Accepted Manuscript

The influence of cash flow volatility on capital structure and the use of debt of different maturities

Michael O'Connor Keefe, Mona Yaghoubi

PII: S0929-1199(16)30025-6
DOI: doi: 10.1016/j.jcorpfin.2016.03.001
Reference: CORFIN 1022

To appear in: *Journal of Corporate Finance*

Received date: 1 August 2015
Revised date: 3 March 2016
Accepted date: 4 March 2016

Please cite this article as: Keefe, Michael O'Connor, Yaghoubi, Mona, The influence of cash flow volatility on capital structure and the use of debt of different maturities, *Journal of Corporate Finance* (2016), doi: 10.1016/j.jcorpfin.2016.03.001

The influence of cash flow volatility on capital structure and the use of debt of different maturities. [1]

Michael O'Connor Keefe
Victoria University of Wellington
School of Economics and Finance
PO Box 600, Wellington 6140, NZ
Email: michael.keefe@vuw.ac.nz
Phone: 64 4 463 5708
Fax: 64 4 463 5014

Mona Yaghoubi
Victoria University of Wellington
School of Economics and Finance

Abstract

The empirical literature on the relationship between capital structure and firm cash flow volatility is inconclusive. We explore this relationship using several measures of a firm's cash flow volatility and econometric methods that account for the non-linear relationship of proportional variables. Overall, our evidence indicates that ceteris paribus a one standard deviation increase from the mean of cash flow volatility implies an approximate 24% decrease in the long-term debt ratio, a 26% decrease in probability of holding debt with over 10 years to maturity, and a 39% increase in the probability of holding neither short nor long term debt.

[1] We thank participants at Mona Yaghoubi's PhD proposal, the 2014 Victoria University of Wellington Brown Bag Seminar, the 2014 Auckland Finance Meeting and the 2015 New Zealand Finance Colloquium and PhD Symposium. All remaining errors are our own.

The influence of cash flow volatility on capital structure and the use of debt of different maturities.

Abstract

The empirical literature on the relationship between capital structure and firm cash flow volatility is inconclusive. We explore this relationship using several measures of a firm's cash flow volatility and econometric methods that account for the non-linear relationship of proportional variables. Overall, our evidence indicates that ceteris paribus a one standard deviation increase from the mean of cash flow volatility implies an approximate 24% decrease in the long-term debt ratio, a 26% decrease in probability of holding debt with over 10 years to maturity, and a 39% increase in the probability of holding neither short or long term debt.

1 Introduction

Despite the theoretical literature about the relationship between cash flow volatility and a firm's use of debt, there is little empirical evidence. For example, Frank and Goyal (2009) investigate twenty five explanatory variables used in prior studies and find six factors that reliably explain a firm's capital structure, but do not find volatility robustly explains capital structure. Likewise, Leary and Roberts (2005) and Antoniou, Guney, and Paudyal (2008) do not find that volatility matters in explaining capital structure. In a seminal study of international firms, Rajan and Zingales (1995) do not include volatility as an independent variable. Also, Leary and Roberts (2014) and Kayhan and Titman (2007) do not include volatility in their studies. Lastly, Friend and Lang (1988) find a positive relationship between volatility and leverage, whereas Bradley, Jarrell, and Kim (1984) and Kim and Sorensen (1986) find a negative relationship. In this paper, we re-examine the relationship between cash flow volatility and both a firm's capital structure and use of debt of different maturities.

The variable of interest in our study is cash flow volatility. To construct our volatility measures, we identify measures used in prior literature and find those studies use a variety of measures. Because of the lack of uniformity, we make several choices. First, we define cash flow as either operating income before depreciation or cash-based operating profit as defined by Ball, Gerakos, Linnainmaa, and Nikolaev (2015). Second, we scale each cash flow measure by net assets. Third, we estimate the volatility of each of the two cash flow measures using the panel regression method of De Veirman and Levin (2015), the rolling standard deviation method of Kim and Sorensen (1986) and the rolling standard deviation of first differences method of Stohs and Mauer (1996). Fourth, we choose window sizes of five years or in the case of the De Veirman and Levin (2015) method one or five years. This approach leads to eight measures of cash flow volatility. Lastly, in robustness tests, we evaluate our measures using different window lengths. We find that our volatility measures are similar but not identical and further our conclusions hold regardless of which measure or window is used.

We first study the effects of cash flow volatility on the firm's debt ratio. To test our first question, we consider the fact that our dependent variable (debt ratio) is a proportional variable, and therefore the conditional expectation is a nonlinear function of independent variables. Following Papke and Wooldridge (1996) and Kieschnick and McCullough (2003), we use a GLM (Generalized Linear Model) to test the effect of cash flow volatility on capital structure. We take into account the Welch (2011) critique that some debt ratios implicitly treat non-financial liabilities as equity and construct three book and three market debt ratios where debt is defined as either all liabilities, short and long-term debt, or just long-term debt. For each measure, we find that cash flow volatility has an economically important and statistically significant negative effect on a firm's capital structure.[2] Our results show that ceteris paribus one standard deviation increase from the mean of cash flow volatility implies an approximate 24% decrease in the long-term market debt ratio.

Second, we study the relationship between cash flow volatility and the use of debt of different maturities. Prior literature explores the use of zero debt in a firm's capital structure. Implicit in the zero debt question is the accounting rule that distinguishes short-term from long-term debt based upon whether the debt matures in one year. We extend this debate by constructing a measure that places a firm's use of debt into five maturity categories and then test the influence of cash flow volatility on the probability of a firm's use of debt by category.

As a categorical debt by maturity variable is novel, we explain its construction. Using Compustat debt definitions, we define five categories based on a firm using or not using debt with different times to maturity. At one extreme, we place a firm which uses debentures (usually with maturity greater than 10 years) in category one. Likewise, a firm in category two uses notes but not debentures. At the other extreme, we place a firm which uses neither long nor short-term debt in category five. Firms in category four use debt with maturity of less than one year, but do not use long-term debt. Firms in category three use long-term debt with maturity that is not as long as notes. In summary, as the zero by maturity variable increases from one to five, the firm uses less debt of longer maturity.

Using the zero-debt by maturity variable as the dependent variable in an ordered probit model, we find that cash flow volatility has a statistically significant and economically important influence on a firm's use of debt of different maturities. Specifically, the probability of a firm holding debt of

[2] To control for simultaneity all explanatory variables are lagged.

longer maturity decreases with cash flow volatility. Similarly, the probability of a firm holding only short maturity debt (or zero-debt) increases with cash flow volatility. Overall, in both absolute and percentage terms, the effect of cash flow volatility on the use of debt of different maturities is strongest at the extremes. Specifically, a one standard deviation increase in cash flow volatility implies a 26% decrease in the probability of using debt with maturity greater than ten years and a 39% increase in the probability of neither using long nor short-term debt. Our evidence shows that firms with high cash flow volatility are more likely to use debt in shorter maturity categories.

We employ a series of robustness tests. First, we re-estimate using panel, zero inflated beta and OLS estimation methods. Second, we re-estimate using eight different measures of cash flow volatility. Third, we re-estimate using estimation windows for our cash flow volatility measures for one through five years. Lastly, we re-estimate using the debt maturity measure of Barclay and Smith (1995). Across all these robustness tests our findings are qualitatively unchanged.

This paper proceeds as follow, Section 2 reviews the literature and develops our hypotheses. Section 3 reviews the data, constructs the variables and reports the univariate statistics. Section 4 tests the hypotheses and discusses the results. Section 5 discusses the relationship between cash flow volatility and the other explanatory variables as well as tests for robustness to other econometric methods and volatility measures. Section 6 provides concluding remarks.

2 Hypothesis development

Using the Black and Scholes (1973) model, we illustrate the positive relationship between cash flow volatility and the cost of debt. Black and Scholes (1973) price a European call option as

$$Call_{BS}(V_t, B, r, T-t, \sigma) = V_t N(d_1) - Be^{-r(T-t)} N(d_2), \tag{1}$$

where V_t is the value of underlying assets, B is the strike price, r is the annual risk free rate, $T-t$ is the time in years to expiration date, σ is the standard deviation of the return of the asset, and

$$d_1 = \frac{[ln\,(V_t/B) + (r+\sigma/2)(T-t)]}{\sqrt{\sigma(T-t)}}$$

and

$$d_2 = d_1 - \sqrt{\sigma(T-t)}, \tag{2}$$

where $N(d)$ is the cumulative standard normal distribution.[3]

Stoll (1969) shows the relationship between the price of a European call option and a European put option with identical strike price and expiry date as

$$Put_{BS}(V_t, B, r, T-t, \sigma) = Be^{-r(T-t)} - V_t + Call_{BS}(V_t, B, r, T-t, \sigma). \tag{3}$$

The relationship shown in Equation (3) is called put-call parity. Equations (1) and (3) imply that the price of call and put options increase with volatility σ.[4]

Black and Scholes (1973) and Merton (1973) recognize that the option pricing model could be applied to develop a model to price corporate equity and liabilities in general. By following the option pricing model, Merton (1974) develops a model to price the debt and equity of the firm. In Merton's model, equity holders own the firm V_T and borrow debt at $t = 0$ from debt holders (creditors) with face value B payable at T. Due to the limited liability, in the case of default at T when $B \geq V_T$, the creditors receive V_T. Otherwise, the creditors receive B. Therefore, the uncertain payoff to the creditors is

$$D(V_T, T) = min(V_T, B). \tag{4}$$

By employing Black and Scholes (1973) formula, Merton (1974) expresses value of the firm as

$$FirmValue = Call_{BS}(V_t, B, r, T-t, \sigma) + Be^{-r(T-t)} - Put_{BS}(V_t, B, r, T-t, \sigma), \tag{5}$$

where the value of equity is

$$E(V_t, t) = Call_{BS}(V_t, B, r, T-t, \sigma), \tag{6}$$

[3]We use notation of Sundaresan (2013). See Sundaresan (2013) for a literature review of extensions of Merton's model.

[4]$\nu = \frac{\partial Call_{BS}}{\partial \sigma} > 0$, measures the sensitivity of a call option to volatility.

and the value of debt is

$$D(V_t, t) = Be^{-r(T-t)} - Put_{BS}(V_t, B, r, T-t, \sigma). \tag{7}$$

Equation (6) shows that the value of the equity of a levered firm is equivalent to a call option on the assets of the borrowing firm. Equation (7) shows that the value of the debt is equal to the value of risk-free debt minus the value of the put option. Because cash flow volatility increases the value of call and put options, higher cash flow volatility increases equity value in Equation (6), while it decreases debt value in Equation (7), which in turn increases the marginal cost of debt. The cost of debt is

$$R_D = \frac{B}{D(V_t, t)} - 1. \tag{8}$$

Because an increase in σ decreases $D(V_t, t)$, an increase in σ also increases R_D. Thus, high volatility firms have a relatively high cost of debt, implying:

Hypothesis 1. *Firms with high cash flow volatility use less debt.*

The application of Black and Scholes (1973) model to a firm's capital structure implies that the cost of debt increases with debt maturity. Equation (7) shows the value of debt equals risk free debt minus a put option with the strike price equal to the face. The first term $Be^{-r(T-t)}$ decreases with time to maturity T. The second term Put_{BS} increases with time to maturity. Hence, the value of debt $D(V_t, t)$ decreases with maturity due to both the time value of money (term one) and the issuance (put option) of the debt (term two). Thus, by Equation (8) the cost of debt increases with time to maturity.

Hypothesis 2. *The probability of a firm using zero debt of longer (shorter) maturity decreases (increases) with cash flow volatility.*

3 Sample, variable construction, and univariate statistics

3.1 Sample

We obtain annual data from 1974 through 2012 of US corporations from the Compustat CRSP Merged database. Following Frank and Goyal (2009), we exclude financial firms, firms involved in major mergers (Compustat footnote code AB) and firms with missing book value of assets.[5] We also exclude firms with zero and negative common (ordinary) equity, utility firms, firms with negative total assets or total revenue. We also exclude firms with missing revenue, total liabilities or total assets. We next investigate Compustat debt items that Compustat codes as missing, which are actually zero. Appendix A provides the Compustat definitions of the variables. To illustrate, PFIZER INC ($gvkey$ = 008530) in fiscal year 2009 has long-term debt ($dltt$) of \$ 43,193 million, and notes (dn) of \$ 43,193 million, but reports missing debentures (dd). Clearly, debentures are not missing, but are zero. Our inspection of $dd1$, $dd2$, $dd3$, $dd4$ and $dd5$ shows a similar pattern. To address this issue, we replace missing observations with zero for dd and $dd1$ through $dd5$. Consistent with the literature, we also change missing RnD to zero. Due to the previous edits, the change from missing to zero is only done for firms with positive total assets and liabilities.

Following Kale and Shahrur (2007), we winsorize the data at the 1% level in both tails of the distribution. After variable filtrations, the sample includes 134,581 firm-year observations from 1974-2012. Because we use the lag of all control variables, our sample reduces to 111,496 firm-year observations. Depending on which cash flow volatility measure is used, our sample further reduces to between 89,035 and 109,613 observations.

3.2 Variable Construction

3.2.1 Capital Structure Measures

Welch (2011, page 2) states,

[5] Compustat assigns a footnote AB to total sales ($revt$) and create variable $revt\_fn$, if sales increase by more than 50 percent in response to a merger or an asset acquisition.

> There is no universally used measure of leverage. Most researchers probably spend little time pondering their measure and simply copy what their predecessors have adopted. An informal census of the recent literature suggests that about half of all recently published papers have defined leverage as financial-debt divided by assets (FD/AT). Unfortunately, this measure is incorrect.

The financial-debt-to-asset ratio (FD/AT), implicitly treats non-financial liabilities as equity, which is clearly wrong. We refer to this issue as the Welch (2011) critique.

In constructing our measures of capital structure, we are guided by two questions. First, what liabilities should be included in debt? Most broadly, debt consists of all liabilities including non-financial liabilities. Most narrowly, debt consists of only long-term debt. Debt may also consist of both short-term and long-term debt but exclude non-financial liabilities. Thus, the capital structure may be defined in three ways. Second, should debt be measured using book or market value? Keeping in mind the Welch (2011) critique and addressing both questions, we define three measures of capital structure for both market and book values, which generates six capital structure variables.

The broadest definition of debt includes all liabilities. The Compustat item total liabilities (lt) includes non-financial liabilities. To construct the all liabilities market debt ratio, we follow Rajan and Zingales (1995) and Welch (2011). The numerator is total liabilities and the denominator is total assets minus common shareholders's equity plus market value of common stock. We define the all liabilities market debt ratio as

$$MDR1 = \frac{lt}{(at - ceq) + csho * prcc\_f}. \tag{9}$$

Rajan and Zingales (1995) and Welch (2011) define the all liabilities book debt ratio as the total liabilities in the numerator and total assets in the denominator. We construct the all liabilities book debt ratio as

$$BDR1 = \frac{lt}{at}. \tag{10}$$

Both $MDR1$ and $BDR1$ categorize non-financial liabilities as debt.

The second debt ratio includes short-term plus long-term debt. Rajan and Zingales (1995) construct the short and long-term market debt ratio as the long plus short-term debt divided by short and long-term debt plus the market value of equity. We define the short-term plus long-term market debt ratio as

$$MDR2 = \frac{dltt + dlc}{dltt + dlc + csho * prcc\_f}. \quad (11)$$

To construct singular book debt ratio we follow Rajan and Zingales (1995). The numerator of this measure is the short plus long-term debt and the denominator is short plus long-term debt plus common shareholders' equity. We define the short-term plus long-term book debt ratio as

$$BDR2 = \frac{dltt + dlc}{dltt + dlc + ceq}. \quad (12)$$

Both $MDR2$ and $BDR2$ are consistent with the Welch (2011) critique as the denominators exclude non-financial liabilities.

The most narrow definition of debt includes only long-term debt in the debt ratio. We follow Bradley et al. (1984) and define the long-term market debt ratio as the total long-term debt over the total long-term debt plus market value of equity. We define the long-term market debt ratio as

$$MDR3 = \frac{dltt}{dltt + csho * prcc\_f}. \quad (13)$$

To measure the long-term book debt ratio, we construct a long-term book debt ratio as total long-term debt divided by the total long-term debt plus common shareholders' equity. We define the long-term book debt ratio as

$$BDR3 = \frac{dltt}{dltt + ceq}. \quad (14)$$

Both $MDR3$ and $BDR3$ are consistent with the Welch (2011) critique as the denominators exclude non-financial liabilities.

insert Table 1

To test Hypothesis 2, we construct an ordered categorical variable based on a firm's use of debt at different maturities. To construct the variable, we use Compustat items *dd*, *dn*, *dltt*, *dlc* and *dclo*. Appendix A provides the Compustat definitions of the variables. Table 1 summarizes the $ZerobyMaturity$ variable construction. Table 1 shows that $ZerobyMaturity$ is set to one when a firm uses debentures. Because debentures are a component of long-term debt, a firm that uses debentures also uses long-term debt. Table 1 denotes the use of debentures and long-term debt by a "Yes" in columns (1) and (3). The other debt types are marked "N.A", in columns (2), (4) and (5) as the use of these types of debt is not used to define a firm in Category 1. For example, a firm in Category 1 might use debentures or possibly both debentures and notes. Table 1 shows that firms in Category 2 use notes and hence hold long-term debt, but do not hold debentures. At the other extreme, Table 1 shows firms in Category 5 hold zero long or short-term debt. Likewise, firms in Category 4 hold debt in current liabilities, but all other debt items are denoted with "No". Category 5 matches the zero debt definitions by Strebulaev and Yang (2013) and Lee and Moon (2011). Lastly, Category 3 represents firms that hold long-term debt but do not hold debentures or notes. This variable shows use of debt with different maturity by firm and does not measure when the debt actually matures. For example, when a firm-year observation includes a debt debenture in its capital structure, our variable does not indicate the years to maturity of the debenture, rather it shows the use of debt debentures by a firm.

In addition to our $ZerobyMaturity$ variable, we test Hypothesis 2 in the robustness section using the Barclay and Smith (1995) measure of debt maturity. To measure the maturity structure of a firm's debt, Barclay and Smith (1995) use the percentage of the firm's total debt that matures in more than three years. We follow Barclay and Smith (1995) and construct

$$DebtMat\_D = (dltt - dd2 - dd3)/(dltt + dlc),$$

where the numerator captures debt greater than three years and the denominator includes short and long-term debt. One issue with the Barclay and Smith (1995) debt maturity measure ($DebtMat\_D$) is that it does not include non-financial liabilities in the denominator. As high cash flow volatility firms use non-financial liabilities like trade credit, we construct a debt maturity measure that includes non-financial liabilities. We measure the percentage of the firm's total liabilities that matures in more than three years as

$$DebtMat\_L = (dltt - dd2 - dd3)/(lt).$$

3.2.2 Control Variables

To test our hypotheses, we use the following Frank and Goyal (2009) most reliable factors as control variables:

i) $MarketToBook$ is the ratio of market value of assets to total assets (proxy of growth opportunities).

ii) $IndustLev$ is the median industry leverage and is the median of total debt to market value of assets by year and four-digit SIC code.

iii) $Tangibility$ is the asset tangibility. It is the ratio of fixed assets-to-total assets.

iv) $FirmSize$ is a proxy for firms' size. It is the natural log of the total assets of the firm.

v) $Profitability$ shows the profitability of a firm and is the ratio of the firm operating income before depreciation to total assets.

vi) $Inflation$ is the expected change in the consumer price index over the coming year.

To lessen the effect of possible omitted variable bias, we also construct five additional explanatory variables.

vii) $LnRnD$ is the natural logarithm of (1+ the ratio of R&D expenses to sale) (Frank and Goyal, 2009).

viii) $EquIssue$ is the net equity issuance of a firm (Lemmon, Roberts, and Zender, 2008).

ix) $CreditRating$ is a dummy variable. It is equal to one if S&P rates the debt as investment grade (BBB) debt and is equal to zero if the firm is rated less than investment grade (Frank and Goyal, 2009).

x) *FirmAge* computed as the number of years a firm has been listed in the Compustat (Bergstresser and Philippon, 2006).

3.2.3 Key Variable of Interest

insert Table 2

The key variable of interest in this study is cash flow volatility. Table 2 surveys many of the volatility measures used in the empirical corporate finance literature. A perusal of Table 2 highlights that there are a large number of closely related measures, but no one agreed upon measure. Due to the lack of a standard definition, we estimate several alternative measures. We test using one measure of cash flow volatility in Section 4 and test using alternative measures in the robustness section. We review below our approach to constructing our cash flow volatility measures.

First, we need a measure of cash flow. Table 2 shows the prior literature uses several related cash flow measures including *ebitda*, *ebitd*, and *ebit*. Of these measures *ebitda* excludes interest expense or taxes, which are related to the level of debt (our dependent variable) in the firm, and depreciation and amortization, which are non-cash expenses. Note that Compustat items *ebitda* (earnings before interest) and *oibdp* (operating income before depreciation) both represent net sales minus operating expenses.[6] We use *oibdp* as our first cash flow measure and denote volatility variables based on it using *oi* (operating income) in the variable name. For our second measure of cash flow we follow Ball et al. (2015) who adjust *op* (operating profit)

$$op = sale - cogs - (xsga - xrd),$$

using accruals to find *cbop* (cash-based operating profit)

$$cbop = op - D.rect - D.invt - D.xpp + D.(drc + drlt) + D.ap + D.xacc.$$

[6]Compustat defines $ebitda = sale - cogs - xsga$ and $oibdp = sale - xopr$, where $xopr = cogs + xsga$. Therefore, $ebitda = oibdp$.

We use *cbop* as our second cash flow measure and denote volatility variables based on cash-based operating profit by including *cbop* in the variable name. Note that operating profit equals *ebitda* minus xrd (research and development expenses).[7]

Second, most of the volatility measures in Table 2 are scaled by the total assets of a firm. Total assets includes cash. Pinkowitz and Williamson (2007) show that a firm's cash holdings are a function of the volatility of the firm's cash flows. By removing cash from total assets we remove this functional relationship.[8] We scale volatility measures by net assets (total assets minus cash and marketable securities) of a firm. In addition, scaling by the net assets generates a measure of return, which is comparable across firms. Thus, our volatility measures capture the cash flow return volatility of the net assets of a firm.

Third, in estimating volatility, Table 2 shows the literature uses a variety of different estimation windows. The length of the window ranges from a minimum of five years to twenty eight years. If firms partially adjust towards the target capital structure, a five year window represents a period of time that is plausibly consistent with firms' adjustment policies.[9] In our robustness checks, we also test using one, two, three and four year windows.

The fourth issue relates to how to measure volatility. Most of the studies listed in Table 2 measure volatility either using the standard deviation of the cash flow or the standard deviation of first differences of the cash flow. We estimate cash flow volatility using three methods. First we follow Kim and Sorensen (1986) and estimate the rolling standard deviation of *oi* and *cbop* over the last five years. Second, we follow Stohs and Mauer (1996) and estimate the rolling standard deviation of first differences of *oi* and *cbop* over the last five years. One issue with the first difference approach is that it requires one additional observation. As an alternative to these rolling measures, we estimate cash flow volatility using the method of De Veirman and Levin (2015) and used by De Veirman and Levin (2012) and Keefe and Tate (2013). To denote the method used to construct the cash flow volatility measures, we include KS, SM and DL in the variable names.

[7]In untabulated results, we find the correlation coefficient between *ebitda* and *op* is 98.8 %.

[8]We thank the referee for this insight.

[9]The Kraus and Litzenberger (1973) trade-off theory and several empirical studies like Jalilvand and Harris (1984), Leary and Roberts (2005), Flannery and Rangan (2006), Harford, Klasa, and Walcott (2009) support the existence of an optimal capital structure and firms' tendencies to adjust towards the target.

To construct the De Veirman and Levin (2015) cash flow volatility measure, we estimate

$$\omega_{i,t} = \alpha_i + Year\beta_1 + \epsilon_{i,t} \tag{15}$$

where $\omega_{i,t}$ represents the first difference of operating income (oi) scaled by net assets from $t-1$ to t for firm i and $Year$ is a matrix of year dummies.[10] The residual $\epsilon_{i,t}$ represents the difference between the observed and the estimated value of operating cash flow of firm i when controlling for time and firm fixed effects.[11] De Veirman and Levin (2015) show that $\hat{\sigma}_{i,t}$ is an unbiased estimator of the true conditional volatility

$$\hat{\sigma}_{i,t} = \sqrt{\pi/2} * |\hat{\epsilon}_{i,t}| \,, \tag{16}$$

where $\hat{\epsilon}_{i,t}$ is the estimated residual from Equation (15). We estimate Equation (16) and define $CFV\_DL\_oi\_1$ as cash flow volatility measured using the method of De Veirman and Levin (2015) using operating income (oi) for one year. We also define $CFV\_DL\_oi\_5$ as the rolling five year average of $\hat{\sigma}_{i,t}$.

Using the guidelines developed above, we estimate eight measures of cash flow volatility. For example, $CFV\_KS\_oi\_5$ represents cash flow volatility measured as the five year rolling standard deviation of cash flow as measured by operating income. $CFV\_KS\_cbop\_5$ is a similar measure but estimated using cash-based operating profit. Likewise, $CFV\_SM\_oi\_5$ represents cash flow volatility measured as the five year rolling standard deviation of the first differences of operating income. In summary, we construct the following four cash flow volatility measures using operating income: $CFV\_KS\_oi\_5$, $CFV\_SM\_oi\_5$, $CFV\_DL\_oi\_1$ and $CFV\_DL\_oi\_5$. In addition, we construct the following four volatility measures using cash-based operating profitability: $CFV\_KS\_cbop\_5$, $CFV\_SM\_cbop\_5$, $CFV\_DL\_cbop\_1$ and $CFV\_DL\_cbop\_5$.

To address the effect of outliers, we winsorize each measure at the 1% level in both tails. To better approximate a normal distribution, we then take the natural log of all volatility measures. To illustrate, the skewness and the kurtosis of $CFV\_KS\_oi\_5$ is 35 and 2464, respectively. After

[10] Total assets is calculated using Compustat items. $Total\ assets = at - che$ where, at is total assets and che is cash and short-term investment.

[11] We also control for industry and the results are qualitatively identical.

taking the natural logarithm of the measure the skewness and the kurtosis is 0.62 and 4.7, respectively.[12] Lastly, to address possible simultaneity issues, we lag the volatility measure by one year in all tests. In Section 4, we test our hypotheses using $CFV\_KS\_oi\_5$. In Section 5, we explore if our findings are sensitive to the choice of volatility measures.

insert Table 3

Table 3 reports the pairwise correlations between our eight volatility measures. Table 3 shows that all measures are positively correlated. Furthermore, the cash flow volatility measures tend to be highly correlated if they have the same underlying measure of cash flow. For example, the correlation coefficient between $CFV\_KS\_oi\_5$ and $CFV\_SM\_oi\_5$ is 0.832 and between $CFV\_KS\_oi\_5$ and $CFV\_DL\_oi\_5$ is 0.811. Also, volatility measures constructed by the same method are highly correlated. For example, the correlation coefficients between $CFV\_KS\_oi\_5$ and $CFV\_KS\_cbop\_5$ is 0.755 and between $CFV\_KS\_cbop\_5$ and $CFV\_DL\_cbop\_5$ is 0.851. Lastly, volatility variables with one and five year windows have relatively smaller correlation coefficients. Specially, the correlation coefficient between $CFV\_KS\_oi\_5$ and $CFV\_DL\_oi\_1$ is 0.574.

3.2.4 Univariate Statistics

insert Table 4

Table 4 reports the summary statistics. The means of the three categories of capital structure measures show that the more broadly we define the debt, the higher market and book debt ratios. The mean of $MDR1$, which includes all liabilities of a firm, is greater than the mean of $MDR2$, which includes the long and short-term debt of a firm, and the mean $MDR2$ is greater than the mean of $MDR3$, which includes the long-term debt of a firm. For example the mean of $MDR1$ is 0.367, the mean of $MDR2$ is 0.238 and the mean of $MDR3$ is 0.194. Book debt ratios follow a similar pattern. The mean of $BDR1$ is 0.466, the mean of $BDR2$ is 0.296, and the mean of $BDR3$ is 0.242. The mean of $MarketToBook$ is 1.622 which is consistent with lower market than book

[12] A normal distribution has a skewness of 0 and a kurtosis of 3.

debt ratios. The average $FirmAge$ is 9.77 years and the mean of $FirmSize$ is 4.642 million dollars based on total assets.

insert Table 5

Table 5 reports the categorical variable $ZerobyMaturity$ frequency, percent and cumulative percent. The table shows several empirical regularities. First, in approximately 17.05% of the sample firm-year observations, firms use long-term debt (e.g. debentures). Second, in approximately 44.67% of the sample firm-year observations, firms use notes but not debentures. Third, in approximately 18.66% of the sample firm-year observations, firms use debt with maturity that is not as long as notes but greater than one year. Fourth, in approximately 5.61% of the sample firm-year observations, firms use debt with maturity of less than one year. Fifth, in approximately 14.02% of the sample firm-year observations, firms hold neither long nor short-term debt.

insert Table 6

Table 6 reports the correlation coefficients between explanatory variables. Table 6 shows that cash flow volatility measure is negatively correlated with $Profitability$, $IndusLev$, $FirmSize$ and positively correlated with $LnRnD$, and $MarketToBook$. The correlation coefficients between $CFV\_KS\_oi\_5$ and $FirmSize$, $Profitability$ and $IndustLev$ are -43.6%, -42.2% and -40.4% , respectively. On the other hand, the correlation coefficients between $CFV\_KS\_oi\_5$ and $MarketToBook$ is 42.9% and $LnRnD$ is 45%. Overall, highly cash flow volatile firms are smaller, less profitable, belong to industries with low levels of debt, have more growth opportunities and spend more on research and development projects.

insert Figure 1

To depict the relationship between cash flow volatility and the market debt ratios, we construct 20-quantiles of cash flow volatility. Figure 1 plots $MDR1$ and $MDR3$ over twenty cash flow volatility quantiles.[13] In Figure 1, $MDR1$ declines slowly from quantile 1 to quantile 16. From quantile 16 to quantile 20, $MDR1$ declines the same amount as in the first sixteen quantiles, which

[13] All figures in this paper plot the means of every variable in each quantile.

represents a rate of decrease four times as fast as in the first 16 quantiles. In quantile 20 the magnitude of $MDR1$ drops to approximately 15%, which indicates that firms with very high cash flow volatility continue to use debt, when debt is broadly defined as including all liabilities. $MDR3$ follows a similar pattern; however the magnitude of $MDR3$ is less than 5%, indicating firms with very high cash flow volatility use very little long-term debt. Plotting the other market and book debt ratios, show us the same pattern between volatility and debt ratios.

4 Testing

4.1 Testing Hypothesis 1 - The relationship between cash flow volatility and leverage.

Frank and Goyal (2009) do not study potential nonlinearities. Frank and Goyal (2009, page 26) write:

> There are a number of other things that we have not studied in this paper. We have not allowed for alternative functional forms and general nonlinearities. ... All of these are potentially interesting, and we hope to explore many of them in the future.

The dependent variable of this study is a proportion variable bounded between zero and one. Cook, Kieschnick, and McCullough (2008) address some common specification errors in using a linear prediction equation to model a proportional or fractional variable and show the conditional expectation is a nonlinear function of the independent variables.[14] To mitigate the estimation problems caused by a bounded dependent variable, we use a GLM (Generalized Linear Model) with a logit link function.

$$E(DebtRatio_{i,t}|X_{i,t-1}, LnCFV_{i,t-1}) = G(\alpha + X_{i,t-1}\beta_1 + \beta_2 LnCFV_{i,t-1} + \epsilon) \tag{17}$$

where

- G(.) is the logistic link function,

[14] Cook et al. (2008) finding is consistent with Papke and Wooldridge (1996), Cox (1996), Paolino (2001).

- $DebtRatio_{i,t}$ is market or book debt ratio, $MDR1$, $MDR2$, $MDR3$, $BDR1$, $BDR2$ and $BDR3$,
- $X_{i,t-1}$ is a matrix of lagged control variables listed in Section 3.2.2, and
- $LnCFV_{i,t-1}$ is the lag of the natural logarithm of the volatility measure.

insert Table 7

Table 7 shows GLM estimation results of Equation (17) using $CFV\_KS\_oi\_5$ as the variable of interest, with standard errors clustered by firm. The table reports that the coefficients associated with $CFV\_KS\_oi\_5$ are statistically significant at less than the 1% significance level in explaining all capital structure measures. Columns (1), (3) and (5) show the estimated coefficients using the market debt ratios and Columns (2), (4) and (6) show the estimated coefficients using the book debt ratios. Each coefficient associated with $CFV\_KS\_oi\_5$ is negative, implying that firms with high cash flow volatility use less debt. In addition, Table 7 shows that the magnitude of the coefficients associated with cash flow volatility increases as debt is more narrowly defined to include only long-term debt. Specifically, the coefficients associated with cash flow volatility are -0.203, -0.295 and -0.309 using $MDR1$, $MDR2$ and $MDR3$, respectively. This is consistent with high cash flow volatile firms substituting short-term and non-financial liabilities for long-term debt.

To obtain the economic importance of cash flow volatility coefficients in Equation (17), we estimate the change in the long-term market debt ratio due to a one standard deviation increase in cash flow volatility. Using the estimated coefficients from Column (5) of Table 7, we predict the long-term market debt ratio evaluated at the mean of $CFV\_KS\_oi\_5$ and the mean plus a one standard deviation of $CFV\_KS\_oi\_5$. All other explanatory variables are evaluated at their means. Table 4 reports the mean and the standard deviation of $CFV\_KS\_oi\_5$ as 1.961 and 0.992, respectively. Predicted $MDR3$ evaluated at the mean of $CFV\_KS\_oi\_5$ is equal to 0.153 and at the mean plus a one the standard deviation of $CFV\_KS\_oi\_5$ is equal to 0.116, implying a one standard deviation increase in cash flow volatility leads to a decrease of 24.18% in market long-term debt ratio.[15]

[15] $PercentageChange = \frac{0.116-0.153}{0.153} = -24.18\%$.

Table 7 also reports that the coefficients associated with the reliable factors of Frank and Goyal (2009) are statistically significant at less than the 1% level. We note Frank and Goyal (2009) did not identify research and development expenses as one of the six reliable factors but we find that the coefficient associated with RnD is statistically significant at less than the 1% level. This negative coefficient indicates that firms with higher research and development spending employ less debt. We note that the correlation coefficient between $LLnRnD$ and $CFV\_KS\_oi\_5$ is 45%.

insert Figure 2

To visually show how the GLM (Generalized Linear Model) estimates the relationship between capital structure and the explanatory variables, we use the estimated GLM coefficients to predict $MDR1$. We then estimate the mean of the predicted $MDR1$ over twenty cash flow volatility quantiles. Figure 2 plots the mean of predicted versus actual $MDR1$ over twenty cash flow volatility quantiles. Figure 2 shows the predicted values closely match the actual values. Plots of other predicted market and book debt ratios show fits that are similar to Figure 2. Overall, Figure 2 shows a negative relationship between volatility and the use of long-term debt. Lastly, Figure 2 shows that the use of long-term debt rapidly declines in higher volatility quantiles.

Overall, our evidence supports Hypothesis 1 and suggests that firms with more volatile cash flows use less debt. We suggest two reasons our results differ from Frank and Goyal (2009). First, Frank and Goyal (2009) use the variance of stock returns, whereas we use cash flow volatility. The volatility of stock prices may be caused by many reasons unrelated to a firm's cash flow and is not as direct a measure of the lenders' risk. Second, Frank and Goyal (2009) use OLS, which does not account for non-linear relationship between cash flow volatility and debt ratios.[16]

4.2 Testing Hypothesis 2 - The effects of cash flow volatility on a firm's use of debt of different maturities

We test Hypothesis 2 using an ordered probit model which estimates the relationship between cash flow volatility and our categorical variable debt by maturity. We construct $ZerobyMaturity$ in

[16]Column (3) of Table 11 reports the estimation results of Hypothesis 1 testing using OLS, the coefficients of cash flow volatility remain statistically significant at the 1% level, but the magnitude of the coefficients decrease relative to GLM estimation.

Section 3.2.1. The ordering starts from firms that hold debt with more than ten years of maturity to firms with no long and short-term debt. The ordered probit model allows us to test the debt maturity hypothesis using five categories of $ZerobyMaturity$. We estimate

$$Pr(ZerobyMaturity > i|\kappa, X_{t-1}, \upsilon_j) = \Phi(X_{t-1}\beta_1 + \beta_2 LnCFV_{t-1} + \upsilon_j - \kappa_i), \tag{18}$$

where, residual υ_j has the standard normal distribution N(0,1), and κ is a set of cut-points, where i is the category number. The model has $\kappa = 4$ cut-points as there are $i = 5$ categories of $ZerobyMaturity$.

insert Table 8

Table 8 reports estimation results of an ordered probit model using $CFV\_KS\_oi\_5$. Column (1) reports cross-sectional results and Column (2) reports panel results. The coefficients associated with the $CFV\_KS\_oi\_5$ are statistically significant at less than the 1% level. The positive coefficients of $CFV\_KS\_oi\_5$ suggest that when cash flow volatility increases, the probability of a firm using shorter (longer) maturity debt increases (decreases).

insert Table 9

To show the economic magnitude of cash flow volatility on the use of debt of different maturities, we calculate the absolute and percentage change in the probability of a firm falling within one of the five categories due to a one standard deviation increase in cash flow volatility. Table 9 reports the economic magnitude by category. For example the probability of using notes but not debentures at the mean of $CFV\_KS\_oi\_5$ is equal to 46.4% and at the mean plus one standard deviation is equal to 43.3%, implying an absolute decrease of about 0.031 or equivalently a 7% increase in the probability of using notes but not debentures. In both absolute and percentage terms at the extremes, a one standard deviation increase in cash flow volatility has the largest economic magnitude. In category five a one standard deviation increase implies an approximate 0.046 absolute increase and a 39% relative increase in the probability of a firm using zero long or short term debt.[17] At the other extreme (category one), a one standard deviation change in cash flow volatility implies a 4.7% absolute and a 26% relative decrease in the probability of using debt with greater than ten years maturity. Overall, our estimation results support Hypothesis 2.

insert Figure 3

The economic magnitude estimates started at the mean of the explanatory variables. To visualize how a change in the probability of holding debt of different maturities changes by volatility, Figure 3 plots the percentage of the sample firms existing in each debt maturity category relative to the mean of the predicted probability by volatility quantiles using ordered probit model Equation (18). As shown in the figure, predicted values closely match the actual values. Overall, consistent with the above analysis of the economic magnitudes, the probability of holding debentures or notes (Categories 1 and 2) decreases with cash flow volatility whereas the probability of holding short-term debt (Categories 3, 4 and 5) increases with cash flow volatility. Lastly, consistent with the economic magnitude analysis, in high volatility quantiles the magnitude of the slopes in the Category 2 (use notes) and Category 5 (no debt) greatly increase.

5 Discussion and Robustness

In this section we discuss the relationship between cash flow volatility and our other explanatory variables and evaluate if our findings are robust to alternative estimation methods, volatility measures and window lengths and measures of debt maturity.

5.1 Relationship of Cash Flow Volatility with Other Explanatory Variables

insert Table 10

In our estimation of the marginal effects, we assume that firm characteristics remain constant as volatility increases. However, based on the correlation analysis firm characteristics also change between quintiles. To illustrate, Table 10 shows the mean of each explanatory variable for each

[17]The 39% increases matches with using the dichotomous zero short and long-term debt variables, where zero short and long-term debt variables are indicator variables set to one if a firm's long-term plus short-term debt is zero and if a firm's long-term debt equals zero, respectively.

5-quantiles of cash flow volatility. Column (1) represents the lowest cash flow volatility quintile and Column (5) represents the highest cash flow volatility quintile. To test whether the characteristics of firms differ from one cash flow volatility quintile to another, we test if differences in mean is zero using the first versus the fifth, as well as the fourth versus the fifth quintile of cash flow volatility for each variable. As it can be seen in the last two columns of Table 10, the *t*-statistics are very high, showing that there is a statistically significant difference between the mean of each variable in the first and the fifth quintiles as well as the fourth and the fifth quintiles. Overall, the evidence that explanatory variables also change with volatility suggests that our estimates of the economic importance of cash flow volatility represent a lower bound. For example, a high cash flow volatile firm also tends to have less asset tangibility. Higher volatility and lower asset tangibility tend to reduce debt levels, but our marginal effect analysis only considers the direct effect of volatility.

5.2 Alternative Estimation Methods

insert Table 11

To control for time invariant firm heterogeneity, we follow Flannery and Rangan (2006) and Lemmon et al. (2008) and estimate Equation (17) using a panel data method. In keeping with our estimation approach for fractional dependent variables, we use GLM panel data estimation. Column (1) of Table 11 reports the coefficients associated with $CFV\_KS\_oi\_5$ are negative and statistically significant at less than the 1% level for all six debt ratios. In the panel model, the identification is only through changes within a firm and not across firms. As a result, the magnitude of the coefficients decrease relative to the result in Table 7.

In addition to the fractional dependent variables issue, some of our proportion dependent variables (short and long-term and long-term book and market debt ratios) contain a considerable number of zero values. To address this issue we follow (Cook et al., 2008) and use a zero-inflated beta model to test Hypothesis 1 as some of the debt ratios may cluster at zero. We do not use the Tobit model because the debt ratios are not censored; rather, firms may simply use zero debt. Column (2) of Table 11 shows negative and statistically significant coefficients at less than the 1% level associated with the $CFV\_KS\_oi\_5$. These results are qualitatively identical to the main results in Table 7. Following Frank and Goyal (2009), we also test using an ordinary least squares (OLS). Column (3) of Table 11 reports that the coefficient associated with the $CFV\_KS\_oi\_5$ is negative and statistically significant at less than the 1% level. By comparing the coefficients in column (3) with the ones in columns (1) and (2), we can see that the column (3) coefficients are smaller. We interpret the decrease in the size of the coefficients as plausibly due to the inherent non-linearity of the fractional dependent variables.

5.3 Robustness to Volatility Measures and Window Lengths

insert Table 12

Using all the six debt ratios as the dependent variables, we re-test Hypothesis 1 using eight different cash flow volatility measures as defined in Section 3.2.3. Columns (1) to (6) of Table 12 report that coefficients associated with all volatility measures for every debt measures are negative and statistically significant at less than the 1% level. In addition, we re-test Hypothesis 2 by using an ordered probit model. Column (7) reports the coefficients associated with all volatility measures are positive and statistically significant at less than the 1% level. Overall, our main results remain qualitatively unchanged due to different measures of volatility.

insert Table 13

Table 13 reports negative and statistically significant coefficients associated with several cash flow volatility measures with different rolling windows. In this table, we test Hypothesis 1 using GLM with a logit link function and $MDR3$. Rolling measures require five observations. Due to this requirement, the sample size is reduced, leading to possible sample selection bias. In our main results, we used an estimation window of five. For the KS measure, which uses a rolling method, we constructed the measures using a three and four year windows. For the DL measure, we estimate the mean over two, three, four and five years. As can be seen in the table, the number of observations increases as the window size decreases. In addition, the magnitude of the coefficients decrease with the window size. For any window size or measure, the coefficient is statistically significant at less than the 1% level. Overall, our results do not appear to be driven by a sample selection issue.

5.4 Robustness to Different Measures of Debt Maturity

insert Table 14

Table 14 shows estimation results of re-testing Hypothesis 2 using $DebtMat\_D$ and $DebtMat\_L$ constructed in Section 3.2.1. In Columns (1) and (2) we use GLM with a logit link function. In Columns (3) and (4) we use a zero inflated beta model. The coefficients associated with $LCFV\_KS\_oi\_5$ in all four columns are negative and statistically significant at less than the 1% level. The negative relationship between cash flow volatility and the use of debt of lower maturity is consistent with our main findings. Columns (1) and (3) of Table 14 test using the strict Barclay and Smith (1995) measure as the dependent variable. Columns (2) and (4) of Table 14 test using our modified measure where long-term debt is scaled by total liabilities. Table 14 shows the coefficients associated with $LCFV\_KS\_oi\_5$ in Columns (2) and (4) are much larger than in Columns (1) and (3). Our interpretation of the original measure is that it understates the effect of volatility on firms substituting non-financial liabilities for debt.

6 Conclusion

The literature on the relationship between capital structure and cash flow volatility is inconclusive. We re-address this important question by carefully developing a set of cash flow volatility measures, conducting tests using methods that account for the non-linearity, and subjecting our analysis to a wide range of capital structure measures, alternative estimation methods, and window sizes. Across all these approaches, we find cash flow volatility is an important determinant of both a firm's debt ratio and use of debt of different maturities.

In testing our first hypothesis, we reject at less than the 1% level that cash flow volatility does not influence a firm's debt ratio, regardless of how capital structure is measured. The relationship is not only statistically significant, but also economically important. For example, a one standard deviation increase in cash flow volatility implies an approximate 24% decrease in the long-term market debt ratio. We find the magnitude of the effect is strongest when debt is strictly defined as long term. This finding suggests that high cash flow volatile firms tend to reduce long term debt but continue to use short term and non-financial liabilities. Our results are consistent with several recent working papers like Reindl, Stoughton, and Zechner (2013), Levine and Wu (2014) and Chen, Wang, and Zhou (2014).

Accounting standards categorize debt into either short (one year or less) or long term (greater than one year). This distinction hides firm heterogeneity in the use of debt of different maturities. In our second hypothesis, we investigate the effect of cash flow volatility on the use of debt of different maturities. Using our constructed categorical variable, we test if cash volatility effects a firm's use of debt in these maturity categories. We reject at less than a 1% level that cash flow volatility does not influence a firm's use of debt by maturity category. Again, the relationship is economically important, especially at the extremes. For example, a one standard deviation increase from the mean of cash flow volatility implies an approximate 24.18% decrease in the long-term debt ratio, a 26% decrease in probability of holding debt with over 10 years to maturity, and a 39% increase in the probability of holding neither short or long term debt.

In closing, we note that in our testing we control for many explanatory variables that are highly correlated with cash flow volatility. Our analysis suggests a high cash flow volatile firm tends to be smaller, less profitable, have a higher market to book ratio, and spend more on research and development than a low cash flow volatile firm. Nonetheless, even when controlling for all of these characteristics the effect of cash flow volatility on the debt ratio and use of debt of different maturities is both statistically significant and economically important.

A Appendix

Compustat Variable Definitions
This table provides Compustat variable definitions. Column (1) provides the variable name. Column (2) defines the variables.

Compustat Variable	Compustat Definition
dd	Debt debentures, long-term debt containing a promise to pay a specific amount of money on a fixed date usually more than 10 years after issuance and a promise to pay interest on stated dates.
$dd1$	Debt - Due in 1st year, the total long-term debt falling due within the first year from the balance sheet date, including all long-term bank, finance lease and etc.
$dd2$ through $dd5$	Debt - due in 2nd, 3rd, 4th and 5th years, the dollar amount of long-term debt payable in the second (or third, fourth, or fifth) year from the balance sheet date.
dn	Debt-notes, long-term debt possibly secured by the pledge of property or securities owned by the company.
dltt	Total long-term debt, debt obligations due more than one year from the company's balance sheet date.
dlc	Total debt in current liabilities, the total amount of short-term notes and the current portion of long-term debt (debt due in one year).
dclo	Debt-capitalized lease obligations, the debt obligation a company incurs when capitalizing leases.
lt	Total liabilities, current liabilities plus long-term debt plus other non-current liabilities, including deferred taxes and investment tax credit.
at	Total assets, the total assets/liabilities of a company at a point in time.
ceq	Total common/ordinary equity, the common shareholders' interest in the company.
csho	Number of common shares outstanding, the net number of all common shares outstanding at year-end, excluding treasury shares and scrip.
prcc_f	Price close at the end of fiscal year.
sale	gross sales (the amount of actual billings to customers for regular sales completed during the period) reduced by cash discounts, trade discounts, and returned sales and allowances for which credit is given to customers, for each operating segment.
cogs	Cost of goods sold, all costs directly allocated by the company to production, such as material, labor and overhead.
xsga	Selling, general and administrative expense, all commercial expenses of operation (i.e., expenses not directly related to product production) incurred in the regular course of business pertaining to the securing of operating income.
ebitda	Earnings before interest, the sum of Sales - Net (*sale*) minus cost of goods sold (*cogs*) minus selling, general & administrative expense (*xsga*).
oibdp	Operating income before depreciation and includes the effects of adjustments for (*cogs*) of goods sold and selling, general & administrative expense (*xsga*).
ebit	Earnings before interest and taxes, the sum of Sales - Net (*sale*) minus cost of goods sold (*cogs*) minus selling, general & administrative expense (*xsga*) minus depreciation/amortization (*dp*).
xopr	Total operating expense, the sum of different components based on the format the company uses to report its income account.
xrd	Research and development expense, all costs incurred during the year that relate to the development of new products or services.

Compustat Variable	Compustat Definition
xacc	Accrued expenses, expenses incurred with the passage of time.
rect	Total receivables, claims against others, after applicable reserves, collectible in money, generally within one year.
invt	Total inventories, this item represents merchandise bought for resale and materials and supplies purchased for use in production of revenue.
xpp	Prepaid expenses, advance payments for services or benefits that are to be received within one operating cycle.
drc	Current deferred revenue, revenue which has not yet been earned, but is expected to be classified as earned during the current year.
drlt	Long-term deferred revenue, revenue which has not yet been earned.
ap	Accounts payable - trade, this item represents only trade obligations due within one year or the normal operating cycle of the company.
che	Cash and short-term investments, cash and all securities readily transferable to cash as listed in the Current Asset section.

B 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.

Variable	Definition	Construction	Data Sources
$MDR1$	The ratio of total liabilities to total assets minus common shareholders equity plus market value of common stock, Rajan and Zingales (1995) and Welch (2007).	$\frac{lt}{(at-ceq)+csho*prcc\_f}$	Compustat
$BDR1$	The ratio of total liabilities to total assets, Rajan and Zingales (1995) and Welch (2011).	$\frac{lt}{at}$	Compustat
$MDR2$	The ratio of short plus long-term debt to short plus long-term debt plus common shareholder equity, Rajan and Zingales (1995).	$\frac{dltt+dlc}{dltt+dlc+csho*prcc\_f}$	Compustat
$BDR2$	The ratio of total liabilities to total assets, Rajan and Zingales (1995).	$\frac{dltt+dlc}{dltt+dlc+ceq}$	Compustat
$MDR3$	The ratio of long-term market debt ratio over the total long-term debt plus market value of equity, Bradley et al. (1984).	$\frac{dltt}{dltt+csho*prcc\_f}$	Compustat
$BDR3$	The ratio of total long-term debt over total long-term debt plus common share holder equity	$\frac{dltt}{dltt+ceq}$	Compustat
$CFV\_KS\_oi\_5$	Natural logarithm of cash flow volatility.	Section 3.2.3	Compustat
$Tangibility$	The assets tangibility of a firm is the ratio of(ppent) net property, plant, and equipment(at) toatal assets, (Lemmon et al., 2008) and (Frank and Goyal, 2009).	$\frac{ppenb}{at}$	Compustat
$IndustLev$	The median industry leverage of the sector which a firm is classified by four-digit SIC code, (Frank and Goyal, 2009).	The median of $\frac{LT}{MVA}$ [18]	Compustat
$FirmSize$	The proxy for a firm size.	$ln(at)$	Compustat
$Profitability$	Shows the profitability of a firm.	$\frac{oibdp}{at}$	Compustat
$MarketToBook$	The proxy for a firm's growth opportunities and is the ratio of market value of asset to total assets.	$\frac{MVA}{at}$	Compustat
$Inflation$	The expected change in the consumer price index (CPI) over the coming year, (Frank and Goyal, 2009).	$\frac{Forecast12Month-BasePeriod}{BasePeriod}$	Livingston Survey
$LnRnD$	The ratio of R&D expenses to sale of a firm, (Frank and Goyal, 2009).	$ln(1+\frac{xrd}{revt})$	Compustat
$EquIssue$	The split-adjusted change in shares outstanding times the split-adjusted average stock price dividend by the end of year t-1 total assets, (Lemmon et al., 2008).	[19]	Compustat

[18] Market 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 ($txditc$).

[19] $EquIssue_{i,t}$=$[(csho_t - csho_{t-1}) * (adjexf_{t-1}/adjexf_t)] * [(prccf_t - prccf_{t-1}) * (adjexf_t/adjexf_{t-1})]/at$.

Variable	Definition	Construction	Data Sources
$CreditRating$	Indicator variable: One if a firm is listed as investment grade by S&P, and zero otherwise.	=1 if SPLTICRM or SPSDRM < 13	Compustat
$FirmAge$	The number of years a firm has had data in Compustat.	fyear-First year in Compustat	Compustat
$ZerobyMaturity$	An ordered categorical variable based on debt maturity	Section 3.2.1 defines the five categories of $ZerobyMaturity$.	Compustat
$DebtMat\_D$	The percentage of a firm's total debt that matures in more than three years, Barclay and Smith (1995).	$\frac{dltt-dd2-dd3}{dltt+dlc}$	Compustat
$DebtMat\_L$	The percentage of a firm's total liabilities that matures in more than three years	$\frac{dltt-dd2-dd3}{lt}$	Compustat

References

Antoniou, A., Guney, Y., Paudyal, K., 2008. The determinants of capital structure: Capital market-oriented versus bank-oriented institutions. The Journal of Financial and Quantitative Analysis 43 (1), 59–92.

Ball, R., Gerakos, J., Linnainmaa, J. T., Nikolaev, V. V., 2015. Accruals, cash flows, and operating profitability in the cross section of stock returns. Journal of Financial Economics, forthcoming (15-12).

Barclay, M. J., Smith, C. W., 1995. The maturity structure of corporate debt. The Journal of Finance 50 (2), 609–631.

Bergstresser, D., Philippon, T., 2006. CEO incentives and earnings management. Journal of Financial Economics 80 (3), 511–529.

Black, F., Scholes, M., 1973. The pricing of options and corporate liabilities. Journal of Political Economy 81 (3), 637–654.

Bradley, M., Jarrell, G. A., Kim, E. H., 1984. On the existence of an optimal capital structure: Theory and evidence. The Journal of Finance 39 (3), 857–878.

Chen, H., Wang, H., Zhou, H., 2014. Stock return volatility and capital structure decisions. Working paper, available at SSRN: http://ssrn.com/abstract=2346642, 1–42.

Cook, D., Kieschnick, R., McCullough, B. D., 2008. Regression analysis of proportions in finance with self selection. Journal of Empirical Finance 15 (5), 860–867.

Cox, C., 1996. Nonlinear quasi-likelihood models: applications to continuous proportions. Computational Statistics & Data Analysis 21 (4), 449–461.

Dang, V. A., 2012. An empirical analysis of zero-leverage firms : Evidence from the UK, 1–53. URL `Working paper available at SSRN: http://ssrn.com/abstract=890719;`

De Veirman, E., Levin, A., 2015. Cyclical changes in firm volatility. Journal of Money, Credit and Banking, forthcoming.

De Veirman, E., Levin, A. T., 2012. When did firms become more different? time-varying firm-specific volatility in japan. Journal of the Japanese and International Economies 26 (4), 578–601.

Dierker, M. J., Kang, J.-K., Lee, I., Seo, S. W., 2013. Do Firms Adjust Capital Structures to Manage Risk? KAIST College of Business Working Paper Series No. 2013-031. available at http://ssrn.com/abstract=2360903;, 1–64.

Flannery, M. J., Rangan, K. P., 2006. Partial adjustment toward target capital structures. Journal of Financial Economics 79 (3), 469–506.

Frank, M. Z., Goyal, V. K., 2009. Capital structure decisions: Which factors are reliably important? Financial Management 38 (1), 1–37.

Friend, I., Lang, L. H. P., Jun. 1988. An empirical test of the impact of managerial self-interest on corporate capital structure. The Journal of Finance 43 (2), 271–281.

Harford, J., Klasa, S., Walcott, N., 2009. Do firms have leverage targets? evidence from acquisitions. Journal of Financial Economics 93 (1), 1–14.

Jalilvand, A., Harris, R. S., 1984. Corporate behavior in adjusting to capital structure and dividend targets: An econometric study. The Journal of Finance 39 (1), 127–145.

Kale, J. R., Shahrur, H., 2 2007. Corporate capital structure and the characteristics of suppliers and customers. Journal of Financial Economics 83 (2), 321–365.

Kane, A., Marcus, A. J., McDonald, R. L., 1985. Debt policy and the rate of return premium to leverage. Journal of Financial & Quantitative Analysis 20 (4), 479–499.

Kayhan, A., Titman, S., 2007. Firms' histories and their capital structures. Journal of Financial Economics 83 (1), 1–32.

Keefe, M. O., Tate, J., 2013. Is the relationship between investment and conditional cash flow volatility ambiguous, asymmetric or both? Accounting & Finance 53 (4), 913–947.

Kester, W. C., Spring 1986. Capital and ownership structure: A comparison of united states and japanese manufacturing corporations. Financial Management 15 (1), 5–16.

Kieschnick, R., McCullough, B. D., 2003. Regression analysis of variates observed on (0, 1): percentages, proportions and fractions. Statistical Modelling: An International Journal 3 (3), 193.

Kim, W. S., Sorensen, E. H., Jun. 1986. Evidence on the impact of the agency costs of debt on corporate debt policy. The Journal of Financial and Quantitative Analysis 21 (2), 131–144.

Kraus, A., Litzenberger, R. H., Sep. 1973. A state-preference model of optimal financial leverage. The Journal of Finance 28 (4), 911–922.

Leary, M., Roberts, M., 2005. Do firms rebalance their capital structures? The Journal of Finance 60 (6), 2575–2619.

Leary, M. T., Roberts, M. R., 2014. Do peer firms affect corporate financial policy? The Journal of Finance 69 (1), 139–178.

Lee, H., Moon, G., 2011. The long-run equity performance of zero-leverage firms. Managerial Finance (10), 872.

Lemmon, M. L., Roberts, M. R., Zender, J. F., 2008. Back to the beginning: Persistence and the cross-section of corporate capital structure. Journal of Finance 63 (4), 1575–1608.

Levine, O., Wu, Y., 2014. Asset volatility and financial policy: Evidence from corporate mergers. Working paper available at SSRN: http://ssrn.com/abstract=2399154.

Merton, R. C., 1973. Theory of rational option pricing. The Bell Journal of Economics and Management Science 4 (1), 141–183.

Merton, R. C., 1974. On the pricing of corporate debt: The risk structure of interest rates. The Journal of Finance 29 (2), 449–470.

Paolino, P., 2001. Maximum likelihood estimation of models with beta-distributed dependent variables. Political Analysis 9 (4), 325–346.

Papke, L. E., Wooldridge, J. M., 1996. Econometric methods for fractional response variables with an application to 401(k) plan participation rates. Journal of Applied Econometrics 11 (6), 619–632.

Pinkowitz, L., Williamson, R., 2007. What is the market value of a dollar of corporate cash? Journal of Applied Corporate Finance 19 (3), 74–81.

Rajan, R. G., Zingales, L., 1995. What do we know about capital structure? some evidence from international data. The Journal of Finance 50 (5), 1421–1460.

Reindl, J., Stoughton, N., Zechner, J., 2013. Market implied costs of bankruptcy. Working paper available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2324097.

Stohs, M. H., Mauer, D. C., 1996. The determinants of corporate debt maturity structure. The Journal of Business 69 (3), 279–312.

Stoll, H. R., 1969. The relationship between put and call option prices. The Journal of Finance 24 (5), 801–824.

Strebulaev, I., Yang, B., 2013. The mystery of zero leverage firms. Journal of Financial Economics 109 (1), 1–23.

Sundaresan, S., 2013. A review of merton s model of the firm s capital structure with its wide applications. Annual Review of Financial Economics 5 (1).

Titman, S., Wessels, R., Mar. 1988. The determinants of capital structure choice. The Journal of Finance 43 (1), 1–19.

Welch, I., 2007. Common flaws in empirical capital structure research. AFA 2008 New Orleans Meetings Paper, 1–33.

Welch, I., 2011. Two common problems in capital structure research: The financial-debt-to-asset ratio and issuing activity versus leverage changes. International Review of Finance 11 (1), 1–17.

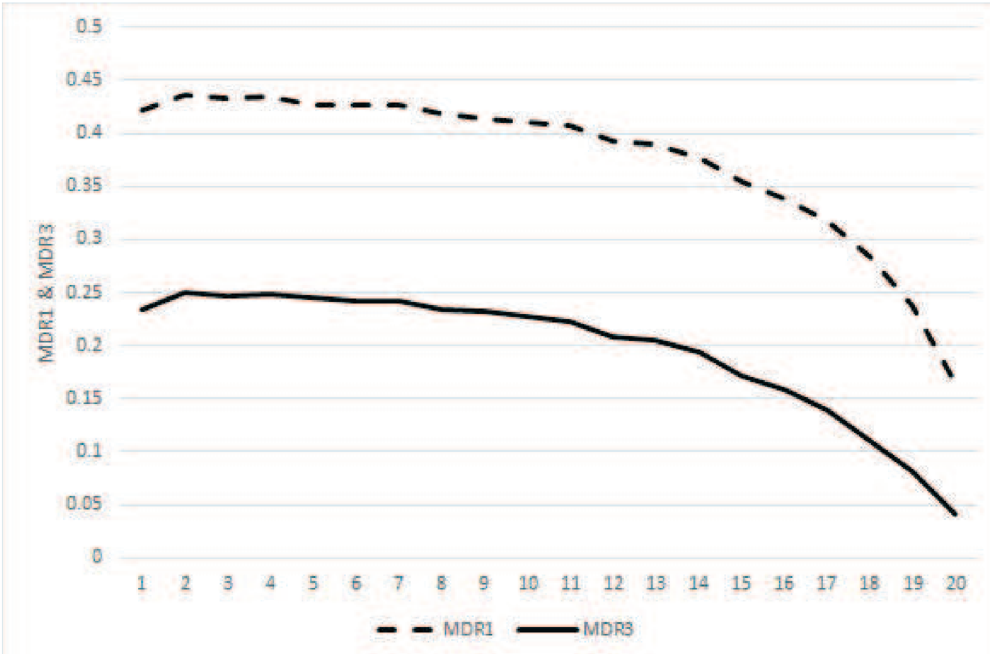

Figure 1: The horizontal axis shows the 20-Quantiles of $CFV\_KS\_oi\_5$. The vertical axis shows the debt ratio. The figure plots the mean of $MDR1$ and $MDR3$ in each volatility quantile.

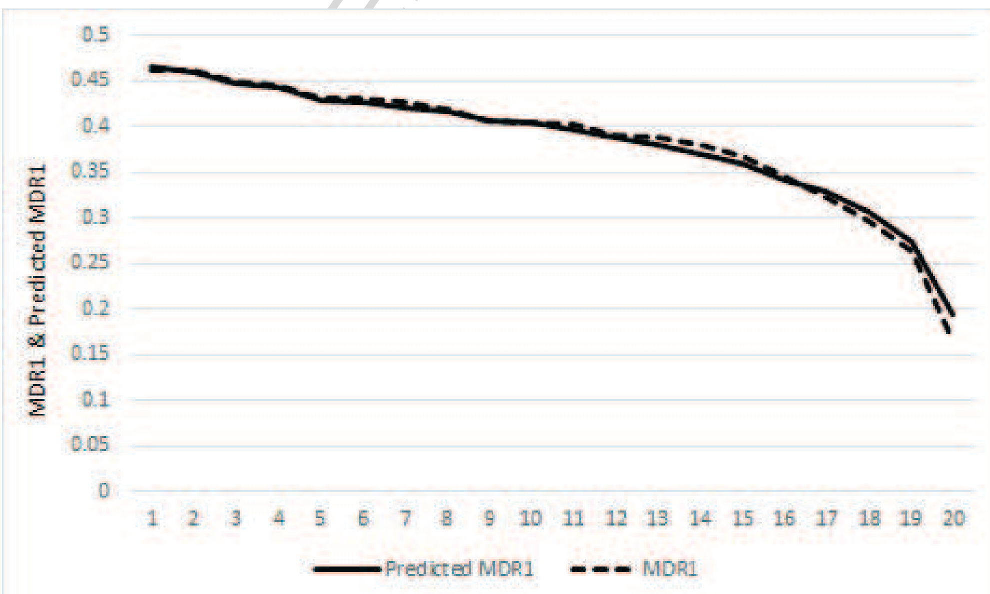

Figure 2: The horizontal axis shows the 20-Quantiles of $CFV\_KS\_oi\_5$. The vertical axis shows the debt ratio. The figure plots by quantile the mean of actual versus predicted $MDR1$. $MDR1$ predicted values are obtained using GLM with a logit link function shown in Equation (17).

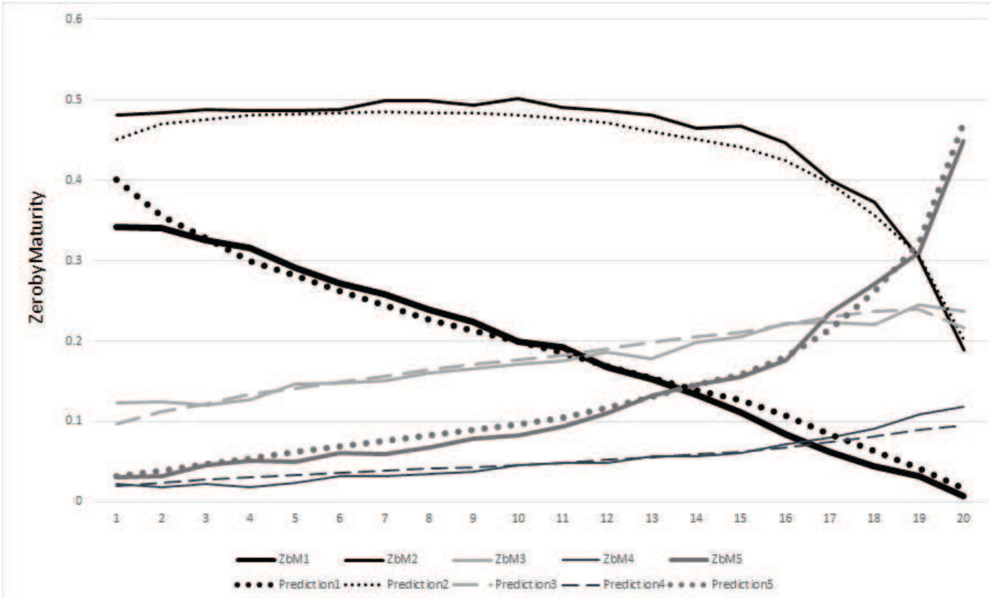

Figure 3: The horizontal axis shows the 20-Quantiles of $CFV\_KS\_oi\_5$. The vertical axis shows the percentage of the sample firms in the each category of $ZerobyMaturity$ ($ZbM1$ to $ZbM5$, where for example $ZbM1$ represents the percentage of the sample firms existing in the first category $ZerobyMaturity$=1). The figure plots by quantile the predicted mean probability and actual percentage for each maturity category. Predicted mean probabilities are obtained from the ordered probit model shown in Equation (18). From the top, first, second, third, fourth and fifth set of lines depicts second, first, third, fifth and fourth categories of $ZerobyMaturity$, respectively.

Table 1: This table shows the $ZerobyMaturity$ variable construction. The first column shows the number the variable is set to. The other columns depict the rules by which the variable is set, where "yes" denotes a firm holds that type of debt, "No" denotes a firm does not hold that type of debt, and "N.A" (not applicable) implies a firm may or may not hold that type of debt. We use Compustat items *dd*, *dn*, *dltt*, *dlc* and *dclo*. See Appendix A for Compustat definition of these variables.

	Debt-debentures	Debt-notes	Total long-term debt	Total debt in current liabilities	Debt-capitalized lease obligations
$ZerobyMaturity$	*dd*	*dn*	*dltt*	*dlc*	*dclo*
1	Yes	N.A	Yes	N.A	N.A
2	No	Yes	Yes	N.A	N.A
3	No	No	Yes	N.A	N.A
4	No	No	No	Yes	No
5	No	No	No	No	No

Table 2: Empirical Literature Volatility Measures
This table shows the volatility measures used by existing empirical literature.

Study	Volatility Measure	Window
Bradley et al. (1984, page 872)	"The standard deviation of the first difference in annual earnings before interest, depreciation and taxes over the period 1962-1981 divided by the average value of total assets over the same time period."	20 years
Kane, Marcus, and McDonald (1985, page 481)	"Instantaneous standard deviation of the rate of return of the market value of the unlevered assets."	NA
Kim and Sorensen (1986, page 138)	"The coefficient of variation in earnings before interest and taxes (EBIT) measured over the years 1970 to 1980."	10 years
Kester (1986, page 12)	"OLS (Ordinary Least Squares) prediction of return on assets is calculated for each company using observations for the five preceding years. The sum of squared residuals from each of these regressions is used in the final regression as a proxy for the volatility, or risk, of return on assets."	5 years
Friend and Lang (1988, page 273 & 274)	"Standard deviation of earnings (before interest payments and taxes)/ asset ratio used as a proxy for risk ... on a ten-year basis (1974-1983). "	10 years
Titman and Wessels (1988, page 6 & 8)	"The standard deviation of the percentage change in operating income ... It was measured using all nine years in the sample in order to obtain as efficient a measure as possible."	9 years
Stohs and Mauer (1996, page 295)	"The ratio of the standard deviation of the first difference in earnings before interest, depreciation, and taxes to the average of assets over the period 1980-89."	10 yaers
Antoniou et al. (2008, page 88)	"First difference of annual earnings (% change) minus average of the first differences, over 1987-2000."	13 years
Frank and Goyal (2009, page 33)	"Variance of asset returns (StockVar) is the annual variance of asset returns that is obtained by unleveraging the variance of equity returns, with other asset values assumed to be equal to their book values." Data should be available for 100 days.	NA
Lee and Moon (2011, page 878)	"The standard deviation of return on sales with a minimum of $2 million sales over the prior five years, over the prior five years."	5 years
Dang (2012, page 41)	"The absolute value of the difference between the annual % change in EBITD and the (time-series) average of this change over 1980-2007."	28 years
Strebulaev and Yang (2013, page 21)	"Volatility of profitability calculated for the past 10 years."	10 years
Dierker, Kang, Lee, and Seo (2013, page 33)	"Operating risk, is measured as the annualized standard deviation of past 20 quarterly operating cash flows as a percentage of total assets (quarterly ATQ) at the beginning of the quarter over the past five years."	5 years

Table 3: Volatility Measures Correlations

This table shows the pairwise correlations between volatility measures. See Section 3.2.3 for the discussion on the volatility measures. Reference numbers in columns and rows refer to the variables associated with the pairwise correlation.

Pairwise Correlations Volatility Measures	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) $CFV\_KS\_oi\_5$	1							
(2) $CFV\_KS\_cbop\_5$	0.755	1						
(3) $CFV\_SM\_oi\_5$	0.832	0.692	1					
(4) $CFV\_SM\_cbop\_5$	0.632	0.875	0.715	1				
(5) $CFV\_DL\_oi\_1$	0.574	0.482	0.606	0.461	1			
(6) $CFV\_DL\_cbop\_1$	0.422	0.556	0.444	0.589	0.396	1		
(7) $CFV\_DL\_oi\_5$	0.811	0.689	0.893	0.669	0.704	0.473	1	
(8) $CFV\_DL\_cbop\_5$	0.655	0.851	0.698	0.922	0.514	0.650	0.748	1

Table 4: Summary Statistics

This table shows summary statistics of variables of the study for non-financial and non-utility US companies during 1974-2012. All the variables are winsorized at 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. Appendix B defines the variables.

Variable	N	mean	p25	p50	p75	sd
$MDR1$	134581	0.367	0.160	0.338	0.549	0.241
$BDR1$	134581	0.466	0.299	0.472	0.621	0.216
$MDR2$	134581	0.238	0.0236	0.167	0.389	0.238
$BDR2$	134581	0.296	0.0562	0.270	0.471	0.250
$MDR3$	134581	0.194	0.00454	0.113	0.319	0.219
$BDR3$	134581	0.242	0.0116	0.191	0.399	0.237
$Tangibility$	134367	0.283	0.110	0.231	0.398	0.219
$FirmSize$	134581	4.642	3.162	4.500	6.003	2.060
$FirmAge$	134581	9.779	3	7	14	8.851
$Profitability$	134034	0.0718	0.0385	0.117	0.179	0.208
$MarketToBook$	130515	1.622	0.714	1.054	1.794	1.682
$EquIssue$	134576	0.523	0	0	0.163	2.914
$IndustLev$	134581	0.344	0.232	0.338	0.446	0.142
$LnRnD$	132772	0.0796	0	0	0.0437	0.263
$Inflation$	134581	0.0454	0.0260	0.0394	0.0601	0.0247
$CreditRating$	134581	0.0681	0	0	0	0.252
$CFV\_KS\_oi\_5$	104408	1.961	1.302	1.876	2.512	0.992
$CFV\_KS\_cbop\_5$	97960	2.229	1.670	2.169	2.708	0.853
$CFV\_SM\_oi\_5$	97377	1.854	1.125	1.776	2.484	1.071
$CFV\_SM\_cbop\_5$	91394	2.397	1.806	2.349	2.920	0.893
$CFV\_DL\_oi\_1$	131119	1.885	0.986	1.916	2.837	1.552
$CFV\_DL\_cbop\_1$	124281	2.263	1.476	2.364	3.161	1.413
$CFV\_DL\_oi\_5$	97327	2.135	1.410	2.002	2.724	1.061
$CFV\_DL\_cbop\_5$	91373	2.543	1.945	2.479	3.066	0.893

Table 5: Summary of $ZerobyMaturity$

This table shows summary of $ZerobyMaturity$ for non-financial and non-utility US companies during 1974-2012. The table reports the number of observations, the frequency and the percentage of the sample firms existing in the each category of $ZerobyMaturity$. Appendix B defines the variables.

Category	Description	Freq.	Percent	Cum.
1	Debt maturity more than ten years	22,944	17.05	17.05
2	Zero debt that matures in more than ten years	60,117	44.67	61.72
3	Zero debt that matures in five to ten years	25,110	18.66	80.38
4	Zero total long term debt	7,548	5.610	85.98
5	Zero long-term and short-term debt	18,862	14.02	100
Total		134,581	100	

Table 6: Correlations

This table shows the pairwise correlation coefficients between explanatory variables. Appendix B defines the variables. Reference numbers in columns and rows refer to the variables associated with the pairwise correlation coefficients.

Pairwise Correlations Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) $Tangibility$	1										
(2) $FirmSize$	0.144	1									
(3) $FirmAge$	0.0211	0.410	1								
(4) $Profitability$	0.187	0.307	0.127	1							
(5) $MarketToBook$	-0.155	-0.137	-0.108	-0.231	1						
(6) $EquIssue$	-0.0592	0.0298	-0.0764	-0.0567	0.361	1					
(7) $IndustLev$	0.263	0.203	0.103	0.237	-0.361	-0.120	1				
(8) $LnRnD$	-0.196	-0.129	-0.110	-0.578	0.355	0.133	-0.365	1			
(9) $Inflation$	0.0778	0.490	0.361	0.105	-0.0135	-0.0145	0.0880	-0.0576	-0.153	1	
(10) $CreditRating$	0.0773	0.493	0.352	0.103	-0.00100	-0.0111	0.0732	-0.0557	-0.157	1	
(11) $CFV\_KS\_oi\_5$	-0.218	-0.436	-0.297	-0.422	0.429	0.164	-0.404	0.450	-0.0990	-0.230	1

Table 7: Testing Hypothesis 1 - The effects of cash flow volatility on capital structure
This table shows estimation results of Equation (17) using GLM with a logit link function. All explanatory variables are lagged by one year. Columns (1) to (6) show estimation results using the different capital structure measures as the dependent variable and $LCFV\_KS\_oi\_5$ as the variable of interest. Appendix B 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) $MDR1$	(2) $BDR1$	(3) $MDR2$	(4) $BDR2$	(5) $MDR3$	(6) $BDR3$
$LCFV\_KS\_oi\_5$	-0.203***	-0.106***	-0.295***	-0.223***	-0.309***	-0.234***
	(0.00721)	(0.00755)	(0.0108)	(0.0106)	(0.0114)	(0.0112)
$LTangibility$	0.204***	0.290***	0.784***	0.930***	1.089***	1.218***
	(0.0298)	(0.0321)	(0.0439)	(0.0437)	(0.0470)	(0.0465)
$LFirmSize$	0.0404***	0.0772***	0.0276***	0.0539***	0.0782***	0.106***
	(0.00391)	(0.00423)	(0.00584)	(0.00592)	(0.00619)	(0.00628)
$LFirmAge$	-0.0105***	-0.00595***	-0.0178***	-0.0125***	-0.0182***	-0.0128***
	(0.000798)	(0.000880)	(0.00122)	(0.00125)	(0.00128)	(0.00131)
$LProfitability$	-1.483***	-1.180***	-1.761***	-1.512***	-1.516***	-1.270***
	(0.0400)	(0.0377)	(0.0589)	(0.0550)	(0.0634)	(0.0596)
$LMarketToBook$	-0.478***	-0.0671***	-0.522***	-0.0918***	-0.523***	-0.0876***
	(0.00725)	(0.00422)	(0.0109)	(0.00678)	(0.0122)	(0.00756)
$LLnRnD$	-0.682***	-0.512***	-1.070***	-0.630***	-0.863***	-0.450***
	(0.0422)	(0.0339)	(0.113)	(0.0687)	(0.126)	(0.0758)
$LEquIssue$	0.00138	-0.00224*	-0.00235	-0.000987	-0.00332	-0.000769
	(0.00140)	(0.00125)	(0.00191)	(0.00189)	(0.00207)	(0.00204)
$LIndustLev$	1.690***	1.223***	2.030***	1.603***	2.017***	1.583***
	(0.0540)	(0.0557)	(0.0841)	(0.0804)	(0.0899)	(0.0856)
$LInflation$	3.318***	1.858***	3.143***	1.958***	3.129***	1.700***
	(0.220)	(0.233)	(0.311)	(0.322)	(0.334)	(0.346)
$LCreditRating$	-0.0860***	0.207***	-0.119***	0.232***	-0.233***	0.0939***
	(0.0202)	(0.0243)	(0.0319)	(0.0340)	(0.0328)	(0.0346)
Constant	-0.208***	-0.588***	-0.834***	-1.233***	-1.451***	-1.843***
	(0.0385)	(0.0392)	(0.0576)	(0.0554)	(0.0617)	(0.0594)
Observations	95,244	95,244	95,244	95,244	95,244	95,244

Table 8: Testing Hypothesis 2 - The effects of cash flow volatility on maturity of debt
This table shows estimation results of Equation (18) using an ordered probit model. The dependent variable is the categorical variable $ZerobyMaturity$. Columns (1) and (2) report the estimation results using a cross-sectional and a panel ordered probit model, respectively. Appendix B defines the variables. Clustered standard errors by firm are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

	Dependent variable = $ZerobyMaturity$	
	(1)	(2)
VARIABLES	Cross-sectional	Panel
$LCFV\_KS\_oi\_5$	0.238***	0.181***
	(0.00511)	(0.0134)
$LTangibility$	-0.936***	-1.658***
	(0.0172)	(0.0763)
$LFirmSize$	-0.125***	-0.173***
	(0.00241)	(0.0113)
$LFirmAge$	-0.00229***	0.0234***
	(0.000493)	(0.00214)
$LProfitability$	0.419***	0.319***
	(0.0263)	(0.0567)
$LMarketToBook$	0.0594***	0.0374***
	(0.00303)	(0.00635)
$LLnRnD$	0.0570***	0.213***
	(0.0203)	(0.0485)
$LEquIssue$	-0.00907***	-0.00660***
	(0.00153)	(0.00191)
$LIndustLev$	-0.897***	-2.475***
	(0.0294)	(0.117)
$LInflation$	-13.24***	-7.053***
	(0.173)	(0.436)
$LCreditRating$	-0.718***	-0.535***
	(0.0168)	(0.0650)
Observations	95,244	95,235

Table 9: Predicted $ZerobyMaturity$

This table shows predicted values of $ZerobyMaturity$ using an ordered probit model. The table reports the predicted $ZerobyMaturity$ at mean and at mean+1SD of $LCFV\_KS\_oi\_5$. All other explanatory variables are set to mean values. Appendix B defines the variables.

Category	Description	Predicted $atmean$	Predicted $atmean + 1SD$	Δ	$\%\Delta$
1	Debt maturity more than ten years	0.181	0.134	-0.047	-26%
2	Zero debt that matures in more than ten years	0.464	0.433	-0.031	-7%
3	Zero debt that matures in five to ten years	0.186	0.207	0.021	11%
4	Zero total long term debt	0.051	0.062	0.011	22%
5	Zero long-term and short-term debt	0.118	0.164	0.046	39%

Table 10: Capital Structure Variables by Cash Flow Volatility Quantiles
This table shows the mean of the capital structure control variables by 5-quantiles of cash flow volatility. Column 1 represents the lowest cash flow volatility quantile and Column 5 represents the highest cash flow volatility quantile. The t-test columns show the t-stat of the difference in the mean between the first versus the fifth quantiles and the fourth versus the fifth quantiles. Note that the P-values are less than 0.01 for every test. Appendix B defines the variables.

	Cash Flow Volatility Quantiles						
	1	2	3	4	5	t-stat	t-stat
VARIABLES	Low				High	1 vs 5	4 vs 5
$Tangibility$	0.327	0.317	0.309	0.286	0.197	63.77	43.6715
$FirmSize$	6.043	5.247	4.699	4.126	3.394	145.53	44.16
$FirmAge$	13.64	11.46	9.876	8.378	6.124	92.81	33.2
$Profitability$	0.132	0.135	0.134	0.112	-0.0530	83.99	71.45
$MarketToBook$	1.031	1.164	1.339	1.659	2.873	-99.12	-61.2
$LnRnD$	0.0137	0.0194	0.0271	0.0498	0.262	-73.47	-60.92
$EquIssue$	0.204	0.292	0.412	0.552	1.203	-39.11	-22.65
$IndustLev$	0.409	0.384	0.364	0.329	0.251	128.84	63.24
$Inflation$	0.0464	0.0498	0.0504	0.0491	0.0418	26.34	34.25
$CreditRating$	0.19	0.103	0.06	0.028	0.009	61.26	13.75

Table 11: Robustness to econometric method

This table reports the coefficients associated with $LCFV\_KS\_oi\_5$ using different econometric procedures. Column (1) uses the GLM panel data model, Column (2) uses the zero inflated beta model, and Column (3) uses OLS (ordinary least squares). Appendix B defines the variables. Clustered standard errors by firm are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

Dependent variables	(1) GLM panel data model	(2) Zero inflated beta model	(3) OLS
$MDR1$	-0.162***	-0.205***	-0.0489***
	(0.00571)	(0.00345)	(0.00159)
$BDR1$	-0.0447***	-0.101***	-0.0254***
	(0.00567)	(0.00346)	(0.00179)
$MDR2$	-0.200***	-0.246***	-0.0522***
	(0.00786)	(0.00469)	(0.00177)
$BDR2$	-0.109***	-0.162***	-0.0419***
	(0.00773)	(0.00479)	(0.00201)
$MDR3$	-0.212***	-0.237***	-0.0470***
	(0.00834)	(0.00490)	(0.00164)
$BDR3$	-0.121***	-0.154***	-0.0381***
	(0.00819)	(0.00502)	(0.00187)

Table 12: Robustness to volatility measures

This table reports the coefficients associated with eight cash flow volatility variables using the GLM model with the logit link function in columns (1) to (6) and an ordered probit model in column (7). Appendix B defines the variables. The standard errors are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

	Dependent Variables						
Cash flow	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Volatility Variables	$MDR1$	$BDR1$	$MDR2$	$BDR2$	$MDR3$	$BDR3$	$ZerobyMaturity$
$L.CFV\_KS\_oi\_5$	-0.203***	-0.106***	-0.296***	-0.223***	-0.309***	-0.234***	0.238***
	(0.00755)	(0.00755)	(0.0108)	(0.0106)	(0.0114)	(0.0112)	(0.00511)
$L.CFV\_KS\_cbop\_5$	-0.0775***	-0.0170**	-0.146***	-0.112***	-0.185***	-0.148***	0.234***
	(0.00827)	(0.00836)	(0.0127)	(0.0122)	(0.0134)	(0.0129)	(0.00569)
$L.CFV\_SM\_oi\_5$	-0.0706***	-0.0682***	-0.142***	-0.140***	-0.168***	-0.162***	0.219***
	(0.00698)	(0.00732)	(0.0106)	(0.0105)	(0.0114)	(0.0112)	(0.00480)
$L.CFV\_SM\_cbop\_5$	0.00958	0.0278***	-0.0488***	-0.0393***	-0.0926***	-0.0791***	0.179***
	(0.00823)	(0.00846)	(0.0128)	(0.0124)	(0.0135)	(0.0132)	(0.00554)
$L.CFV\_DL\_oi\_1$	-0.0333***	-0.0337***	-0.0484***	-0.0494***	-0.0540***	-0.0534***	0.0803***
	(0.00260)	(0.00273)	(0.00372)	(0.00373)	(0.00398)	(0.00397)	(0.00259)
$L.CFV\_DL\_cbop\_1$	-0.00378	0.00105	-0.0142***	-0.0124***	-0.0250***	-0.0221***	0.0570***
	(0.00267)	(0.00272)	(0.00387)	(0.00381)	(0.00408)	(0.00404)	(0.00273)
$L.CFV\_DL\_oi\_5$	-0.0903***	-0.0811***	-0.136***	-0.127***	-0.157***	-0.141***	0.248***
	(0.00760)	(0.00793)	(0.0115)	(0.0113)	(0.0123)	(0.0121)	(0.00503)
$L.CFV\_DL\_cbop\_5$	0	0.0252***	-0.0309**	-0.0150	-0.0691***	-0.0484***	0.204***
	(0.00875)	(0.00904)	(0.0133)	(0.0131)	(0.0141)	(0.0139)	(0.00567)

Table 13: Robustness to window size

This table shows the coefficients associated with the cash flow volatility measures using GLM with a logit link function. The dependent variable is $MDR3$. The rolling years column shows the number of years in the window. Columns (1), (3), (5), (7), (9) and (11) represent the coefficients associated with KS-operating income, KS-cash based operating profitability, DL-operating income, DL-cash based operating profitability, SM-operating income, SM-cash based operating profitability, respectively. Columns (2), (4), (6), (8), (10) and (12) show the number of observations in the model using each cash flow volatility measures. Appendix B defines the variables. The standard errors are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

	Cash flow volatility							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Window	KS_oi	Obs	KS_cbop	Obs	DL_oi	Obs	DL_cbop	Obs
1	na	na	na	na	-0.0540***	109,613	-0.0250***	104,018
2	na	na	na	na	-0.0982***	103,871	-0.0427***	97,226
3	-0.215***	109,363	-0.126***	103,863	-0.120***	103,628	-0.0568***	97,083
4	-0.212***	97,045	-0.124***	90,833	-0.132***	90,574	-0.0316**	82,634
5	-0.309***	95,245	-0.185***	89,378	-0.157***	89,035	-0.0691***	83,563

Table 14: Robustness to different debt maturity variables
This table shows estimation results of re-testing Hypothesis 2 with alternative debt maturity variables using the $LCFV\_KS\_oi\_5$ as the variable of interest. The alternative debt maturity variables are constructed in Section 3.2.1. In columns (1) and (2) we use GLM with a logit link function. In columns (3) and (4) we use zero inflated beta model. Appendix B defines the variables. The standard errors are shown in parentheses with 1%, 5% and 10% significance level denoted by ***, ** and *, respectively.

	GLM		Zero Inflated Beta	
	(1)	(2)	(3)	(4)
VARIABLES	$DebtMat\_D$	$DebtMat\_L$	$DebtMat\_D$	$DebtMat\_L$
$LCFV\_KS\_oi\_5$	-0.0687***	-0.222***	-0.0640***	-0.143***
	(0.0114)	(0.0112)	(0.00667)	(0.00555)
$LTangibility$	0.910***	1.465***	0.698***	1.207***
	(0.0492)	(0.0481)	(0.0223)	(0.0183)
$LFirmSize$	0.228***	0.130***	0.187***	0.112***
	(0.00676)	(0.00625)	(0.00307)	(0.00251)
$LFirmAge$	-0.00650***	-0.0153***	-0.00495***	-0.00909***
	(0.00126)	(0.00128)	(0.000619)	(0.000519)
$LProfitability$	0.345***	-0.367***	0.377***	-0.0977***
	(0.0649)	(0.0619)	(0.0399)	(0.0325)
$LMarketToBook$	0.0111	-0.0326***	0.0152***	-0.0109***
	(0.00755)	(0.00730)	(0.00447)	(0.00362)
$LLnRnD$	0.306***	0.103	0.211***	0.213***
	(0.0531)	(0.0672)	(0.0320)	(0.0268)
$LEquIssue$	0.00136	0.00606***	0.00304	0.00164
	(0.00238)	(0.00209)	(0.00211)	(0.00173)
$LIndustLev$	0.460***	0.749***	0.477***	0.718***
	(0.0844)	(0.0891)	(0.0373)	(0.0315)
$LInflation$	6.290***	3.963***	5.313***	5.329***
	(0.377)	(0.329)	(0.198)	(0.161)
$LCreditRating$	-0.0798**	-0.0440	-0.0725***	0.0199
	(0.0376)	(0.0323)	(0.0185)	(0.0155)
Constant	-1.662***	-2.190***	-1.507***	-2.196***
	(0.0592)	(0.0589)	(0.0297)	(0.0246)
Observations	82,510	95,244	82,510	95,244

Highlights

- Construct several alternative measures of cash flow volatility.
- Test the relationship between cash flow volatility and a firm's use of debt.
- A one standard deviation increase from the mean of cash flow volatility implies:
- A 24% decrease in the long-term debt ratio,
- A 39% increase in the probability of holding zero short or long term debt, and
- A 26% decrease in the probability of holding debt with over ten years to maturity.