 + \frac{aqc}{at})$	Compustat
<i>Capx</i>	The ratio of capital expenditure to the total assets, (Bates et al., 2009)	$\ln(1 + \frac{capx}{at})$	Compustat
<i>InvVol_DL_{t-5,t}</i>	The capital expenditures plus acquisitions investment volatility measure estimated using (De Veirman and Levin, 2015) method	See Section 3.2.2	Compustat
<i>CapxVol_DL_{t-5,t}</i>	The capital expenditures investment volatility measure estimated using (De Veirman and Levin, 2015) method	See Section 3.2.2	Compustat
<i>AcqVol_DL_{t-5,t}</i>	The acquisitions investment volatility measure estimated using (De Veirman and Levin, 2015) method	See Section 3.2.2	Compustat
<i>RnDVol_DL_{t-5,t}</i>	The research and development investment volatility measure estimated using (De Veirman and Levin, 2015) method	See Section 3.2.2	Compustat
<i>InvSpike_DL_t</i>	An investment spike of <i>Capx</i> + <i>Acq</i>	See Section 3.2.2	Compustat
<i>CapxSpike_DL_t</i>	An investment spike of <i>Capx</i>	See Section 3.2.2	Compustat
<i>AcqSpike_DL_t</i>	An investment spike of <i>Acq</i>	See Section 3.2.2	Compustat
<i>RnDSpike_DL_t</i>	An investment spike of <i>RnD</i>	See Section 3.2.2	Compustat

Table 2: Summary Statistics

This table shows summary statistics of variables of the study for non-financial and non-utility US companies from 1974-2015. All variables are winsorized at 0.1% level in both tails of the distribution before the summary statistics are calculated. The table reports the number of observations, mean, 25th percentile, median, 75th percentile and standard deviation. Table 6.1 defines the variables.

Variable	N	mean	p25	p50	p75	max	min	sd
<i>BDR</i>	146668	0.291	0.0488	0.262	0.466	0.924	0	0.250
<i>Cash</i>	146668	0.181	0.0274	0.0876	0.251	0.923	0.000325	0.219
<i>Tangibility</i>	146455	0.276	0.103	0.222	0.390	0.894	0.00367	0.219
<i>FirmSize</i>	146668	4.693	3.192	4.541	6.074	10.04	0.472	2.086
<i>FirmAge</i>	146668	9.098	2	6	13	38	0	8.779
<i>Profitability</i>	146342	0.0637	0.0314	0.114	0.176	0.404	-0.993	0.218
<i>MarketToBook</i>	142098	1.674	0.725	1.082	1.861	11.10	0.279	1.740
<i>IndustLev</i>	146668	0.341	0.199	0.323	0.465	0.907	0.0104	0.175
<i>Inflation</i>	146668	0.0437	0.0238	0.0379	0.0560	0.121	0.0166	0.0246
<i>CreditRating</i>	146668	0.0683	0	0	0	1	0	0.252
<i>RnD</i>	144689	0.0910	0	0	0.0500	2.202	0	0.300
<i>Acq</i>	146661	0.0197	0	0	0.00184	0.319	-0.00264	0.0551
<i>Capx</i>	145209	0.0798	0.0275	0.0543	0.101	0.434	0	0.0806
<i>CFV_{t-5,t}</i>	95179	2.083	1.502	1.972	2.531	4.940	0.602	0.827
<i>InvVol_DL_{t-5,t}</i>	85987	1.945	1.385	1.895	2.471	3.636	0.430	0.753
<i>InvSpike_DL_t</i>	129818	0.152	0	0	0	1	0	0.359
<i>CapxVol_DL_{t-5,t}</i>	85987	1.423	0.917	1.329	1.846	3.114	0.282	0.659
<i>CapxSpike_DL_t</i>	129818	0.161	0	0	0	1	0	0.367
<i>AcqVol_DL_{t-5,t}</i>	85987	1.180	0.176	1.017	1.972	3.387	0.00438	1.014
<i>AcqSpike_DL_t</i>	129818	0.127	0	0	0	1	0	0.333
<i>RnDVol_DL_{t-5,t}</i>	85987	0.591	0.125	0.310	0.831	2.762	0.0414	0.662
<i>RnDSpike_DL_t</i>	129818	0.149	0	0	0	1	0	0.356

Table 3: Correlations

This table shows the pairwise correlation coefficients between investment, market to book and investment volatility variables.

Table 6.1 defines the variables. Reference numbers in columns and rows refer to the variables associated with the pairwise correlation coefficients.

Correlations Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) <i>Inv</i>	1													
(2) <i>Capx</i>	0.91	1												
(3) <i>Acq</i>	0.57	0.18	1											
(4) <i>RnD</i>	0.50	0.43	0.30	1										
(5) <i>MarketToBook</i>	-0.02	-0.02	-0.01	0.03	1									
(6) <i>InvVol_DL_{t-5,t}</i>	0.0	-0.04	0.07	-0.04	0.04	1								
(7) <i>InvSpike_DL_t</i>	0.06	0.00	0.14	-0.01	0.04	0.34	1							
(8) <i>CapxVol_DL_{t-5,t}</i>	-0.051	-0.02	-0.07	-0.09	0.08	0.53	0.21	1						
(9) <i>CapxSpike_DL_t</i>	0.02	0.02	0.00	-0.03	0.09	0.20	0.50	0.35	1					
(10) <i>AcqVol_DL_{t-5,t}</i>	0.04	-0.01	0.12	0.02	-0.02	0.64	0.20	-0.15	-0.03	1				
(11) <i>AcqSpike_DL_t</i>	0.07	-0.01	0.19	0.01	-0.02	0.23	0.55	-0.06	0.03	0.37	1			
(12) <i>RnDVol_DL_{t-5,t}</i>	-0.05	-0.05	-0.02	0.06	0.342	-0.01	-0.01	0.00	0.01	-0.02	-0.02	1		
(13) <i>RnDSpike_DL_t</i>	-0.02	-0.03	0.00	0.03	0.22	0.00	0.07	0.02	0.08	-0.02	0.04	0.461	1	
(14) <i>CFV_{t-5,t}</i>	-0.09	-0.08	-0.06	-0.05	0.43	0.04	0.03	0.41	0.2	0.09	-0.13	0.06	0.55	1

Table 4: Testing Hypotheses 1a and 1b

This table shows estimation results of Equation (7) using GLM with a logit link function, where the short and long-term book debt ratio (BDR) and the ratio of cash over total assets ($Cash$) are the dependent variables. All the RHS variables are in information set and are used in the lagged form. Columns (1) to (4) show the estimation results using BDR and Columns (5) to (8) show the estimation results using $Cash$. The variables of interest are the investment volatility that is measured using several investment definitions including the sum of capital expenditures and acquisitions ($Inv = Capx + Acq$), capital expenditures ($Capx$), acquisitions (Acq) and research and development expenditures ($R\&D$). Section 3.2 defines the variables. Clustered standard errors by firm are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$InvVol_DL_{t-6,t-1}$	0.309*** (0.0162)				-0.186*** (0.0162)			
$CapxVol_DL_{t-6,t-1}$		0.187*** (0.0172)				0.0381** (0.0176)		
$AcqVol_DL_{t-6,t-1}$			0.210*** (0.0134)				-0.170*** (0.0134)	
$RnDVVol_DL_{t-6,t-1}$				0.0771*** (0.0287)				-0.00507 (0.0232)
$CFV_{t-5,t}$	-0.252*** (0.0184)	-0.284*** (0.0142)	-0.227*** (0.0184)	-0.265*** (0.0190)	0.582*** (0.0175)	0.607*** (0.0135)	0.567*** (0.0174)	0.578*** (0.0159)
Acq_{t-1}	0.704*** (0.0889)	2.629*** (0.0994)	0.857*** (0.0879)	2.540*** (0.137)	-2.164*** (0.114)	-3.341*** (0.123)	-1.955*** (0.112)	-3.145*** (0.141)
$Capx_{t-1}$	-0.914*** (0.243)	-0.361** (0.158)	-0.0322 (0.249)	0.0435 (0.248)	-0.598** (0.274)	-1.501*** (0.157)	-1.194*** (0.279)	-1.135*** (0.215)
RnD_{t-1}	-1.144*** (0.300)	-0.435*** (0.0720)	-1.139*** (0.297)	-0.397*** (0.0776)	1.125*** (0.117)	0.684*** (0.0353)	1.116*** (0.117)	0.660*** (0.0361)
$Tangibility_{t-1}$	0.889*** (0.0769)	0.665*** (0.0603)	1.029*** (0.0772)	1.073*** (0.107)	-1.692*** (0.0939)	-1.554*** (0.0637)	-1.792*** (0.0934)	-2.039*** (0.103)
$FirmSize_{t-1}$	0.0852*** (0.00909)	0.0871*** (0.00688)	0.0732*** (0.00913)	0.0591*** (0.00893)	0.0344*** (0.00894)	0.0317*** (0.00702)	0.0389*** (0.00884)	0.0611*** (0.00808)
$FirmAge_{t-1}$	0.000543 (0.00176)	-0.00470*** (0.00152)	-0.000556 (0.00176)	0.00117 (0.00209)	-0.00788*** (0.00173)	-0.00282*** (0.00143)	-0.00753*** (0.00172)	-0.00811*** (0.00168)
$Profitability_{t-1}$	-1.828*** (0.110)	-1.534*** (0.0663)	-1.866*** (0.111)	-1.346*** (0.0821)	0.396*** (0.0825)	0.324*** (0.0476)	0.422*** (0.0827)	0.300*** (0.0518)
$MarketToBook_{t-1}$	-0.0712*** (0.0127)	-0.0770*** (0.00822)	-0.0689*** (0.0127)	-0.0591*** (0.00902)	0.0515*** (0.00721)	0.0450*** (0.00519)	0.0492*** (0.00722)	0.0399*** (0.00525)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			BDR			Cash		
<i>IndustLev_{t-1}</i>	1.691*** (0.0902)	1.706*** (0.0679)	1.685*** (0.0904)	1.539*** (0.100)	-1.492*** (0.0996)	-1.408*** (0.0779)	-1.489*** (0.0989)	-1.489*** (0.106)
<i>Inflation_{t-1}</i>	0.819 (1.402)	-1.374 (1.121)	0.200 (1.398)	1.939 (1.660)	-10.57*** (1.425)	-10.13*** (1.138)	-11.19*** (1.433)	-13.61*** (1.455)
<i>CreditRating_{t-1}</i>	0.133*** (0.0392)	0.175*** (0.0353)	0.119*** (0.0392)	0.268*** (0.0445)	-0.288*** (0.0416)	-0.315*** (0.0371)	-0.278*** (0.0413)	-0.405*** (0.0441)
Constant	-1.937*** (0.116)	-1.481*** (0.0881)	-1.671*** (0.112)	-1.547*** (0.119)	-1.588*** (0.104)	-1.997*** (0.0807)	-1.618*** (0.102)	-1.715*** (0.0956)
Obs	43,973	80,293	43,973	45,873	43,973	80,293	43,973	45,873
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: Hypotheses 2a and 2b

This table shows estimation results of Equation (7) using GLM with a logit link function, where the short and long-term book debt ratio (*BDR*) and the ratio of cash over total assets (*Cash*) are the dependent variables. All the RHS variables are in information set and are used in the lagged form. Columns (1) to (4) show the estimation results using *BDR* and Columns (5) to (8) show the estimation results using *Cash*. The variables of interest are the investment spikes measured using several investment definitions including the sum of capital expenditures and acquisitions (*Capex + Acq*), capital expenditures (*Capex*), acquisitions (*Acq*) and research and development expenditures (*R&D*). Section 3.2 defines the variables. Clustered standard errors by firm are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	BDR				Cash			
<i>InvSpike_DL_t</i>	0.352*** (0.0137)				-0.370*** (0.0154)			
<i>CapexSpike_DL_t</i>		0.117*** (0.0112)			-0.150*** (0.0119)			
<i>AcqSpike_DL_t</i>			0.248*** (0.0132)				-0.318*** (0.0140)	
<i>RnDSpike_DL_t</i>				0.0368** (0.0169)				-0.0648*** (0.0139)
<i>CFV_{t-5,t}</i>	-0.247*** (0.0176)	-0.273*** (0.0133)	-0.236*** (0.0176)	-0.260*** (0.0176)	0.581*** (0.0167)	0.618*** (0.0125)	0.574*** (0.0166)	0.586*** (0.0143)
<i>Acq_{t-1}</i>	2.524*** (0.103)	2.701*** (0.0943)	2.510*** (0.104)	2.639*** (0.132)	-3.291*** (0.125)	-3.331*** (0.117)	-3.307*** (0.125)	-3.153*** (0.136)
<i>Capex_{t-1}</i>	-0.110 (0.231)	0.511*** (0.146)	-0.0997 (0.232)	0.272 (0.228)	-0.843*** (0.250)	-1.197*** (0.144)	-0.868*** (0.251)	-0.915*** (0.201)
<i>RnD_{t-1}</i>	-1.144*** (0.261)	-0.453*** (0.0645)	-1.155*** (0.262)	-0.367*** (0.0665)	1.047*** (0.0978)	0.668*** (0.0316)	1.046*** (0.0975)	0.645*** (0.0315)
<i>Tangibility_{t-1}</i>	0.991*** (0.0741)	0.830*** (0.0535)	1.034*** (0.0741)	1.040*** (0.0997)	-1.751*** (0.0888)	-1.461*** (0.0585)	-1.798*** (0.0886)	-2.060*** (0.0939)
<i>FirmSize_{t-1}</i>	0.0682*** (0.00878)	0.0699*** (0.00644)	0.0634*** (0.00876)	0.0501*** (0.00849)	0.0390*** (0.00850)	0.0293*** (0.00656)	0.0437*** (0.00846)	0.0636*** (0.00772)
<i>FirmAge_{t-1}</i>	-0.00303* (0.00169)	-0.00626*** (0.00144)	-0.00293* (0.00169)	0.000117 (0.00198)	-0.00612*** (0.00168)	-0.00261* (0.00136)	-0.00628*** (0.00168)	-0.00795*** (0.00160)
<i>Profitability_{t-1}</i>	-1.796*** (0.0981)	-1.514*** (0.0603)	-1.758*** (0.0979)	-1.361*** (0.0745)	0.416*** (0.0729)	0.348*** (0.0437)	0.397*** (0.0726)	0.315*** (0.0479)
<i>MarketToBook_{t-1}</i>	-0.0793*** (0.0114)	-0.0733*** (0.00738)	-0.0740*** (0.0114)	-0.0554*** (0.00819)	0.0571*** (0.00667)	0.0479*** (0.00475)	0.0529*** (0.00660)	0.0396*** (0.00484)
<i>IndustLev_{t-1}</i>	1.681*** (0.0114)	1.713*** (0.00738)	1.685*** (0.0114)	1.504*** (0.00819)	-1.507*** (0.00667)	-1.446*** (0.00475)	-1.513*** (0.00660)	-1.509*** (0.00484)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	BDR			Cash				
<i>Inflation_{t-1}</i>	(0.0864) -4.193*** (1.154)	(0.0641) -3.174*** (0.935)	(0.0867) -4.614*** (1.157)	(0.0938) 0.220 (1.396)	(0.0938) -5.679*** (1.149)	(0.0730) -6.969*** (0.919)	(0.0937) -5.424*** (1.152)	(0.0978) -10.19*** (1.172)
<i>CreditRating_{t-1}</i>	0.119*** (0.0388)	0.169*** (0.0347)	0.118*** (0.0388)	0.288*** (0.0438)	-0.283*** (0.0408)	-0.333*** (0.0363)	-0.283*** (0.0409)	-0.420*** (0.0433)
Constant	-1.153*** (0.0991)	-1.208*** (0.0798)	-1.137*** (0.0992)	-1.381*** (0.106)	-2.025*** (0.0904)	-2.044*** (0.0734)	-2.025*** (0.0902)	-1.815*** (0.0864)
Obs	48,284	88,951	48,284	50,546	48,284	88,951	48,284	50,546
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Testing Hypotheses 3a and 3b

This table shows estimation results of Equation (7) using GLM with a logit link function, where the short and long-term book debt ratio (BDR) and the ratio of cash over total assets ($Cash$) are the dependent variables. All the RHS variables are in information set and are used in the lagged form. Columns (1) to (4) show the estimation results using BDR and Columns (5) to (8) show the estimation results using $Cash$. The variables of interest are the lag and leads of investment spikes measured using several investment definitions including the sum of capital expenditures and acquisitions ($Capx + Acq$), capital expenditures ($Capx$), acquisitions (Acq) and research and development expenditures ($R\&D$). Section 3.2 defines the variables. Clustered standard errors by firm are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, **, and *, respectively.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			BDR				Cash	
$InvSpike_DL_{t-1}$	0.0379* (0.0194)				0.0776*** (0.0220)			
$InvSpike_DL_t$	0.355*** (0.0143)				-0.358*** (0.0161)			
$InvSpike_DL_{t+1}$	-0.164*** (0.0140)				0.214*** (0.0143)			
$CapxSpike_DL_{t-1}$		0.117*** (0.0137)				-0.0609*** (0.0138)		
$CapxSpike_DL_t$		0.123*** (0.0110)				-0.153*** (0.0118)		
$CapxSpike_DL_{t+1}$		-0.121*** (0.0115)				0.122*** (0.0113)		
$AcqSpike_DL_{t-1}$			-0.135*** (0.0175)				0.0819*** (0.0195)	
$AcqSpike_DL_t$			0.249*** (0.0136)				-0.310*** (0.0144)	
$AcqSpike_DL_{t+1}$			-0.179*** (0.0129)				0.195*** (0.0134)	
$RnDSpike_DL_{t-1}$				0.0160 (0.0145)				-0.0539*** (0.0123)
$RnDSpike_DL_t$				0.0427*** (0.0139)				-0.0661*** (0.0121)
$RnDSpike_DL_{t+1}$				-0.110*** (0.0147)				0.0543*** (0.0127)
$CFV_{t-5,t}$	-0.258*** (0.0179)	-0.292*** (0.0135)	-0.252*** (0.0178)	-0.282*** (0.0178)	0.587*** (0.0169)	0.625*** (0.0128)	0.585*** (0.0168)	0.595*** (0.0145)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	BDR			Cash				
Acq_{t-1}	2.332*** (0.148)	2.589*** (0.0946)	3.180*** (0.145)	2.548*** (0.131)	-3.690*** (0.178)	-3.283*** (0.119)	-3.795*** (0.181)	-3.068*** (0.137)
$Capx_{t-1}$	-0.275 (0.250)	0.0666 (0.179)	-0.182 (0.233)	0.224 (0.231)	-1.034*** (0.272)	-0.937*** (0.172)	-0.813*** (0.254)	-0.791*** (0.202)
RnD_{t-1}	-1.345*** (0.298)	-0.489*** (0.0690)	-1.348*** (0.300)	-0.400*** (0.0714)	1.063*** (0.106)	0.673*** (0.0326)	1.060*** (0.105)	0.656*** (0.0326)
$Tangibility_{t-1}$	1.019*** (0.0757)	0.898*** (0.0553)	1.034*** (0.0750)	1.037*** (0.101)	-1.761*** (0.0902)	-1.525*** (0.0603)	-1.798*** (0.0897)	-2.087*** (0.0962)
$FirmSize_{t-1}$	0.0668*** (0.00884)	0.0681*** (0.00647)	0.0632*** (0.00879)	0.0462*** (0.00851)	0.0425*** (0.00857)	0.0306*** (0.00664)	0.0436*** (0.00854)	0.0636*** (0.00785)
$FirmAge_{t-1}$	-0.00297* (0.00169)	-0.00618*** (0.00144)	-0.00288* (0.00169)	0.000178 (0.00198)	-0.00617*** (0.00170)	-0.00247* (0.00137)	-0.00613*** (0.00169)	-0.00784*** (0.00162)
$Profitability_{t-1}$	-1.704*** (0.0993)	-1.458*** (0.0614)	-1.661*** (0.0990)	-1.323*** (0.0763)	0.362*** (0.0752)	0.321*** (0.0448)	0.343*** (0.0748)	0.306*** (0.0491)
$MarketToBook_{t-1}$	-0.0776*** (0.0116)	-0.0747*** (0.00758)	-0.0716*** (0.0115)	-0.0350*** (0.00841)	0.0526*** (0.00682)	0.0472*** (0.00488)	0.0492*** (0.00672)	0.0390*** (0.00495)
$IndustLev_{t-1}$	1.637*** (0.0879)	1.691*** (0.0646)	1.641*** (0.0880)	1.454*** (0.0945)	-1.497*** (0.0954)	-1.424*** (0.0738)	-1.495*** (0.0953)	-1.477*** (0.0987)
$Inflation_{t-1}$	-3.356*** (1.161)	-2.003** (0.946)	-3.472*** (1.164)	1.204 (1.400)	-5.782*** (1.164)	-7.290*** (0.930)	-5.698*** (1.168)	-10.50*** (1.183)
$CreditRating_{t-1}$	0.123*** (0.0385)	0.179*** (0.0344)	0.123*** (0.0384)	0.300*** (0.0434)	-0.277*** (0.0410)	-0.332*** (0.0365)	-0.277*** (0.0410)	-0.421*** (0.0435)
Constant	-1.156*** (0.100)	-1.242*** (0.0803)	-1.135*** (0.100)	-1.363*** (0.107)	-2.073*** (0.0910)	-2.056*** (0.0738)	-2.077*** (0.0910)	-1.828*** (0.0878)
Observations	47,523	87,373	47,523	49,609	47,523	87,373	47,523	49,609
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: Economic importance

This table reports the predicted percentage change in *BDR* and *Cash* of all three hypotheses of this study using GLM . For Hypotheses 1a and 1b the predicted percentage changes are the result of one standard deviation increase from the mean of the investment volatility variables, for Hypotheses 2a, 2b, 3a and 3b the predicted percentage changes are the result of the change in the dummy spike variables from zero to one, where other control variables are evaluated at their means.

$\Delta BDR\%$				$\Delta Cash\%$			
<i>Inv</i>	<i>Capx</i>	<i>Acq</i>	<i>RnD</i>	<i>Inv</i>	<i>Capx</i>	<i>Acq</i>	<i>RnD</i>
Hypothesis 1a				Hypothesis 1b			
<i>DLVol_{t-6,t-1}</i>				<i>DLVol_{t-6,t-1}</i>			
16.1%	9.2%	13.3%	4.3%	-12.4%	1.6%	-12.7%	-0.6%
Hypothesis 2a				Hypothesis 2b			
<i>Spike_t</i>				<i>Spike_t</i>			
27.1%	8.9%	18.5%	3.0%	-28.9%	-13.3%	-25.5%	-5.0%
Hypothesis 3a				Hypothesis 3b			
<i>Spike_{t+1}</i>				<i>Spike_{t+1}</i>			
-10.0%	-8.5%	-10.7%	-9.2%	19.0%	11.5%	14.8%	4.9%

Table 8: Robustness

This table summarizes the robustness testing of Section 5. Panel A tests all three hypotheses using panel GLM as an alternative estimation method. Panel B tests Hypothesis 1 using alternative measures of investment volatility and Hypotheses 2 and 3 using alternative measures of investment spike. Panel C tests Hypotheses 2a and 2b using two consecutive spike variables that represent firms with two consecutive spikes (large investments).

Panel A: Robustness to alternative estimation method - Panel GLM						
Hyp 1	$InvVol_DL_{t-6,t-1}$	$CapxVol_DL_{t-6,t-1}$	$AcqVol_DL_{t-6,t-1}$	$RnDVol_DL_{t-6,t-1}$		
<i>BDR</i>	0.222***	0.133***	0.143***	0.137***		
<i>Cash</i>	-0.195***	-0.0160	-0.164***	-0.0097		
Hyp 2	$InvSpike_DL_t$	$CapxSpike_DL_t$	$AcqSpike_DL_t$	$RnDSpike_DL_t$		
<i>BDR</i>	0.291***	0.0776***	0.214***	0.0258**		
<i>Cash</i>	-0.374***	-0.159***	-0.307***	-0.0459***		
Hyp 3	$InvSpike_DL_{t+1}$	$CapxSpike_DL_{t+1}$	$AcqSpike_DL_{t+1}$	$RnDSpike_DL_{t+1}$		
<i>BDR</i>	-0.196***	-0.132***	-0.196***	0.120***		
<i>Cash</i>	0.216***	0.118***	0.213***	0.0665***		
Panel B: Robustness to alternative measures of investment volatility and investment spike						
Hyp 1	$InvVol_KS_{t-6,t-1}$	$CapxVol_KS_{t-6,t-1}$	$AcqVol_KS_{t-6,t-1}$	$RnDVol_KS_{t-6,t-1}$		
<i>BDR</i>	0.227***	0.135***	0.132***	-0.0547**		
<i>Cash</i>	-0.129***	-0.0315***	-0.0944***	0.00190		
Hyp 2	$InvSpike_DDW_t$	$CapxSpike_DDW_t$	$AcqSpike_DDW_t$	$RnDSpike_DDW_t$		
<i>BDR</i>	0.628***	0.206***	0.562***	-0.0937		
<i>Cash</i>	-0.631***	-0.246***	-0.626***	-0.156***		
Hyp 3	$InvSpike_DDW_{t+1}$	$CapxSpike_DDW_{t+1}$	$AcqSpike_DDW_{t+1}$	$RnDSpike_DDW_{t+1}$		
<i>BDR</i>	-0.138***	-0.0883***	-0.121***	-0.178***		
<i>Cash</i>	0.300***	0.245***	0.224***	0.0574*		
Panel C: Robustness to two consecutive spikes variable (Hypotheses 2a and 2b)						
Hyp 2	$ConsInvSpike_DL$	$ConsCapxSpike_DL$	$ConsAcqSpike_DL$	$ConsRnDSpike_DL$		
<i>BDR</i>	0.471***	0.238***	0.287***	0.0115		
<i>Cash</i>	-0.349***	-0.212***	-0.332***	-0.0735***		

Table 9: Investment Volatility Autocorrelations

This table shows the pairwise correlation coefficients between 5 years lag and 5 years lead of *Capx*, *Acq* and *RnD* investment volatility. Table 6.1 defines the variables. Reference numbers in columns and rows refer to the variables associated with the pairwise correlation coefficients.

Correlations									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) <i>CapxVol_DL_{t-10,t-5}</i>	1								
(2) <i>CapxVol_DL_{t-5,t}</i>	0.59	1							
(3) <i>CapxVol_DL_{t,t+5}</i>	0.51	0.60	1						
(4) <i>AcqVol_DL_{t-10,t-5}</i>	-0.14	-0.19	-0.18	1					
(5) <i>AcqVol_DL_{t-5,t}</i>	-0.12	-0.16	-0.20	0.54	1				
(6) <i>AcqVol_DL_{t,t+5}</i>	-0.09	-0.12	-0.15	0.45	0.52	1			
(7) <i>RnDVol_DL_{t-10,t-5}</i>	0.12	0.03	-0.03	-0.03	-0.02	0.02	1		
(8) <i>RnDVol_DL_{t-5,t}</i>	0.07	0.03	-0.05	-0.05	0.00	0.02	0.83	1	
(9) <i>RnDVol_DL_{t,t+5}</i>	0.05	0.00	-0.02	-0.05	-0.04	0.02	0.75	0.82	1

Table 10: Testing Hypothesis 1a and 1b using future investment volatility
This table shows estimation results of Equations (7) using GLM with a logit link function and Equation (8) using panel GLM, where the short and long-term book debt ratio (*BDR*) and the ratio of cash over total assets (*Cash*) are the dependent variables. Columns (1) to (4) show the estimation results using the *BDR* and Columns (5) to (8) show the estimation results using *Cash*. The variables of interest are the investment volatility measured using several investment definitions including the sum of capital expenditures and acquisitions ($Capx + Acq$), capital expenditures ($Capx$), acquisitions (Acq) and research and development expenditures ($R\&D$). Section 3.2 defines the variables. Clustered standard errors by firms are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GLM								
<i>InvVol_DL_{t,t+5}</i>	0.0260 (0.0185)				0.0299 (0.0216)			
<i>InvCapx_DL_{t,t+5}</i>		0.0139 (0.0211)				0.107*** (0.0220)		
<i>InvAqc_DL_{t,t+5}</i>			0.0206 (0.0149)				0.0155 (0.0171)	
<i>InvRnD_DL_{t,t+5}</i>				-0.0433 (0.0343)				0.0713** (0.0302)
Panel GLM								
<i>InvVol_DL_{t,t+5}</i>	-0.100*** (0.0143)				0.0919*** (0.0150)			
<i>InvCapx_DL_{t,t+5}</i>		-0.0297* (0.0163)				0.0497*** (0.0169)		
<i>InvAqc_DL_{t,t+5}</i>			-0.0813*** (0.0121)				0.0872*** (0.0128)	
<i>InvRnD_DL_{t,t+5}</i>				-0.115*** (0.0287)				0.135*** (0.0232)