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 realizations of future investment volatility hold relatively low levels of debt and high levels of cash, ii) firms fund large investment by increasing (issuing) debt and/or decreasing (using) cash, iii) immediately after funding large investments firms reduce debt levels and increase cash holdings. Overall, our results are consistent with the DeAngelo, DeAngelo and Whited (2011) model. In particular, firms with high realizations of future investment volatility keep their debt levels low and cash levels high to finance uncertain future investments.

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 other studies examined the relationship between large investments (investment spikes) and capital structure (Denis and McKeon, 2012, Dudley, 2012, Elsas, Flannery and Garfinkel, 2014); the relationship between debt priority structure and growth opportunities (Hackbarth and C. Mauer, 2012); and the relationship between acquisition valuation and capital structure considerations (Ang, Daher and Ismail, 2019). 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. Also, 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 in explaining 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.\footnote{Using 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.} In a related study, Lambrinoudakis, Skiadopoulos and Gkionis (2019) test the effects of firms’ investment shocks on their leverage in the context of financial flexibility. They use market prices of equity options to measure small and large future investment shocks. Unlike Lambrinoudakis et al. (2019), we calculate firm-level investment volatility and spike variables using firms’ capital expenditures and acquisition costs. In addition, we explore the effect of future investment volatility on firms’ cash holdings.

To create our investment measure, we follow DeAngelo et al. (2011) and define investment as capital expenditures plus acquisitions. To measure investment volatility, we estimate investment volatility using the method of De Veirman and Levin (2015). This method constructs investment volatility using the difference between predicted and actual annual investment growth. For our main measure, we take the natural logarithm of the five year rolling average of this measure. Because we test the effect of the future investment uncertainty on firms’ current debt and cash levels, our
variable of interest is the 5-year lead of the investment volatility measure. In robustness tests, we use the method of Kim and Sorensen (1986) and estimate the rolling five year standard deviation of scaled investment. In addition, we use a 3 and 4 year lead of the investment volatility measure to test the relationship between current debt and cash policy and future investment volatility.

Closely related to investment volatility are investment spikes (large investments). Intuitively, firms with high investment volatility exhibit investment that diverges markedly from predicted investment. To construct an investment spike 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 annual investment volatility is in the top tercile. Because our investment spike variable is estimated from realizations used to estimate conditional volatility, our investment 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.3

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 realizations of future investment volatility hold relatively low levels of debt and high levels of cash, ii) firms fund large investment by increasing debt and/or decreasing cash, iii) immediately after funding large investments firms reduce debt levels and increase cash holdings. Our results are consistent with the model of DeAngelo et al. (2011).4 Many of these findings have not been empirically tested in the literature.

The dependent variable is either the book debt ratio or cash to total assets ratio. Because 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 as proposed by Kieschnick and McCullough (2003) and used by Keefe and Yaghoubi (2016). To control for time invariant firm heterogeneity, we

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3DeAngelo et al. (2011) define investment spikes as investments that are two standard deviations from the two digit SIC code average. We test using their spike variable in robustness section.

4DeAngelo 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.
follow Lemmon, Roberts and Zender (2008) and Flannery and Rangan (2006) and estimate panel GLM.

The first hypothesis is about the relationship between a firm’s future investment volatility and current debt and cash levels. Our evidence indicates that firms with high realizations of future investment volatility hold low levels of debt and high levels of cash. One standard deviation increase from the mean of the 5-year lead of the investment volatility variable, leads to a 4.5% decrease in the debt ratio and a 4.2% increase in the cash level. All in all, our evidence supports the DeAngelo et al. (2011) model prediction and Lambrinoudakis et al. (2019) findings that firms with high expected productivity shocks (and hence high investment volatility), keep debt levels low and cash levels high. To our knowledge, we are the first to empirically test the relationship between financing (both debt and cash holdings) and investment volatility as measured using capital expenditures plus acquisitions.

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 results are statistically significant and economically important - our evidence suggests a 19.1% increase in the debt ratio and a 25.4% 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 investments. Unlike the first hypothesis, which has not been previously tested, our contribution relative to the second hypothesis is the construction of our investment spike variable, which shows the tight connection between firm-level investment volatility and investment spikes.

The third hypothesis explores 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 aggressively 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 12.6% decrease in the
debt ratio and a 19.3% 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.

Overall, our paper contributes to the literature by making both novel and confirmatory findings.
We structure our hypotheses to include confirmatory hypotheses for two reasons. First, we use
different methods to construct investment volatility and the related investment spike. Second, and
more importantly, the hypotheses are inter-related and communicate how firms plan for and execute
against uncertain future investments. Growth options are ephemeral and the hypotheses structure
provides guideline for how a firm finances future growth options.

We also evaluate if our findings are robust to different measures of the 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 (staged large investments), an investment volatility measure constructed following
Kim and Sorensen (1986), 3 and 4-years lead of the investment volatility and an investment spike
variable constructed following DeAngelo et al. (2011). All in all, our main result remain unchanged.

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

Jensen and Meckling (1976), Myers (1977) advance in the presence of risky debt and the managerial
incentive to maximize shareholders’ value and not the total firm’s value, managers tend to under-
invest or over-invest in future growth opportunities. Due to this agency cost of debt, Billett, King
and Mauer (2007) argue it is in the firm’s best interest to alleviate the potential conflict between
the shareholders and bondholders over the exercise of future growth options by avoiding the conflict by holding less debt.

In addition, 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 future 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 implies firms with high investment shock volatility hold less debt. Intuitively, a firm with high investment shocks maintains a low debt ratio to preserve debt capacity in order to fund uncertain investments. Although we cannot observe the 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 future investment volatility maintain lower debt ratios than would be optimal under a static trade-off model; which implies:

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

Opler, Pinkowitz, Stulz and Williamson (1999) state that firms set cash levels so that the marginal benefits of holding cash equal the marginal cost. One of the benefits of cash holdings is having the option to finance investment opportunities using cash when other sources of financing are costly. Likewise, 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:

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5 Examples of the drawbacks of holding cash are incremental taxes on interest income and lower rates of return.
**Hypothesis 1b.** *Firms with high future investment volatility hold more cash, ceteris 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 paper, 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. This literature implies:

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

The model of DeAngelo et al. (2011) finds 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 find 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, ceteris 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, ceteris 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, ceteris paribus.*
These hypotheses test the relationship between the volatility of investments and large realization of investment on debt and cash levels. We follow DeAngelo et al. (2011) and employ the sum of capital expenditures and acquisitions (\(Capx + Acq\)) as our investment measure. This paper contributes to the literature both in terms of the hypotheses tested and the range of our methods used to develop of investment volatility measures. To our knowledge, Hypotheses 1a, 1b and 3b have not been tested before. Hypotheses 2a, 2b and 3a have been tested by DeAngelo et al. (2011) using Simulated Method of Moments (SMM). Although some of these hypotheses have been tested in prior literature (using different methods), for exposition purposes we include them to stress the inter-connected nature of the related financing policies. To test our hypotheses we use firm-year observations and the Panel GLM (Generalized Linear Model) with a logit link function, as well as firm-level measures of investment volatility and investment spike.

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

\textsuperscript{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.

\begin{equation}
BDR = \frac{dltt + dlc}{ceq + dltt + dlc}.
\end{equation}

\textsuperscript{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.

\begin{equation}
BDR_{lt} = \frac{lt}{at}.
\end{equation}

Note that in $BDR$ both the numerator and the denominator exclude the non-financial liabilities,
and in $BDR_{lt}$ non-financial liabilities are 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.

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

\[
Cash_{at} = \frac{che}{at}. \tag{3}
\]

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).

\[
Cash = \frac{che}{at - che}. \tag{4}
\]

3.2.2 Variables of Interest

To measure investment 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, \(Inv = Capx + Acq\).\(^7\) We follow DeAngelo et al. (2011) and scale our investment measure 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

\[
\omega_{i,t} = \alpha_i + Year\beta + \epsilon_{i,t} \tag{5}
\]

where \(\omega_{i,t}\) represents the first difference of the 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

\[
\hat{\sigma}_{i,t} = \sqrt{\frac{\pi}{2}} * |\hat{\epsilon}_{i,t}|, \tag{6}
\]

\(^7\)Note that Compustat item capital expenditure \(Capx\) excludes the acquisitions \(Acq\).
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 $t-5,t$. To closely match the normal distribution of the investment volatility measures, we take the natural logarithm of the investment volatility measure. $InvVol_{DL,t-5,t} = \ln(\frac{1}{5}\sum_{t-5}^{t}\hat{\sigma}_{i,t})$. Hypotheses 1a and 1b test the effect of the uncertain future investments volatility on firms’ debt and cash levels. Therefore, we use a 5-years lead of the constructed investment volatility measure to represent the volatility of future investments. To denote the 5-year lead, we use the subscript $t,t+5$. In our main results, we report results using $InvVol_{DL,t,t+5}$.

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. $InvSpike_{DL,t}$ is set to one when actual investment growth is higher than predicted from Equation (5) and investment volatility from Equation (6) is in the highest tercile. This method of investment spike construction illustrates the close relationship between an investment spikes 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 construct $InvVol_{KS,t-5,t}$ as the ratio of the five years rolling standard deviation of investment to the five years rolling average of total assets; where, $InvVol_{KS,t-5,t}$ is the investment volatility measure using the Kim and Sorensen (1986) estimation method. Once again, we take the natural logarithm of the volatility measures.\footnote{For 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.}
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 a \( DDW \) spike variable. We first compute the mean and standard deviation by forty one industries by year. 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.

### 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 \((1+ \text{research and development expenses divided by revenue})\).

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 that equal 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 and investment spike measures.

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

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

To mitigate possible omitted variable bias we use all of the control variables in all tests.

### 3.3 Univariate Statistics

Table 1 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 1 shows that on average the cash holding level of the sample firms is about 18.1% 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 1](image)

Table 2 reports the correlation coefficients between our investment volatility, investment spike, $MarketToBook$, investment measure and the components of investment measure $Capx$ and $Acq$. The investment measure is highly and positively correlated with its components $Capx$ and $Acq$, with a correlation coefficient of 0.91 between $Inv$ and $Capx$. 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. Also, the investment volatility and the investment spike variables are positively correlated with a correlation coefficient of 0.34.
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 a GLM (Generalized Linear Model). In addition, 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. We use the GLM panel data model as follows:

\[ E(\text{Ratio}_{i,t}|X_{i,t-1}, I) = G(\alpha_i + X_{i,t-1}\beta_1 + \beta_2 I + \epsilon_{i,t}) \tag{7} \]

where

- \( G(.) \) is the logistic link function,
- \( \text{Ratio}_{i,t} \) 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 the investment volatility variable \( InvVol_{DL,t,t+5} \); for Hypotheses 2a and 2b, \( I \) is the dummy spike variable \( InvSpike_{DL,t} \); for Hypotheses 3a and 3b, \( I \) is the first lag and the first lead of the dummy spike variable \( InvSpike_{DL,t} \).

Table 3 reports estimation results of testing Hypotheses 1a through 3b. In the table, Columns (1), (3) and (5) report the estimation results of Equation (7) using book debt ratio \( BDR \) as the dependent variable and Columns (2), (4) and (6) report the estimation results of Equation (7) using the ratio of cash over total assets \( Cash \) as the dependent variable. Columns (1) & (2) show the...
estimation results of testing Hypotheses 1a and 1b where the variable of interest is $InvVol_{DL_{t,t+5}}$. Columns (3) & (4) show the estimation results of testing Hypotheses 2a and 2b where the variable of interest is $InvSpike_{DL_t}$. Columns (5) & (6) show the estimation results of testing Hypotheses 3a and 3b where the variable of interest is $InvSpike_{DL_{t+1}}$.

In addition, Table 3 reports 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.

Column (1) of Table 3 reports estimation results that test Hypothesis 1a. Hypothesis 1a posits that future investment volatility implies low levels of debt. The intuition behind this hypothesis is that firms with high future investment volatility keep debt levels low to maintain debt capacity to fund uncertain future investments.

Column (1) of Table 3 shows the coefficients associated with the investment volatility variable are negative and statistically significant at less than the 1% level, which is consistent with the predicted relationship. Our evidence suggests that firms with high future investment volatility keep debt levels low. All in all, our evidence supports the DeAngelo et al. (2011) model prediction that firms with productivity shocks that drive high future investment volatility keep current debt levels low.

Column (2) of Table 3 report estimation results test Hypothesis 1b. Hypothesis 1b advances that future investment volatility motivates high levels of cash. The intuition behind this hypothesis is firms with high future investment volatility keep cash levels high to fund uncertain future investments. Column (2) of Table 3 shows the coefficients associated with the investment volatility variable is positive and statistically significant at less than the 1% level, which is consistent with the predicted relationship. Our result indicates that firms with high future investment volatility hold more cash, which is consistent with the DeAngelo et al. (2011) model.
4.3 Testing Hypotheses 2a and 2b - Effect of investment spikes on a firm’s debt and cash levels.

Column (3) of Table 3 reports estimation results that test Hypothesis 2a. Hypothesis 2a 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. Column (3) of Table 3 shows the coefficients associated with investment spike $\text{InvSpike}_{DL}$ is positive and statistically significant at less than the 1% level, which is consistent with the predicted relationship. Our evidence supports firms 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.

Column (4) of Table 3 reports estimation results that test Hypothesis 2b. Hypothesis 2b posits that an investment spike leads to lower levels of cash. The intuition behind this hypothesis is that firms use cash to fund large investments. Column (4) of Table 3 shows the coefficient associated with investment spike $\text{InvSpike}_{DL}$ is 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.

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

Column (5) of Table 3 reports estimation results that test Hypothesis 3a. Hypothesis 3a 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. Column (5) of Table 3 shows the coefficient associated with the lead of investment spike $\text{InvSpike}_{DL_{t+1}}$ is 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. Our findings is consistent with Almeida, Campello and Weisbach (2011); they show that there is a relationship between firms’ today financing choices and future investments. All in all, our findings support the DeAngelo et al. (2011) model prediction that firms decrease their debt level after the spike year.
Column (6) of Table 3 reports estimation results that test Hypothesis 3b. Hypothesis 3b puts forward that firms increase cash levels after funding large investments. The intuition behind this hypothesis is that after large investments, firms rebuild their cash stock to maintain the capacity to fund future investment. Column (6) of Table 3 shows the coefficient associated with the lead of investment spike $\text{InvSpike}_{DLt+1}$ is 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. In addition, our findings demonstrate an investment channel that helps explain DeAngelo, S. Gonçalves and Stulz (2017) findings that over long periods of time firms decrease leverage from historical peaks while increasing cash balances.

5 Discussion and Robustness

In this section we discuss the economic importance of our results, investigate if our findings are robust to alternative measures of investment volatility, investment spike and debt and cash ratios.

5.1 Economic Importance

Table 4 reports the percentage change predicted from our panel model in dependent variables ($BDR$ and $Cash$) for our three Hypotheses. The predicted percentage changes for Hypotheses 1a and 1b are the result of one standard deviation increase from the mean of the 5-year lead of investment volatility variable, where other control variables are evaluated at their means.

Column (1) of Table 4 reports the predicted percentage change in $BDR$ of Hypotheses 1a, 2a and 3a. To obtain the economic importance of $\text{InvVol}_{DLt,t+5}$, we estimate the change in the dependent variable ($BDR$) due to a one standard deviation increase in $\text{InvVol}_{DLt,t+5}$ using Equation (7). $BDR$ at the mean of $\text{InvVol}_{DLt,t+5}$ is 0.29 and at the mean plus one standard deviation of $\text{InvVol}_{DLt,t+5}$ is 0.27, implying a 4.5% decrease in debt ratio as a result of one standard deviation increase in $\text{InvVol}_{DLt,t+5}$.

\[ \text{PercentageChange} = \frac{0.27 - 0.29}{0.29} = -4.5\% . \]
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 mean of $BDR$ when $InvSpike = 0$ is 0.30 and when $InvSpike = 1$ is 0.35, implying a 19.3% increase in debt ratio as a result of a large investment spike. Column (2) of Table 4 reports the predicted percentage change in $Cash$ of Hypotheses 1b, 2b and 3b. For example, the table reports a 4.2% increase in a firm’s cash level as a result of a one standard deviation increase from the mean of $InvVol_{DL,t,t+5}$.

insert Table 4

5.2 Robustness to alternative estimation method and alternative measures of debt, cash and investment volatility

In this section, we test if our results are robust to alternative estimation method and alternative measures of debt ratio, cash ratio and investment volatility. First, to evaluate if our findings are robust to an alternative estimation method, we re-test our hypotheses using a linear panel data model. Panel A of Table 5 tests all three hypotheses using an a linear panel data model. The results are qualitatively unchanged.

Second, we test using different measures of debt and cash ratios. Specifically, we re-estimate all the equations using total liabilities debt ratio $BDR_{lt}$ and cash scaled by net assets $Cash_{na}$ variables constructed in Section 3.2.1. Our main results are robust to using $BDR_{lt}$ and $Cash_{na}$ as our dependent variables.

Third, we test if our results are robust to alternative measures of investment volatility and investment spikes. 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 5 summarizes these results.

insert Table 5

Lastly, because firms may carry out investment programs over more than one year, we construct a two consecutive investment spike variable that represents firms with two consecutive large investments. Panel C of Table 5 tests Hypotheses 2a and 2b using two consecutive spike variables. The
use of two investment spikes increases the magnitude of the coefficients associated with the spike variables in Hypothesis 2a testing. Panel C of Table 5 tests Hypothesis 1 using $\text{InvVol}_{DL_{t-2,t+3}}$ and $\text{InvVol}_{DL_{t-1,t+4}}$ which are 3 and 4-year lead of the investment volatility variables, respectively.

All in all, Table 5 shows our main results remain qualitatively unchanged using a linear panel estimation, alternative measures of investment volatility and investment spikes, and a shorter investment volatility estimation window.

5.3 Example

In this section, following our main result, we illustrate how one small, rather young firm finances future investment by dynamically managing its debt and cash ratios.

Figure 1 plots the investment spikes, investment to total assets, cash to total assets, and the book debt ratio of Gaiam Vivendi Entertainment from 1999 to 2015. As shown in the figure, Gaiam Vivendi Entertainment has three investment spikes in 2000, 2008 and 2012. According to the Gaiam 10-K reports, these spikes are due to purchasing a business in 2012, and purchasing property, equipment and media rights in 2000 and 2008. As can be seen in the figure, both debt and cash ratios align with the investment spikes. For example, prior to the investment in 2008 of property, equipment and media rights, Gaiam kept its debt ratio low and its cash level high. Also, consistent with our third hypotheses, after the 2008 large investment, the firm decreased debt and increased cash.

6 Conclusion

Planning to execute an investment plan is one the most important financial strategies of a firm. Growth options are ephemeral and a firm must be positioned to quickly execute these options at the appropriate time. Our paper shows how firms manage their debt and cash levels to provide execute on these options.
The empirical literature on the relationship between firms’ financing options and the volatility of investment is narrow. We address this gap in the literature and empirically test DeAngelo et al. (2011) model predictions. Using several investment volatility and investment spike measures and an estimation method that consider the non-linear relationship between our proportional dependent variables and the explanatory variables, our results are consistent with the DeAngelo et al. (2011) model predictions.

The first hypothesis investigates if firms with higher future investment volatility have lower debt levels and higher cash levels. We predict the percentage change in debt and cash ratios by one standard deviation increase from the mean of the investment volatility variable. Our results are statistically significant and economically important. Our evidence suggests a 4.5% decrease in the debt ratio and a 4.2% increase in the cash level as a result of one standard deviation increase from the mean of the investment volatility variable. All in all, our evidence supports the model that firms with high future investment volatility maintain 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 investment volatility measure. Our results are economically important. Our evidence suggests a 19.3% increase in the debt ratio and a 25.4% 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 variable. Our results are economically important. Our evidence suggests a 12.6% decrease in the debt ratio and a 19.3% increase in the cash levels, one year after the large investment. Our evidence shows 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.
References


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# Appendix

**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.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Construction</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BDR</strong></td>
<td>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).</td>
<td>$\frac{dltt+dlc}{at+dlc+ceq}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>BDR_lt</strong></td>
<td>The ratio of total liabilities over total assets, (Rajan and Zingales, 1995).</td>
<td>$\frac{lt}{at}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>Cash</strong></td>
<td>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).</td>
<td>$\frac{che}{at}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>Cash_na</strong></td>
<td>The ratio of cash and short-term investments over net assets, (Opler et al., 1999).</td>
<td>$\frac{che}{at-che}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>CFV_{t-5,t}</strong></td>
<td>Natural logarithm of cash flow volatility.</td>
<td>See the (Keefe and Yaghoubi, 2016) paper</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>Tangibility</strong></td>
<td>The assets tangibility of a firm is the ratio of net property, plant, and equipment(at) to total assets, (Lemmon et al., 2008) and (Frank and Goyal, 2009).</td>
<td>$\frac{ppenb}{at}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>IndustLev</strong></td>
<td>The median industry leverage of the sector a firm is classified by four-digit SIC code, (Frank and Goyal, 2009).</td>
<td>The median of $\frac{LT}{MV\cdot A}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>FirmSize</strong></td>
<td>The proxy for a firm size.</td>
<td>$\ln(at)$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>Profitability</strong></td>
<td>Shows the profitability of a firm.</td>
<td>$\frac{oibdp}{at}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>MarketToBook</strong></td>
<td>The proxy for a firm’s growth opportunities and is the ratio of market value of asset to total assets.</td>
<td>$\frac{MV\cdot A}{at}$</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>Inflation</strong></td>
<td>The expected change in the consumer price index (CPI) over the coming year, (Frank and Goyal, 2009).</td>
<td>Forecast$\frac{Month-Base\ Period}{Base\ Period}$</td>
<td>Livingston Survey</td>
</tr>
</tbody>
</table>

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10Market value of assets ($MV\cdot A$) = 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 ($txdite$).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Construction</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>RnD</td>
<td>The ratio of R&amp;D expenses to sales of a firm, (Frank and Goyal, 2009).</td>
<td>$\ln(1 + \frac{xx_{R&amp;D}}{xx_{sales}})$</td>
<td>Compustat</td>
</tr>
<tr>
<td>CreditRating</td>
<td>Indicator variable: One if a firm is listed as investment grade by S&amp;P, and zero otherwise.</td>
<td>$=1$ if SPLTRCRM or SPSDRM &lt; 13</td>
<td>Compustat</td>
</tr>
<tr>
<td>FirmAge</td>
<td>The number of years a firm has had data in Compustat.</td>
<td>fyear-First year</td>
<td>Compustat</td>
</tr>
<tr>
<td>Acq</td>
<td>The ratio of acquisitions spending to the total assets, (Bates et al., 2009)</td>
<td>$\ln(1 + \frac{xx_{acq}}{xx_{at}})$</td>
<td>Compustat</td>
</tr>
<tr>
<td>Capx</td>
<td>The ratio of capital expenditure to the total assets, (Bates et al., 2009)</td>
<td>$\ln(1 + \frac{xx_{capx}}{xx_{at}})$</td>
<td>Compustat</td>
</tr>
<tr>
<td>InvVol_DLt−5,t</td>
<td>The capital expenditures plus acquisitions investment volatility measure estimated using (De Veirman and Levin, 2015) method</td>
<td>See Section 3.2.2</td>
<td>Compustat</td>
</tr>
<tr>
<td>InvSpike_DLt</td>
<td>An investment spike of Capx + Acq</td>
<td>See Section 3.2.2</td>
<td>Compustat</td>
</tr>
</tbody>
</table>
Figure 1: Investment spike, cash holdings, and debt ratio of Gaiam Vivendi Entertainment from 1999 to 2015.
Table 1: 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 A defines the variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>mean</th>
<th>p25</th>
<th>p50</th>
<th>p75</th>
<th>max</th>
<th>min</th>
<th>sd</th>
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<td>BDR</td>
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<td>0.291</td>
<td>0.0488</td>
<td>0.262</td>
<td>0.466</td>
<td>0.924</td>
<td>0</td>
<td>0.250</td>
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<td>Cash</td>
<td>146668</td>
<td>0.181</td>
<td>0.0274</td>
<td>0.0876</td>
<td>0.251</td>
<td>0.923</td>
<td>0.000325</td>
<td>0.219</td>
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<tr>
<td>Tangibility</td>
<td>146455</td>
<td>0.276</td>
<td>0.103</td>
<td>0.222</td>
<td>0.390</td>
<td>0.894</td>
<td>0.00367</td>
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<td>FirmSize</td>
<td>146668</td>
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<td>3.192</td>
<td>4.541</td>
<td>6.074</td>
<td>10.04</td>
<td>0.472</td>
<td>2.086</td>
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<tr>
<td>FirmAge</td>
<td>146668</td>
<td>9.098</td>
<td>2</td>
<td>6</td>
<td>13</td>
<td>38</td>
<td>0</td>
<td>8.779</td>
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<tr>
<td>Profitability</td>
<td>146342</td>
<td>0.0637</td>
<td>0.0314</td>
<td>0.114</td>
<td>0.176</td>
<td>0.404</td>
<td>-0.993</td>
<td>0.218</td>
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<tr>
<td>MarketToBook</td>
<td>142098</td>
<td>1.674</td>
<td>0.725</td>
<td>1.082</td>
<td>1.861</td>
<td>11.10</td>
<td>0.279</td>
<td>1.740</td>
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<tr>
<td>IndustLev</td>
<td>146668</td>
<td>0.341</td>
<td>0.199</td>
<td>0.323</td>
<td>0.465</td>
<td>0.907</td>
<td>0.0104</td>
<td>0.175</td>
</tr>
<tr>
<td>Inflation</td>
<td>146668</td>
<td>0.0437</td>
<td>0.0238</td>
<td>0.0379</td>
<td>0.0560</td>
<td>0.121</td>
<td>0.0166</td>
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<tr>
<td>CreditRating</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0.252</td>
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<tr>
<td>RnD</td>
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<td>0</td>
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<td>0.300</td>
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<tr>
<td>Acq</td>
<td>146661</td>
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<td>0.319</td>
<td>-0.00264</td>
<td>0.0551</td>
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<tr>
<td>Capx</td>
<td>145209</td>
<td>0.0798</td>
<td>0.0275</td>
<td>0.0543</td>
<td>0.101</td>
<td>0.434</td>
<td>0</td>
<td>0.0806</td>
</tr>
<tr>
<td>CFV_{t-5,t}</td>
<td>95179</td>
<td>2.083</td>
<td>1.502</td>
<td>1.972</td>
<td>2.531</td>
<td>4.940</td>
<td>0.602</td>
<td>0.827</td>
</tr>
<tr>
<td>InvVol_{DLt-5,t}</td>
<td>85987</td>
<td>1.945</td>
<td>1.385</td>
<td>1.895</td>
<td>2.471</td>
<td>3.636</td>
<td>0.430</td>
<td>0.753</td>
</tr>
<tr>
<td>InvSpike_{DLt}</td>
<td>129818</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.359</td>
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27
Table 2: Correlations
This table shows the pairwise correlation coefficients between investment, market to book and investment volatility variables. Table A defines the variables. Reference numbers in columns and rows refer to the variables associated with the pairwise correlation coefficients.

<table>
<thead>
<tr>
<th>Correlations Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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<tbody>
<tr>
<td>(1) Inv</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>(2) Capx</td>
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<td>0.910</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>(3) Acq</td>
<td></td>
<td></td>
<td>0.567</td>
<td>0.175</td>
<td>1</td>
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</tr>
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<td>(4) MarketToBook</td>
<td></td>
<td></td>
<td>-0.0191</td>
<td>-0.0188</td>
<td>-0.00790</td>
<td>1</td>
<td></td>
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<tr>
<td>(5) InvVol_DL_{t-5,t}</td>
<td></td>
<td></td>
<td>0.000800</td>
<td>-0.0358</td>
<td>0.0730</td>
<td>0.0402</td>
<td>1</td>
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<tr>
<td>(6) InvSpike_DL_{t}</td>
<td></td>
<td></td>
<td>0.0602</td>
<td>0.000300</td>
<td>0.142</td>
<td>0.0441</td>
<td>0.337</td>
</tr>
<tr>
<td>(7) CFV_{t-5,t}</td>
<td></td>
<td></td>
<td>-0.0906</td>
<td>-0.0795</td>
<td>-0.0571</td>
<td>0.430</td>
<td>0.0390</td>
</tr>
</tbody>
</table>
Table 3: Testing Hypotheses 1a through 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) & (2) show the estimation results of testing Hypotheses 1a and 1b where the variable of interest is $InvVol_{DL_{t,t+5}}$. Columns (3) & (4) show the estimation results of testing Hypotheses 2a and 2b where the variable of interest is $InvSpike_{DL_t}$. Columns (5) & (6) show the estimation results of testing Hypotheses 3a and 3b where the variable of interest is $InvSpike_{DL_{t+1}}$. 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.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BDR_{t}$</td>
<td>0.263***</td>
<td>-0.332***</td>
<td>0.256***</td>
<td>-0.307***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00827)</td>
<td>(0.0106)</td>
<td>(0.00880)</td>
<td>(0.0111)</td>
<td></td>
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</tr>
<tr>
<td>$Cash_{t}$</td>
<td>0.0717***</td>
<td>-0.00217</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(0.0102)</td>
<td>(0.0134)</td>
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<td></td>
</tr>
<tr>
<td>$InvSpike_{DL_{t+1}}$</td>
<td></td>
<td></td>
<td>-0.189***</td>
<td>0.208***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.00861)</td>
<td>(0.00950)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$CFV_{t-5}$</td>
<td>-0.124***</td>
<td>0.405***</td>
<td>-0.151***</td>
<td>0.431***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0129)</td>
<td>(0.0150)</td>
<td>(0.00969)</td>
<td>(0.0109)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Acq_{t-1}$</td>
<td>1.487***</td>
<td>-2.304***</td>
<td>1.731***</td>
<td>-2.589***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0911)</td>
<td>(0.103)</td>
<td>(0.0697)</td>
<td>(0.0816)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Capr_{t-1}$</td>
<td>0.515***</td>
<td>-1.415***</td>
<td>0.519***</td>
<td>-1.430***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.131)</td>
<td>(0.173)</td>
<td>(0.0933)</td>
<td>(0.130)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$RnD_{t-1}$</td>
<td>-0.711***</td>
<td>0.529***</td>
<td>-0.470***</td>
<td>0.512***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0884)</td>
<td>(0.0471)</td>
<td>(0.0549)</td>
<td>(0.0272)</td>
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<tr>
<td>$Tangibility_{t-1}$</td>
<td>0.776***</td>
<td>-1.827***</td>
<td>0.851***</td>
<td>-1.824***</td>
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<td></td>
<td>(0.0707)</td>
<td>(0.0878)</td>
<td>(0.0515)</td>
<td>(0.0623)</td>
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<tr>
<td>$FirmSize_{t-1}$</td>
<td>0.0989***</td>
<td>-0.00368</td>
<td>0.116***</td>
<td>-0.0165**</td>
<td></td>
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<tr>
<td></td>
<td>(0.00921)</td>
<td>(0.00885)</td>
<td>(0.00726)</td>
<td>(0.00695)</td>
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<tr>
<td>$FirmAge_{t-1}$</td>
<td>0.00395*</td>
<td>-0.0127***</td>
<td>0.00396***</td>
<td>-0.0120***</td>
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<tr>
<td></td>
<td>(0.00206)</td>
<td>(0.00212)</td>
<td>(0.00147)</td>
<td>(0.00142)</td>
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<tr>
<td>$Profitability_{t-1}$</td>
<td>-1.318***</td>
<td>0.141***</td>
<td>-1.217***</td>
<td>0.189***</td>
<td></td>
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<tr>
<td></td>
<td>(0.0683)</td>
<td>(0.0531)</td>
<td>(0.0465)</td>
<td>(0.0375)</td>
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<td></td>
</tr>
<tr>
<td>$MarketToBook_{t-1}$</td>
<td>-0.0537***</td>
<td>0.0396***</td>
<td>-0.0503***</td>
<td>0.0435***</td>
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<tr>
<td></td>
<td>(0.00766)</td>
<td>(0.00492)</td>
<td>(0.00530)</td>
<td>(0.00375)</td>
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</tr>
<tr>
<td>$IndustLev_{t-1}$</td>
<td>1.080***</td>
<td>-0.739***</td>
<td>1.272***</td>
<td>-0.886***</td>
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<tr>
<td></td>
<td>(0.0619)</td>
<td>(0.0675)</td>
<td>(0.0500)</td>
<td>(0.0539)</td>
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<tr>
<td>$Inflation_{t-1}$</td>
<td>5.967***</td>
<td>-10.61***</td>
<td>2.557***</td>
<td>-13.10***</td>
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<tr>
<td></td>
<td>(1.305)</td>
<td>(1.307)</td>
<td>(1.013)</td>
<td>(0.956)</td>
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</tr>
<tr>
<td>$CreditRating_{t-1}$</td>
<td>0.260***</td>
<td>-0.279***</td>
<td>0.290***</td>
<td>-0.187***</td>
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<tr>
<td></td>
<td>(0.0318)</td>
<td>(0.0411)</td>
<td>(0.0280)</td>
<td>(0.0369)</td>
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<tr>
<td>$Constant$</td>
<td>-1.754***</td>
<td>-1.486***</td>
<td>-1.835***</td>
<td>-1.125***</td>
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<tr>
<td></td>
<td>(0.110)</td>
<td>(0.108)</td>
<td>(0.0828)</td>
<td>(0.0772)</td>
<td></td>
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<tr>
<td>$Obs$</td>
<td>47,479</td>
<td>47,479</td>
<td>88,951</td>
<td>88,951</td>
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<td></td>
</tr>
<tr>
<td>$Number of firms$</td>
<td>4,864</td>
<td>4,864</td>
<td>9,167</td>
<td>9,167</td>
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<td></td>
</tr>
<tr>
<td>$Year$</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Clustered standard errors by firm are shown in parentheses. 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.
Table 4: 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 variable InvVol_DL_{t,t+5} , for Hypotheses 2a, 2b, 3a and 3b the predicted percentage changes are the result of the change in the dummy spike variables InvSpike_DL_t & InvSpike_DL_{t+1} from zero to one, where other control variables are evaluated at their means.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>∆BDR%</td>
<td>∆Cash%</td>
</tr>
<tr>
<td>Hypotheses 1a, 2a &amp; 3a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>InvVol_DL_{t,t+5}</td>
<td>-4.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td>InvSpike_DL_{t}</td>
<td>19.3%</td>
<td>-25.4%</td>
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<tr>
<td>InvSpike_DL_{t+1}</td>
<td>-12.6%</td>
<td>19.3%</td>
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</table>
Table 5: Robustness
This table summarizes the robustness testing of Section 5. Panel A tests all three hypotheses using linear panel data model 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 1a and 1b using 3 and 4-year lead of the investment volatility variable and Hypotheses 2a and 2b using two consecutive spike variables that represent firms with two consecutive spikes (large investments).

<table>
<thead>
<tr>
<th>Panel A: Robustness to alternative estimation method - linear panel data model</th>
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<tbody>
<tr>
<td>Hyp 1</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>InvVol_DL_{t,t+5}</td>
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<tr>
<td>BDR</td>
</tr>
<tr>
<td>Cash</td>
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</table>

<table>
<thead>
<tr>
<th>Panel B: Robustness to alternative measures of investment volatility and investment spike</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyp 1</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>InvVol_KS_{t,t+5}</td>
</tr>
<tr>
<td>BDR</td>
</tr>
<tr>
<td>Cash</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel C: Robustness to 3 and 4-year lead of the investment volatility variable (Hypotheses 1a and 1b), and robustness to two consecutive spikes variable (Hypotheses 2a and 2b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyp 1</td>
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<tr>
<td>-------</td>
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<tr>
<td>InvVol_DL_{t-2,t+3}</td>
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<tr>
<td>BDR</td>
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<td>Cash</td>
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</tbody>
</table>