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ORIGINAL RESEARCH

The joint determinants of cash holdings and debt maturity: the case for financial constraints

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Abstract We examine the joint choices of cash holdings and debt maturity for a large sample of firms for the 1985–2013 period. We find that there is a positive relation between debt maturity and cash holdings. Our results hold after taking into account endogeneity among leverage, debt maturity, and cash holding. We posit that this positive relationship will be found among firms facing financial constraints and we find support for this hypothesis. Our results are robust after we control for agency problems, international taxation, bank loan liquidity covenants and default risk.

Keywords Cash holdings · Debt maturity · Financial constraints

JEL Classifications G32 · G34

1 Introduction

The financial press has noted an interesting anomaly in recent years as exemplified by the following report offered by the *Financial Times*:

> The swelling cash reserves of … have raised the overall liquidity of corporate America to record levels… The figures from Moody's are based on gross cash and liquid investments held by companies and do not reflect the increasing debt levels that have left corporate America with rising financial leverage. However, the agency said many companies had taken advantage of low bond yields to extend the maturity

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of borrowings, and that liquid resources have grown to outweigh all debt repayments due in the next 5 years.[1]

Prior studies have examined the joint choice of leverage and debt maturity and that of leverage and cash. But the above news report suggests that the choice of leverage, debt maturity, and the level of cash are jointly determined by management as a function of the firm characteristics and macroeconomic environment. In this paper, we investigate the determinants of cash holdings and debt maturity (while endogenously controlling for leverage) using a sample of 11,729 firms (76,928 firm-year observations) for the 1985–2013 period. We address the following question: Do firms with more long-term debt tend to have more or less cash?

Firms that suffer from information asymmetry would finance their operations according to Myers and Majluf's (1984) *pecking order hypothesis*. That is, such firms would first use cash and then debt to finance investment opportunities before issuing new equity. According to this argument, if firms must borrow, they would issue short-term debt to reduce the underpricing of claimants before relying on long-term debt. In contrast, Acharya et al. (2007) argue that firms with severe information asymmetry problems may have incentive to hold cash and simultaneously borrow because the firm does not want to use their cash reserve for current investments. They believe such firms may find it difficult to raise external capital to sufficiently fund future investments. Instead, firms may borrow first to fund current investment needs in order to have the flexibility to fund future investments.

Given that firms have an incentive to borrow and hold cash, the question remains as to the maturity of the debt. Sun (2014) develops a multi-period dynamic model to examine the financing decision when access to future credit is risky and there is an exogenous supply of credit. He finds that firms at high risk of not obtaining future credit will optimally borrow long-term debt today in order to build up their cash reserves so that credit availability is not a factor in funding future projects.[2] Moreover, these firms are less likely to issue short-term debt since that would defeat the purpose of having the flexibility of having cash to fund future operations. In addition, Diamond (1991, 1993) demonstrates that short term debt carries an implicit cost. In particular, he argues that lenders have incentive to prematurely liquidate a firm in financial distress because the firm's private information concerning the value of the investment opportunity is not accurately reflected in the market or to the lender. Early liquidation concerns would prevent firms from only issuing short-term debt. Hence, we expect that financially constrained firms are more likely to eschew short-term debt and use long-term debt to enhance a cash reserve. This argument closely resembles the precautionary motive in determining cash holdings (e.g., Jun and Jen 2003; Almeida et al. 2004; Bates et al. 2009; DeAngelo et al. 2011).

We examine both the effect of cash holdings on debt maturity, as well as that of debt maturity on cash holdings. Our pooled regression results show a significantly positive relationship between debt maturity and cash holdings. We then estimate simultaneous equation models using GMM methodology to take into account the endogeneity of cash holdings, debt maturity, and leverage. It is important to take into account the endogeneity of leverage since firms may not have access to long term credit markets in the face of uncertainty. In fact, our results hold even when we account for endogeneity.

[1] http://www.ft.com/cms/s/0/cb4fb6e6-8ff6-11e2-ae9e-00144feabdc0.html#axzz31bmlWm42.

[2] Chaderina (2013) builds a dynamic multi-period model that allows for costly default but assumes that firms have perfect access to the capital markets. In her model, firms face the possibility of a negative exogenous news shock that would induce investors to shun the firm. As a result, she predicts that firms would prefer to build up cash reserves by borrowing long-term debt.

Our predictions are based upon the precautionary motivations for cash holdings. This implies that we should expect our results to be stronger for firms that are financially constrained who are more likely to be governed by the precautionary motive. We use five different measures to characterize firms with financial constraints. We assume that firms facing financial constraints (1) have debt that is not rated; (2) are small in size as proxied by the level of assets; and (3) pay no dividends. These proxies are similar to those used by Fazzari et al. (1988), Erickson and Whited (2000), Fama and French (2002), Frank and Goyal (2003), Faulkender and Petersen (2006), and Acharya et al. (2007). In addition, we follow the investment sensitivity to cash flow literature which has also used Whited and Wu (WW; 2006) index and the Hadlock and Pierce (HP; 2010) index as two additional proxies for financial constraints. Accordingly, we dichotomize the sample between firms facing financial constraints and those that do not. We find that the positive relationship between cash holdings and debt maturity generally holds for those firms facing financial constraints even after controlling for potential endogeneity. The results are robust to alternative measures of debt maturity. We also test whether the positive relation between cash holdings and debt maturity could be explained by entrenched managers. Jensen (1986) argues that entrenched managers are more likely to hold excess cash. In contrast, Harford et al. (2012) find that firms with weaker governance structures have lower cash reserves. Datta et al. (2005) and Brockman et al. (2010) show that entrenched (risk-averse) managers are likely to hold long-term debt even if it is not in the best interest of the firm. Gupta and Lee (2006) develop a multi-period financing model that would minimize cash surplus to reduce agency cost problems. We utilize the Entrenchment Index (E Index) developed by Bebchuk et al. (2009) for all firms followed by the Investor Responsibility Research Center (IRRC) and managerial ownership to proxy for entrenched managers. If indeed agency problems explain the positive relation between cash holdings and debt maturity, then we would expect that this positive relation to be more significant in the subsample of firms with a high E-index (low managerial ownership). We find that there is no significant relation between debt maturity and cash among high E Index (low managerial ownership) firms. It is possible that we fail to find support for the agency cost because we are not estimating cash holdings in excess of those needed for operations and investment. We estimated excess cash following Dittmar and Mahrt-Smith (2007). We find that our results still hold if we use excess cash as our endogenous variable.

We conduct additional robustness tests to ascertain if alternative explanations may cause our results. For example, multinational firms may tend to hold large reserves of cash while borrowing long-term to avoid taxes in the United States. In addition, our results may be driven by distressed firms or low credit firms borrowing short-term debt and holding low cash reserves. In particular, low credit worthy firms may want to borrow long term to avoid liquidity risk, but long-term creditors will shun them. Moreover, capital-constrained firms may rely more on bank loans where such loans may require liquidity reserves, which in turn may explain the positive relationship we find between cash holdings and debt maturity. Finally, we examine whether over-confident CEOs drive our results. We show that these alternative explanations do not overturn our results.

Our study makes several contributions to the literature. First, we show that there is a positive relationship between cash holdings and debt maturity for firms facing financial constraints. Researchers who empirically study the firm’s debt maturity structure have found that firm characteristics such as asset maturity, growth opportunities, firm size, managerial ownership, compensation risk, firm location, institutional quality, and country culture impact the debt maturity structure.[3] Our results complement these authors' findings by showing that cash holdings are useful in helping to avoid adverse shocks to cash flows, which ultimately impact the structure of debt maturity.

Second, our paper helps fill a gap between two strands of literature: the determinants of cash holdings and that of debt maturity. There is a growing debate on the maturity choices of firms in light of the recent financial crisis. Custódio et al. (2013) suggest that there has been a decrease in debt maturity for all U.S. firms, which exacerbated the effects of the 2007–2008 financial crisis on the real economy. Short-term debt is implicated as a contributing factor to excessive defaults. Although *long-term* debt is usually attributed to debt overhang problems (Myers 1977), Duchin et al. (2010), Veronesi and Zingales (2010), and Almeida et al. (2012) have all pointed out that *short-term* debt also causes debt overhang problems, especially during the recent financial crisis. Diamond and He (2014) model the tradeoff between short-term debt overhang and long-term debt overhang and propose cash holding to be a potential solution for the overhang problem. They suggest that cash reserves can be used to pay off short- or long-term debt depending on the state realization. Therefore, debt maturity and cash holdings are chosen together ex ante to minimize debt overhang problems and maximize firm value. Our findings indicate that cash holdings allow firms to hold longer-term debt.

The paper most close to our own is the paper by Harford et al. (2014). Their paper analyzes how refinancing risk impacts upon the cash holdings. They find support for their hypothesis that as firms shorten their debt maturity, the cash holdings increase to mitigate refinancing risk. As a result of their paper's focus, they do not include in their debt maturity variable any debt that was issued with a maturity of less than 1 year.[4] We were able to replicate Harford et al. (2014) results when we use their definition of debt maturity. In contrast, our paper includes in our debt maturity definition all debt regardless of its original maturity as is done by Barclay and Smith (1995), Guedes and Opler (1996), Barclay et al. (2003), Johnson (2003), and Custódio et al. (2013).

Much media and academic attention has been devoted to the increase in cash holdings of U.S. firms. For example, Internal Revenue Service (IRS) data show that in 2009 non-financial companies held \$4.8 trillion in liquid assets, with 11.3 % of their assets in cash.[5] An article in *The Wall Street Journal* reports how 11 companies, including Apple Inc., Microsoft, and Cisco Systems Inc., held foreign cash balances of \$10 billion or more.[6] The increase in cash holdings is not an exclusive phenomenon of the recent financial crisis. Even prior to the crisis, Bates et al. (2009) documented a secular increase in the cash holdings of a typical firm from 1980 to 2006. Meanwhile, Custódio et al. (2013) find a decrease in debt maturity since the 1980s. Thus one might conclude that cash holdings and debt maturity should be negatively related based upon these secular trends. However, not all firms are equally equipped with extra liquidity. As shown by Campello et al. (2010), managers' report that they often felt credit constrained in the global financial crisis of 2008

[3] See for example, Arena and Dewally (2012), Barclay and Smith (1995), Billet et al. (2009), Brockman et al. (2010), Cheng et al. (2008), Datta et al. (2005), Guedes and Opler (1996), Johnson (2003), Kirch and Terra (2012), Jun and Jen (2005), Stohs and Mauer (1996) and Zheng et al. (2012).

[4] As they state in their paper: "However, we exclude debt with less than a year to maturity when issued from our debt maturity/refinancing risk measure. We do so because non-financial firms typically pay this debt when it is due rather than refinancing it, as it is used to finance a firms short-term assets and other short-term liquidity needs that are often seasonal in nature." Although our sample period is somewhat different, we replicated their results using the identical sample period which ends 2008. The sample period in our paper ends in 2013.

[5] http://www.reuters.com/article/2012/07/16/us-column-dcjohnston-idlecash-idUSBRE86F0GK20120716.

[6] http://online.wsj.com/article/SB10001424053111903927204576574720017009568.html.

and burned through more cash despite deeper cuts in capital, technology, and employment spending. Our hypotheses are built upon a cross-sectional relationship and our tests include year fixed effects and/or time trends. Interestingly, when we consider debt maturity, cash holdings (and leverage) jointly, we find a positive relationship for financially constrained firms consistent with our hypothesis.

2 Data and methodology

We construct our sample from the CRSP/Compustat Merged file for a large unbalanced panel of firms for the years 1985–2013. As is traditionally done in empirical corporate finance studies, we have deleted firms from our final sample that are from the financial services industry (SIC Codes between 6000 and 6999) and regulated industry (SIC Codes between 4900 and 4999). We did so because financial firms, utilities and other regulated firms may hold cash for regulatory concerns. Similarly, the debt maturity of these firms is also subject to regulations. We also deleted firm observations with assets less than $1 million and a share price of less than $5.[7] Our data consist of 11,729 firms resulting in 76,928 firm observations.

We have two main dependent variables. The first dependent variable is the ratio of the book value of cash and marketable securities to total assets, which we denote as *cash holdings*. For the second dependent variable, we use the percentage of debt that matures in more than 3 years as a proxy for the ratio of long-term debt to total debt.[8] This proxy for debt maturity is similar (in spirit) to Barclay and Smith (1995), Guedes and Opler (1996), Barclay et al. (2003), Johnson (2003), and Custódio et al. (2013).[9] Compustat provides the book value of debt maturing in 2, 3, 4, and 5 years (*DD2, DD3, DD4,* and *DD5*, respectively). Compustat also gives the book value of debt that has a maturity of greater than one year as *DLTT*. Hence our debt maturity proxy equals (*DLTT-DD2-DD3*)/*total debt*. *Total debt* equals *DLTT* + *DLC*, where *DLC* is the Compustat variable for the sum of the current portion of long-term debt (debt due in 1 year) and the total amount of short-term notes. In order to avoid measurement errors, we deleted from our sample any observation with a negative entry for any of the Compustat debt variables. In addition, we restrict our debt maturity proxy to be less than 100 %.

We use analogous control variables for our cash holdings regressions following Opler et al. (1999) and Bates et al. (2009).[10] We proxy the growth opportunity of the firm by the ratio of the *market value of the firm to its book value*. The market value of the firm is

[7] In unreported tables, we remove this filter and obtain similar results.

[8] Our definition of debt maturity is not defined when firms have zero debt. Consequently, those firms are omitted from our analysis.

[9] Guedes and Opler (1996) suggest that some debt maturity questions are better answered using incremental debt issuance data. If we followed this procedure, we would have to omit from our analysis all private loans, especially those with short maturities, in order for us to use the debt maturity of incremental issues of public debt or syndicated loans. Therefore, we would be introducing a measurement error when we calculate debt maturity for financially constrained firms, which by definition are more reliant on the private debt market. Furthermore, both our OLS firm fixed effect model and the Arellano and Bover (1995) GMM model focus on the incremental changes in debt maturity.

[10] We also included as a control variable the cash flow variable defined as EBITDA/total assets since one might expect the level of the cash holdings to be related to the cash flow. Adding this variable did not affect our results and we report only those regressions that contain the same variables as Opler et al. (1999) and Bates et al. (2009).

measured by the book value of its assets minus the book value of its equity plus the market value of the equity at the fiscal year end. We also proxy the growth opportunities of a firm by the ratio of its *R&D expenditures/sales*. If R&D data are missing in Compustat, we assume that the level of R&D expenditures is zero. We include firm size, defined as the logarithm of total assets. Other control variables are a firm's *leverage ratio*, level of *capital expenditures*, total *dividend payments*, *level of acquisition activity*, and industry cash flow risk. We compute the firm's *leverage ratio* as the ratio of *total debt to total assets*. We scale *capital expenditures*, *dividend payments*, and *acquisition activity* by total assets as well. We measure *acquisition activity* by the cash outflow associated with acquisitions. We define industry cash flow risk by finding the average of the standard deviations of the first difference of EBITDA/total assets over 5 years for all firms in the same two-digit SIC code. We denote this variable as *Industry Sigma.* To account for the relation between *cash holdings* and *debt maturity*, we also include our *debt maturity* variable as a control variable. Including this variable in the pooled ordinary least squares (OLS) regressions introduces a potential endogeneity bias in the regression coefficients.

We account for endogeneity by following Arellano and Bover's (1995) generalized method of moments (GMM) methodology. The advantage of the Arellano and Bover's methodology is that we do not have to identify instrumental variables that satisfy exclusion restrictions that the error term of the second stage structured equation is not correlated with the instrumental variable. In particular, Arellano and Bover (1995) first check which lags are uncorrelated with the first-differenced residuals under the null hypothesis of no serial correlation. Consistent with their paper, for each regression specification we conduct an auto-regression test and find that 2 year lags are what we need as valid instrument variables. Further, the Arellano and Bover method uses these instrumental variables in both levels and differences.

For debt maturity regressions, we include control variables following Johnson (2003) and Billett et al. (2007). We include *firm size*, the *square of firm size*, *book leverage*, *cash flow volatility*, and *the ratio of the market value of the firm to the firm's book value*, as defined above. We use *abnormal earnings*, defined as year-over-year change in the operating earnings per share divided by the previous year's share price, to test for signaling effects (Flannery 1986; Diamond 1991). To control for maturity matching, we construct a measure of *asset maturity*, defined as the ratio of property, plant, and equipment divided by depreciation and amortization times the proportion of property, plant, and equipment in total assets, plus one half times the proportion of current assets in total assets (Myers (1977)). Note, since we have removed firms in regulated industries, we do not need a dummy variable for regulated firms as done in Johnson (2003) and Billett et al. (2007). Other control variables include the difference between the yield on 10-year Treasury bonds and the yield on 1-year Treasury bonds to proxy for *term-structure* effect, *investment tax credit dummy*, total *loss carry-forward dummy*, and a zero–one dummy for firms with rated debt.[11] Lastly, to account for the dependency of *debt maturity* to cash, we also include our *cash holding* variable as a control variable.

The sample is a cross-sectional time series, so we estimate four types of regressions. First, we estimate a pooled OLS regression that exploits cross-sectional and time series variation, mainly so that we can compare our results with other published studies. Second, since OLS t statistics from a pooled regression likely overstate the true significance level, we also estimate Fama–MacBeth regressions for two sub-periods: the 1990s and the 2000s.

[11] It is possible that debt maturity is more related to the corporate term structure, defined as the difference between the yields of the AAA and BBB debt found on the Federal Reserve Historical Interest Rate website. Generally, the results are identical to what we report in our tables and the corporate term structure is significantly negative.

We look at the two sub-periods because of the documentation by Bates et al. (2009) of a time trend in which *cash holdings* increased significantly during the millennial period. Third, we consider various specifications with fixed effects, including year, firm, industry, and combinations of these fixed effects. Lastly, we estimate simultaneous equation models using GMM methodology to account for endogeneity concerns with respect to *cash holdings* and *debt maturity*. The lagged level- and first-differences of other control variables, except for *leverage*, which is also jointly determined with *cash holdings* and *debt maturity*, are instruments in the moment conditions. Billett et al. (2007) use GMM and instrumental variables to account for potential endogeneity. We use the Arellano and Bover (1995) dynamic GMM technique since many of the variables (such as cash, leverage and maturity) have a persistent factor and thus it is important to include lagged variables in the estimation. Similar to Billett et al. (2007), we also include the product of (exogenous) control variable and endogenous variables in our estimation of system of equations, which requires a non-linear technique, such as GMM, to produce consistent estimates.

Note that because we use the identical control variables that the literature proposes for debt maturity and cash holdings, the set of control variables for the two regressions are not identical. In particular, the dividend and R&D control variables are not in the debt maturity regression and asset maturity and tax related variables are not included in the cash regression. These variables should not be interpreted as instrumental variables and the instrumental variables are those provided by the lagged and lagged first difference control variables as proposed by Arellano and Bover (1995). Our results are not sensitive when we ensure that control variables are identical across cash and debt maturity regressions.

We summarize the definitions of the variables in Table 1 and report summary statistics for firm characteristics in Panel A of Table 2. We winsorize *cash holdings*, cash flow volatility (*Industry Sigma*), *capital expenditure/assets*, *book leverage*, *R&D/sales*, *acquisitions/assets, asset maturity*, and *abnormal earnings* at the top and bottom 1 % levels. We also winsorize the market-to-book ratio at the top 1 % level. Mean (median) proportion of long-term debt to total debt is 0.5 (0.55) and varies widely across firms, with a standard deviation of 0.35. Mean (median) *leverage* is 0.2 (0.18) and also varies widely across firms, with a standard deviation of 0.17. *Cash holdings* have a mean (median) of 0.10 (0.06). These statistics are consistent with previous studies, such as Johnson (2003), Bates et al. (2009), and Custódio et al. (2013). Firms, on average, have a 60 % higher market value of assets than book value of assets, and show positive *abnormal earnings* (median = 0.04), although it is evident that many firms have negative *abnormal earnings* because its standard deviation is 3.57. *Asset maturity* is about 2.7 years, which is lower than documented in Johnson (2003) (6 years) and Custódio et al. (2013) (9 years). One possible reason for the differences is our sample ends in 2013 and that firms have reduced their capital investment since the 2007 financial crisis. We proxied the asset life of current assets as 0.5 years, whereas both Johnson (2003) and Custódio et al. (2013) defined the short-term asset maturity as equal to the ratio of current assets to the costs of goods sold. Fourteen percent of our sample firms have investment tax credit, 32 % have total loss carry-forwards, and 27 % have bond ratings. Finally, we report the correlation matrix of our variables in Panel B of Table 2.

3 Results

The results are presented in four subsections. In the first subsection, we focus on the results in the cash holdings regression. In the second subsection, we focus on the results of the debt maturity regression. In the third subsection, we examine both *cash holdings* and *debt* *maturity* using a system of equations. We test whether the relation between *cash holdings* and *debt maturity* varies depending on firm characteristics. In the fourth subsection, we use alternative definitions of *debt maturity* as robustness checks.

3.1 Cash regression results

Table 3 presents the results using three definitions of *cash holdings* as the dependent variable: (1) the *cash holdings* defined as the ratio *of cash and marketable securities to total assets*; (2) the natural logarithm of the ratio in (1), denoted as *logcash*; and (3) the changes in *cash holdings* as defined in (1), denoted *dcash*. The traditional measure of cash holdings is the ratio of cash and marketable securities to total assets as in (1), so we use it for most of our regression analyses. However, our results are qualitatively similar

Table 1 Variable definitions

Variable	Definition
Cash/total assets	The ratio of cash and marketable securities to the book value of total assets
Industry sigma	The mean of the standard deviations of cash flow/assets over 5 years for firms in the same industry, as defined by the two-digit SIC code
Fraction of long-term debt (ltmature)	Ratio of long-term debt (debt maturing in three or more years (DD4 + DD5)) to total debt. Total debt is defined as debt in current liabilities (DLC) plus long-term debt (DLTT)
Market-to-book	Measured as (book value of total assets – book value of equity + market value of equity)/book value of total assets
Log firm size	The natural log of the book value of total assets
Capex	The ratio of capital expenditures to the book value of total assets
Leverage	The ratio of total debt to the book value of total assets, where debt includes long-term debt plus debt in current liabilities
R&D/sales	The ratio of research and development expense to sales
Dividend/total assets	The ratio of total dividend to the book value of total assets
Acquisition/total assets	The ratio of acquisition expenditures to the book value of total assets
Log cash	Log of the ratio of cash/total assets
Lag dcash	The cash ratio minus the lagged cash ratio
Asset maturity	Ratio of property, plant, and equipment (PPEGT) over depreciation and amortization (DP) times the proportion of property, plant and equipment in total assets (PPEGT/AT), plus half times the proportion of current assets in total assets (ACT/AT)
Volatility	The standard deviations of cash flow/assets over 5 years
Investment tax credit dummy	Dummy variable that takes the value of one if a firm has a credit rating BBB or above
Total loss carryforward dummy	Dummy variable that takes the value of one if a firm has total operating loss carryforwards and zero otherwise
Rated firm dummy	Dummy variable that takes the value of one if a firm has a S&P domestic long-term issuer credit rating (*SPLTICRM*)
Abnormal earnings	The year-over-year change in the operating earnings per share divided by the previous year's share price
Term structure	Difference between the yield on 10-year government bonds and the yield on 1-year government bonds.
Investment grade dummy	Dummy variable that takes the value of one if a firm has a credit rating BBB or above

Table 2 Summary statistics and correlation matrix

Variable	Mean	Median	SD	Min.	Max.	Obs.
Panel A						
Fraction of long-term debt	0.50	0.55	0.35	0.00	1.00	63,736
Cash/total assets	0.10	0.06	0.10	0.01	0.31	76,928
Industry sigma	0.06	0.06	0.02	0.03	0.09	69,487
Market-to-book	1.60	1.28	0.94	0.00	3.54	76,732
Log firm size	5.95	5.79	2.01	0.04	13.59	76,928
Log firm size squared	39.48	33.51	25.78	0.00	184.68	76,928
Capex	0.06	0.05	0.04	0.01	0.15	76,094
Leverage	0.20	0.18	0.17	0.00	0.48	76,855
Dividend/total assets	0.02	0.00	0.06	0.00	0.14	76,030
R&D/sales	0.04	0.00	0.07	0.00	0.24	76,928
Acquisition/total assets	0.02	0.00	0.03	0.00	0.09	73,548
Abnormal earnings	0.10	0.04	3.57	−6.62	6.84	58,997
Term structure	1.79	1.76	1.18	−0.53	3.76	76,590
Asset maturity	2.73	1.75	2.45	0.48	7.98	74,887
Volatility	0.06	0.04	0.07	0.00	2.96	37,613
Investment tax credit dummy	0.14	0.00	0.34	0.00	1.00	76,928
Total loss carryforward dummy	0.32	0.00	0.47	0.00	1.00	76,928
Rated firm dummy	0.27	0.00	0.45	0.00	1.00	76,928
Investment grade dummy	0.12	0.00	0.33	0.00	1.00	76,928

Table 2 continued

	Fraction of long-term debt	Cash/total assets	Industry sigma	Market-to-book	Log firm size	Log firm size squared	Capex	Leverage	Dividend/total assets	R&D/sales
Panel B										
Fraction of long-term debt	1.000									
Cash/total assets	−0.097[a]	1.000								
Industry sigma	−0.053[a]	0.211[a]	1.000							
Market-to-book	−0.055[a]	0.242[a]	0.171[a]	1.000						
Log firm size	0.266[a]	−0.075[a]	0.009[a]	−0.006[a]	1.000					
Log firm size squared	0.233[a]	−0.072[a]	0.019[a]	−0.011[a]	0.986[a]	1.000				
Capex	0.078[a]	−0.176[a]	−0.044[a]	0.092[a]	0.011[a]	0.011[a]	1.000			
Leverage	0.368[a]	−0.333[a]	−0.138[a]	−0.165[a]	0.185[a]	0.164[a]	0.043[a]	1.000		
Dividend/total assets	0.003[a]	0.000[a]	−0.003[a]	0.152[a]	0.062[a]	0.065[a]	0.009[a]	−0.020[a]	1.000	
R&D/sales	−0.081[a]	0.359[a]	0.340[a]	0.310[a]	−0.001[a]	0.011[a]	−0.153[a]	−0.178[a]	−0.043[a]	1.000
Acquisition/total assets	0.073[a]	−0.101[a]	0.033[b]	0.047[a]	0.065[a]	0.045[a]	−0.163[a]	0.108[a]	−0.031[a]	0.020[a]
Abnormal earnings	0.014[a]	−0.001[a]	0.030	0.028[a]	0.043[a]	0.040[a]	−0.021	0.012[a]	−0.017	0.010[a]
Term structure	−0.022[a]	0.064[a]	−0.056[a]	−0.046[a]	0.045[a]	0.047[a]	−0.083[a]	−0.019[c]	0.010[c]	−0.002[a]
Asset maturity	0.184[a]	−0.273[a]	−0.163[a]	−0.099[a]	0.110[a]	0.105[a]	0.525[a]	0.225[a]	0.031[a]	−0.307[a]
Volatility	−0.079[a]	0.191[a]	0.263[a]	0.140[a]	−0.202[a]	−0.188[a]	0.041[a]	−0.053[a]	−0.021[a]	0.221[a]
Investment tax credit dummy	0.000[a]	0.098[a]	0.057[a]	0.081[a]	0.019	0.017	−0.033[a]	−0.083[a]	−0.004[a]	0.237[a]
total loss carryforward dummy	0.048[a]	0.085[a]	0.091[a]	−0.031[a]	0.136[a]	0.124[a]	−0.128[a]	0.040[a]	−0.055[a]	0.103[a]
Rated firm dummy	0.374[a]	−0.133[a]	−0.022[a]	−0.041[a]	0.666[a]	0.649[a]	0.022[a]	0.339[a]	0.038[a]	−0.082[a]
Investment grade dummy	0.131[a]	−0.110[a]	0.006[a]	0.095[a]	0.568[a]	0.587[a]	0.062[a]	0.031[a]	0.117[a]	0.002
Frac. of Intl. sales	−0.043[a]	0.217[a]	0.274[a]	0.063[a]	0.331[a]	0.330[a]	−0.138[a]	−0.081[a]	0.002	0.290

Table 2 continued

	Acquisition/total assets	Abnormal earnings	Term structure	Asset maturity	Volatility	Inv. tax credit dummy	total loss carry forward dummy	Rated firm dummy	Invest grade dummy
Panel B									
Fraction of long-term debt									
Cash/total assets									
Industry sigma									
Market-to-book									
Log firm size									
Log firm size squared									
Capex									
Leverage									
Dividend/total assets									
R&D/sales									
Acquisition/total assets	1.000								
Abnormal earnings	0.026[a]	1.000							
Term structure	−0.076[a]	−0.003	1.000						
Asset maturity	−0.148[a]	−0.001[a]	0.001[c]	1.000					
Volatility	−0.031[a]	0.016	−0.012	−0.048[a]	1.000				
Investment tax credit dummy	0.019[a]	−0.001	0.035[a]	−0.086[a]	−0.005[a]	1.000			
total loss carryforward dummy	0.037[a]	0.012	0.029[a]	−0.125[a]	0.050[a]	0.052	1.000		
Rated firm dummy	0.036[a]	0.027[a]	0.028[a]	0.135[a]	−0.140[a]	−0.028[a]	0.101[a]	1.000	
Investment grade dummy	0.022[a]	0.019[a]	0.016	0.064[a]	−0.169[a]	0.004[a]	−0.013[a]	0.590[a]	1.000

Table 2 continued

	Acquisition/total assets	Abnormal earnings	Term structure	Asset maturity	Volatility	Inv. tax credit dummy	total loss carry forward dummy	Rated firm dummy	Invest grade dummy
Frac. of Intl. sales	0.025[a]	0.009[a]	0.029[a]	−0.162[a]	−0.002	0.044[a]	0.208[a]	0.147[a]	0.155[a]

This table reports summary statistics for an unbalanced panel of firms for the years 1985–2013 from the CRSP/Compustat Merged file. Firms from the financial services industry (SIC Codes between 6000 and 6999) and regulated industry (SIC Codes between 4900 and 4999), as well as observations with assets less than $1 million and a share price of less than $5 are deleted. Panel A presents the summary statistics for all variables and Panel B summarizes the correlation matrix. See Table 1 for variable definitions. Cash ratio, cash flow volatility, capital expenditure/assets, book leverage, R&D/sales, acquisitions/assets, asset maturity, and abnormal earnings are winsorized at the top and bottom 1 % levels. The market-to-book ratio is winsorized at the top 1 % level. For Panel B, we indicate level significance by [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

Table 3 The regression coefficients when we use different cash definitions as our dependent variable

Control variables	Pooled cross section OLS						Fama and Macbeth		Year FE	Industry FE	Year + Firm FE
	(1)	(2)	(3)	(4)	(5)	(6)	1990s (7)	2000s (8)	(9)	(10)	(11)
	Cash	logcash	dcash	Cash	logcash	dcash	Cash	Cash	Cash	Cash	Cash
Industry sigma	0.348[a]	5.092[a]	0.195[a]	0.250[a]	3.789[a]	0.168[a]	0.114	4.256[a]	0.286[a]	0.488[a]	0.203[a]
	(5.37)	(4.58)	(5.31)	(4.43)	(4.98)	(5.52)	(1.26)	(3.35)	(4.85)	(5.88)	(5.33)
Fraction of long term debt	0.014[a]	0.276[a]	0.010[a]	0.014[a]	0.281[a]	0.010[a]	0.022[a]	0.108	0.014[a]	0.015[a]	0.016[a]
	(4.58)	(6.14)	(6.64)	(4.46)	(8.76)	(6.34)	(8.41)	(1.65)	(4.52)	(5.46)	(11.26)
Market-to-book'	0.032[a]	0.295[a]	0.009[a]	0.031[a]	0.291[a]	0.009[a]	0.029[a]	0.355[a]	0.031[a]	0.029[a]	0.022[a]
	(18.68)	(17.05)	(11.06)	(18.92)	(21.83)	(11.37)	(13.60)	(9.00)	(18.27)	(17.76)	(31.65)
Log firm size	−0.005[a]	0.002	0.000	−0.007[a]	−0.023[a]	−0.001[b]	−0.009[a]	0.021	−0.008[a]	−0.006[a]	−0.013[a]
	(−6.85)	(0.14)	(0.56)	(−11.38)	(−2.94)	(−2.20)	(−20.45)	(1.32)	(−12.99)	(−7.45)	(−18.00)
Capex	−0.333[a]	−4.014[a]	−0.223[a]	−0.296[a]	−3.528[a]	−0.208[a]	−0.252[a]	−4.866[a]	−0.285[a]	−0.374[a]	−0.342[a]
	(−13.46)	(−9.32)	(−17.91)	(−14.09)	(−12.97)	(−18.86)	(−14.74)	(−9.28)	(−14.81)	(−16.43)	(−26.22)
Leverage	−0.157[a]	−2.590[a]	−0.041[a]	−0.153[a]	−2.542[a]	−0.040[a]	−0.167[a]	−1.882[a]	−0.151[a]	−0.161[a]	−0.129[a]
	(−21.22)	(−19.67)	(−10.06)	(−20.71)	(−32.56)	(−9.86)	(−30.05)	(−7.52)	(−21.12)	(−21.86)	(−32.70)
R&D/sales	0.521[a]	4.264[a]	0.070[a]	0.526[a]	4.326[a]	0.075[a]	0.492[a]	4.632[a]	0.523[a]	0.509[a]	0.186[a]
	(20.37)	(19.29)	(3.76)	(21.06)	(23.10)	(4.13)	(21.98)	(16.32)	(20.52)	(17.34)	(9.16)
Dividend/total assets	−0.053[a]	−0.449[a]	−0.074[a]	−0.054[a]	−0.460[a]	−0.073[a]	−0.070[a]	−2.117	−0.059[a]	−0.045[a]	−0.011
	(−4.24)	(−2.82)	(−5.04)	(−4.48)	(−2.80)	(−4.94)	(−6.12)	(−1.47)	(−4.96)	(−3.72)	(−1.46)
Acquisition/total assets	−0.389[a]	−3.709[a]	−0.431[a]	−0.382[a]	−3.612[a]	−0.429[a]	−0.268[a]	−4.576[a]	−0.380[a]	−0.403[a]	−0.226[a]
	(−13.16)	(−9.53)	(−17.18)	(−13.44)	(−14.48)	(−17.01)	(−12.34)	(−17.62)	(−14.07)	(−14.15)	(−17.62)
Lag cash			−0.292[a]			−0.296[a]					
			(−20.50)			(−21.31)					
Lag dcash			−0.132[a]			−0.131[a]					
			(−12.40)			(−12.13)					
1990s dummy				−0.000	0.056[c]	−0.001					
				(−0.53)	(1.84)	(−0.75)					
2000s dummy				0.021[a]	0.274[a]	0.007[a]					
				(5.69)	(11.74)	(4.69)					

Table 3 continued

Control variables	Pooled cross section OLS						Fama and Macbeth		Year FE	Industry FE	Year + Firm FE
							1990s	2000s			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Cash	logcash	dcash	Cash	logcash	dcash	Cash	Cash	Cash	Cash	Cash
Observations	52,946	51,580	33,736	52,946	51,580	33,736	23,735	25,117	52,946	52,402	52,946
R^2	0.312	0.233	0.252	0.318	0.240	0.254	0.318	0.216	0.324	0.336	0.737

Intercept is omitted in the table. The *t* statistics are in parentheses and ^{a} $p < 0.01$; ^{b} $p < 0.05$; ^{c} $p < 0.10$

regardless of the definitions of cash holdings we use, as evidenced in Table 3. The control variables used in this set of regressions are identical to those used by Bates et al. (2009).

We present 11 regression models in Table 3. Models 1–6 are pooled cross-sectional OLS regressions. Models 7 and 8 are Fama–MacBeth regressions for two different sub-periods: the 1990s and 2000s. In Model 9, we control for year fixed effects. In Model 10, we control for industry fixed effects using Fama–French 49 industry definitions. Finally, in Model 11, we control for year and firm fixed effects. All standard errors allow for clustering by firm and by year. Depending on the definitions of cash holdings and specific time periods being analyzed, our sample ranges from 23,735 to 52,946 firm-year observations.

Our most important finding is that the relationship between *cash holdings* and our *debt maturity* variable is positive and significant in all the models in Table 3 (except for Model 8, whereby the relationship is positive but it is not statistically significant). These results are consistent with our supposition that firms will simultaneously issue long term debt and hold cash. Our results are also economically significant. Consider Model 1, where the coefficient for the fraction of long-term debt is 0.014. A one-standard deviation increase in the fraction of long-term debt results in a 0.49 % increase level in *cash holdings*. Since the median *cash holdings* of our sample is 6 % of total assets, the one standard deviation increase in the fraction of long term debt increases 8.2 % of the *cash holdings* of the firm.

The sign and significance on the control variables in Table 3 are consistent with the findings on *cash holdings* of OPSW (1999); Bates et al. (2009). In particular, *cash holdings* increase with industry cash flow risk in all models except Model 7, where we estimate a Fama–MacBeth regression for the 1990s subsample period. Bates et al. (2009) find that *cash holdings* increase with *industry cash flow risk* when they estimate a Fama–MacBeth regression for their sub-sample period of 1990–2006. We suggest that the positive relation between *cash holdings* and *industry cash flow risk* mainly stems from our sub-sample period of 2000s, as evidenced in the Model 8 results.

In addition, *cash holdings* increase with investment opportunities as proxied by the ratio of the *market-to-book value* of the firm, as well as R&D expenses to sales. Firms with better investment opportunities typically value cash more since it is more costly for them to be financially constrained (Almeida et al. (2004)). *Cash holdings* are negatively related to *firm size*, *capital expenditures*, *leverage* ratio of the firm, *dividends*, and *level of acquisition activity*. Note that theoretically *leverage* can affect *cash holdings* in both directions. On the one hand, payment to debt holders reduces the ability of firms to accumulate cash over time (Bates et al. (2009)). At the same time, Acharya et al. (2007) and Gamba and Triantis (2008) argue that firms with higher *leverage* would hold more cash for hedging reasons. Our finding that *leverage* negatively affects *cash holdings* is similar to the findings of Bates et al. (2009).

In Models 4–6 in Table 3, we include dummy variables for the 1990s and 2000s. Note that except for Model 5, where the dummy variable for the 1990s is positive, the dummy variable for the 1990s is negative but not significant and that for the 2000s is always significantly positive and much larger in magnitude even in Model 5. This evidence indicates a general positive trend for firms to hold more cash in the 2000s (i.e., 2000–2013), again consistent with the findings of Bates et al. (2009). All models in Table 3 have a reasonably good fit as evidenced by the R^2s. Not surprisingly, Model 11 has the highest R^2 (0.74) as it includes firm and year fixed effects. Similar variation is observed in the literature, including Haushalter et al. (2007), Harford et al. (2008b), and Bates et al. (2009).

3.2 Debt maturity regression results

Table 4 presents the regression results with our *debt maturity* proxy as the dependent variable. The control variables used in this table are identical to those used by Johnson (2003). Similar to Barclay and Smith (1995), Guedes and Opler (1996), Barclay et al. (2003), and Johnson (2003), we use the percentage of debt that matures in more than 3 years as a proxy for the ratio of short-term debt to total debt. Note that our measure of

Table 4 The regression coefficients when we use the proportion of long-term debt as our dependent variable

Control variables	OLS (1) ltmature	OLS (2) ltmature	OLS (3) ltmature	OLS (4) ltmature	FM (1990s) (5) ltmature	FM (2000s) (6) ltmature	FE Firm + Year (7) ltmature
Book leverage	0.408[a] (12.42)	0.392[a] (11.36)	0.406[a] (12.48)	0.406[a] (12.15)	0.379[a] (20.55)	0.415[a] (15.00)	0.410[a] (27.68)
Cash/total assets	0.121[b] (2.51)	0.160[a] (3.41)	0.134[a] (2.61)	0.124[b] (2.43)	0.283[a] (7.40)	0.068 (1.09)	0.146[a] (5.29)
Market-to-book	−0.002[c] (−1.74)	−0.002[c] (−1.65)	−0.002[c] (−1.67)	−0.002[c] (−1.65)	−0.022[a] (−4.81)	−0.000 (−0.04)	0.001 (1.59)
Asset maturity	0.006[a] (5.15)	0.004[a] (3.21)	0.006[a] (5.16)	0.006[a] (5.14)	0.009[a] (7.03)	−0.000 (−0.04)	0.000 (0.25)
Log firm size	0.166[a] (10.64)	0.169[a] (11.27)	0.169[a] (11.10)	0.170[a] (11.22)	0.206[a] (13.08)	0.229[a] (6.18)	0.109[a] (8.40)
Log firm size squared	−0.011[a] (−10.25)	−0.011[a] (−11.07)	−0.011[a] (−10.50)	−0.011a (−10.65)	−0.015[a] (−15.31)	−0.014[a] (−5.99)	−0.004[a] (−5.00)
Volatility	−0.148[a] (−3.19)	−0.181[a] (−4.40)	−0.142[a] (−3.03)	−0.143[a] (−3.09)	−0.256[a] (−6.86)	−0.071 (−1.52)	−0.189[a] (−4.37)
Investment tax credit dummy	0.034[a] (3.32)	0.035[a] (3.41)	0.035[a] (3.44)	0.029[a] (2.93)	−0.003 (−0.38)	0.057[a] (5.02)	0.015[b] (2.33)
Total loss carryforward dummy	−0.004 (−0.56)	−0.002 (−0.32)	−0.000 (−0.03)	−0.006 (−0.85)	−0.020[a] (−3.83)	−0.016 (−0.88)	−0.004 (−0.91)
Rated firm dummy	0.167[a] (17.18)	0.163[a] (16.80)	0.166[a] (17.44)	0.169[a] (17.95)	0.162[a] (17.08)	0.166[a] (20.29)	0.116[a] (16.03)
Abnormal earnings	−0.000 (−0.29)	−0.000 (−0.50)	−0.000 (−0.24)	0.000 (0.64)	0.000 (0.93)	−0.001 (−1.04)	0.000 (0.11)
Term structure	−0.008 (−1.43)	−0.008 (−1.48)	−0.007 (−1.38)	−0.001 (−0.33)	−0.008 (−0.61)	−0.004 (−0.44)	−0.003 (−0.73)
1990s dummy			0.005 (1.27)				
2000s dummy			−0.019[c] (−1.66)				
Industry dummies	No	Yes	No	No	No	No	No
Year dummies	No	No	No	Yes	No	No	Yes
Observations	29,038	28,816	29,038	29,038	11,383	16,350	29,038
R^2	0.227	0.237	0.227	0.234	0.246	0.214	0.556

Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

debt maturity is based on balance sheet data, which is an aggregation of historical debt issuances. Guedes and Opler (1996) argue that *debt maturity* based on balance sheet data provides a stronger test in situations in which the determinants move slowly.

Table 4 presents seven models. Models 1–4 are pooled cross-sectional OLS regressions, with different fixed effects included. Models 5 and 6 are Fama–MacBeth regressions for two sub-periods: 1990s and 2000s. In Model 7, we control for year and firm fixed effects. All standard errors allow for clustering by firm and by year. Our main sample for the debt maturity regression consists of 29,038 firm-year observations.[12]

We find that the relationship between *cash holdings* and our *debt maturity* variable is positive and significant in all the models except in Model 6 where we examine the 2000s sub-period. This finding confirms our earlier finding from Table 3 that long-term debt positively affects the level of cash holding. This finding is consistent with the notion that firms use long term debt to build up cash reserves for future needs and it is not consistent with the notion that cash can be used together with short-term debt to mitigate underinvestment problems. The economic effect of *cash holdings* on long maturity is also large. Since Model 7 is most inclusive of fixed effects, we focus our discussion on the economic magnitude using its regression results. The coefficient for *cash holdings* is 0.146. A one standard deviation increase in *cash holdings* results in a 1.46 % increase in the proportion of debt maturing in more than 3 years. Since the median of long-term maturity of our sample is 55 %, the one standard deviation increase in *cash holdings* results in a 2.66 % increase in an average firm's fraction of long-term debt.

The coefficients of all variables in Table 4 have the predicted signs. Consistent with Johnson (2003) and Custódio et al. (2013), higher levered firms tend to have more long-term debt. The maturity variable is positively related to *firm size* but negatively related *to firm size squared*, implying a non-linear relationship between *debt maturity* and *firm size*. It is consistent with the non-linear relation between *debt maturity* and credit quality predicted by Diamond (1991). As expected, long-term *debt maturity* is significantly positively related to *asset maturity*, consistent with the matching principle in Myers (1977), although the there is no relationship between *asset maturity* and *debt maturity* in the fixed effects regression of Model 7. Custódio et al. (2013) find a similar insignificant relation between *asset maturity* and *debt maturity* in their firm fixed effects regression. Rated firms are more likely to have more long-term debt since unrated firms face greater asymmetric information between insider and external capital market participants. The *cash flow volatility* is negatively related to *debt maturity*, consistent with notion that firms with volatile cash flows may be excluded from the long-term debt market. This result is similar to the findings in Johnson (2003) and Custódio et al. (2013).

Myers (1977) demonstrates that firms with investment opportunities may suffer from underinvestment if they have debt in their capital structure. He proposes that firms can minimize this underinvestment problem by shortening the *debt maturity*. Traditionally, researchers have used the market to book ratio as a proxy for future investment opportunities. In contrast to this prediction, we generally find in Table 4 that *debt maturity* is weakly negatively related to the market-to-book ratio. This result is inconsistent with that found by Barclay et al. (2003) but is similar to the findings of Johnson (2003) and Billett et al. (2007). When we use the Fama–MacBeth methodology for the two subsample periods, we find a significantly negative relationship between *debt maturity* and the *market-*

[12] The number of observations decreased compared to that of cash holding regressions in Table 3, mainly because in these regressions we include individual firms' cash flow volatility following the literature on debt maturity instead of industry cash flow volatility that is used in the cash holdings regressions.

to-book ratio for the 1990s subsample. We failed to find any significant effect of *abnormal earnings* on *debt maturity*, in contrast to a positive relation posited by the signaling hypothesis (Flannery (1986); Diamond 1991, 1993). Finally, we find that term spread is negative but not significant in all of the models.

In Model 3 in Table 4, we include dummy variables for the 1990 and 2000 decades because Custódio et al. (2013) found a general trend of increased use of short-term debt in the past three decades. Our dummy variable for the 1990s is positive but insignificant, while the dummy variable for the 2000s is significantly negative at the 10 % level. This evidence indicates a general positive trend for firms to use more short-term debt in the 2000s, consistent with Custódio et al. (2013). All models in Table 4 have a reasonably good fit as evidenced by R^2. Not surprisingly, Model 7 has the highest R^2 (0.56) as it includes firm and year fixed effects. Similar variation is observed in Johnson (2003) and Custódio et al. (2013).

3.3 System of equations with cash and debt maturity

In Tables 3 and 4 we included either cash holdings or debt maturity as control variables. However, including such variables in the pooled ordinary least squares (OLS) regressions introduces a potential endogeneity bias in the regression coefficients. We account for the endogeneity by following Arellano and Bover (1995) generalized method of moments (GMM) methodology. The advantage of the Arellano and Bover's methodology is that we do not have to identify instrumental variables that satisfy exclusion restrictions that the error term of the second stage structured equation is not correlated with the instrumental variable. In particular, Arellano and Bover (1995) first check which lags are uncorrelated with the first-differenced residuals under the null hypothesis of no serial correlation. Consistent with their paper, for each regression specification, henceforth, we conduct an auto-regression test. We cannot reject the null hypothesis of no serial correlation for the second-order serial correlation in the first-differenced residuals.

Table 5 reports regression results where the *debt maturity* and *cash holdings* are jointly determined using a pooled sample of 39,619–41,402 firm-year observations from 1985 to 2013. The number of observations for each regression model varies depending on the inclusion of the various control variables. We also estimate a simultaneous equation model of *cash holdings*, *debt maturity*, and *leverage* using the dynamic GMM (Arellano and Bover (1995)) method, which controls for unobservable heterogeneity and the dynamic endogeneity of these relationships. The other control variables are instruments in the moment conditions. Since there is no widely accepted goodness-of-fit measure for non-linear system estimation and the R^2 reported in system estimation techniques does not necessarily lie between zero and one, we omit reporting R^2 for our estimated equations.

There are two panels in Table 5. The Two Equation System panel reports the regression coefficients when estimating a two-equation system by non-linear GMM where *cash holdings* and *debt maturity* are endogenously determined. The Three Equation System panel summarizes the regression coefficients when estimating a three-equation system where cash holding, *debt maturity*, as well as *leverage* are all jointly determined. We omit reporting the regression result estimating *leverage* from the Three Equation System panel because it is not of primary interest to our study. Both panels contain four models. Models 1 and 2 report the regression coefficients when *cash holdings* are the dependent variable. The main difference in these two models is the inclusion of the dummy variables for the 1990 and millennium decade subsamples. Models 3 and 4 report the regressions when

Table 5 The regression coefficients when estimating a system of equations by non-linear GMM

Dependent variables	Two equation system				Three equation system			
	(1) Cash	(2) Cash	(3) ltmature	(4) ltmature	(1) Cash	(2) Cash	(3) ltmature	(4) ltmature
Lag cash	0.395[a] (18.08)	0.403[a] (19.36)			0.389[a] (18.54)	0.397[a] (19.51)		
Lag ltmature			0.433[a] (28.76)	0.429[a] (28.62)			0.420[a] (32.05)	0.418[a] (31.97)
Fraction of long-term debt	0.010[b] (2.15)	0.016[a] (3.28)			0.006 (1.59)	0.010[b] (2.48)		
Cash/total assets			0.189[b] (2.42)	0.229[a] (2.90)			0.136[b] (2.11)	0.171[a] (2.60)
Industry sigma	0.241[a] (6.38)	0.190[a] (5.75)	−0.321[b] (−2.24)	−0.287[c] (−1.85)	0.248[a] (7.07)	0.199[a] (6.19)	−0.295[a] (−2.79)	−0.260[b] (−2.29)
Market-to-book	0.014[a] (14.83)	0.014[a] (14.76)	−0.003 (−0.83)	−0.004 (−1.18)	0.014[a] (14.89)	0.014[a] (14.77)	0.000 (0.12)	−0.001 (−0.20)
Log firm size	−0.001[c] (−1.70)	−0.002[a] (−3.79)	0.099[a] (14.81)	0.103[a] (15.06)	−0.000 (−1.12)	−0.001[a] (−3.35)	0.101[a] (15.34)	0.104[a] (15.60)
Capex	−0.243[a] (−20.86)	−0.233[a] (−20.15)	0.321a (6.48)	0.307[a] (6.21)	−0.250[a] (−21.63)	−0.240[a] (−20.84)	0.314[a] (6.43)	0.302[a] (6.20)
Leverage	−0.076[a] (−12.88)	−0.077[a] (−13.00)	0.496[a] (22.18)	0.500[a] (22.28)	−0.075[a] (−13.36)	−0.073[a] (−13.23)	0.499[a] (26.82)	0.502[a] (26.59)
Dividend/total assets	−0.080[a] (−5.95)	−0.079[a] (−5.77)			−0.073[a] (−5.92)	−0.071[a] (−5.65)		
R&D/sale	0.251[a] (12.39)	0.249[a] (12.31)			0.258[a] (12.77)	0.256[a] (12.66)		
Acquisition/total assets	−0.345[a] (−25.23)	−0.350[a] (−25.55)	0.305[a] (5.43)	0.315[a] (5.63)	−0.349[a] (−26.19)	−0.354[a] (−26.38)	0.275[a] (4.81)	0.284[a] (4.98)
Abnormal earnings	0.000 (1.32)	0.000 (1.48)	0.000 (0.37)	0.000 (0.45)	0.000 (1.41)	0.000 (1.62)	0.000 (0.19)	0.000 (0.26)

Table 5 continued

Dependent variables	Two equation system				Three equation system			
	(1) Cash	(2) Cash	(3) ltmature	(4) ltmature	(1) Cash	(2) Cash	(3) ltmature	(4) ltmature
Term structure	0.002[a] (6.92)	0.002[a] (5.86)	−0.004[a] (−3.27)	−0.003[a] (−3.06)	0.002[a] (6.48)	0.001[a] (5.27)	−0.004[a] (−3.84)	−0.004[a] (−3.49)
1990s dummy		0.001 (0.52)		−0.004 (−0.76)		0.001 (0.72)		−0.001 (−0.23)
2000s dummy		0.010[a] (9.27)		−0.018[a] (−4.37)		0.010[a] (9.61)		−0.017[a] (−4.20)
Asset maturity			−0.000 (−0.47)	−0.000 (−0.72)			0.000 (0.01)	−0.000 (−0.28)
Log firm size squared			−0.005[a] (−11.40)	−0.005[a] (−11.49)			−0.005[a] (−11.63)	−0.006[a] (−11.76)
Investment tax credit dummy			0.018[a] (3.12)	0.018[a] (3.17)			0.017[a] (3.08)	0.018[a] (3.13)
Tax loss carryforward dummy			−0.002 (−0.42)	0.001 (0.13)			−0.000 (−0.09)	0.002 (0.48)
Observations	41,402	41,402	39,619	39,619	41,402	41,402	39,619	39,619

Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

using our *debt maturity* proxy (*ltmature*) as the dependent variable. Model 4 includes the decade unitary variables.

In Models 1 and 2 of the two-equation system in Table 5, we again find that *debt maturity* positively affects *cash holdings* and all other control variables have the same signs as those reported Table 3. When we add *leverage* as an endogenous variable (Models 1 and 2 for the three-equation system), both the economic and statistical significance of the effect of *debt maturity* on *cash holdings* is reduced somewhat. We also included term structure in the estimation for *cash holdings* and find that *cash holdings* increase as term spread increases. An increase in term spread could imply an increase in future borrowing costs and/or default risk and therefore we expect an increase in the precautionary demand for cash. In Models 3 and 4 of the two-equation and three-equation systems in Table 5, we find a positive and statistically significant effect of *cash holdings* on *debt maturity*. We reproduced Table 5 using an alternative *debt maturity* proxy defined as the fraction of total debt that matures in 4 years or more. The results we obtain are strictly analogous to those that we obtain using *ltmature* and therefore we do not formally report the results.[13]

Our predictions are based upon the precautionary motivations for cash holdings. This implies that we should expect our results to be stronger for firms that are financially constrained who are more likely to be governed by the precautionary motive. We use five different measures to characterize firms facing financial constraints. The first rhree proxies are: (1) they have debt that is not rated; (2) they are small in size as proxied by the level of assets; and (3) they pay no dividends. These proxies are similar to those used by Fazzari et al. (1988), Erickson and Whited (2000), Fama and French (2002), Frank and Goyal (2003), Faulkender and Petersen (2006), and Acharya et al. (2007). Accordingly, we dichotomize the sample between firms that face financial constraints and those that do not and then we re-estimate the system of equations for each subsample. Below, we use two other financial constraint measures that have been developed to test the sensitivity of investment to cash flow.

Table 6 presents the results for our set of simultaneous equations for the subsamples of rated and non-rated debt.[14] The dependent variable for Models 1 and 2 is *cash holdings*, while the dependent variable for Models 3 and 4 is *debt maturity*. Models 1 and 3 report the regression coefficients for firms without debt ratings and have debt outstanding, while Models 2 and 4 report the regression coefficients for firms with debt ratings. We find that for Models 1 and 3, the firms that face financial constraints as proxied by the lack of a debt rating, have a positive relationship between *debt maturity* and *cash holdings*. On the other hand, we find no statistically significant relationship between *cash holdings* and *debt maturity* for the firms that have debt ratings and are likely not to face financial constraints. Interestingly, there are some differences in the coefficients of other control variables in the two subsamples. For example, size is an important factor in determining the level of cash holdings only in the unconstrained subsample. Many factors that significantly affect debt maturity seem to be unique to the constrained firms.

Table 7 presents the results for our set of simultaneous equations for the subsamples based on firm size as proxied by total assets. For each year, we sort firms by size and

[13] Results are available from the authors upon request. We also replicate our results using *ltmatur*5, defined as the fraction of total debt maturity maturing in more than 5 years. We find a positive significant relationship between debt maturity and cash holdings when *ltmatur5* is the dependent variable. When the cash holding is the dependent variable, the coefficients on *ltmatur5* are positive but not significant.

[14] Note that firms also need to have at least some long-term debt in order to be categorized as having no debt ratings.

Table 6 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples, firms with rated debt and firms without rated debt

Dependent variables	Two equation system				Three equation system			
	No rated debt (1) Cash	Rated debt (2) Cash	No rated debt (3) ltmature	Rated debt (4) ltmature	No rated debt (1) Cash	Rated debt (2) Cash	No rated debt (3) ltmature	Rated debt (4) ltmature
Lag cash	0.370[a] (14.20)	0.343[a] (12.19)			0.371[a] (15.25)	0.325[a] (12.41)		
Lag ltmature			0.362[a] (18.96)	0.440[a] (21.34)			0.362[a] (21.99)	0.408[a] (23.66)
Fraction of long-term debt	0.027[a] (3.89)	−0.005 (−0.94)			0.017[a] (2.93)	−0.001 (−0.18)		
Cash/total assets			0.322[a] (3.91)	0.089 (0.89)			0.245[a] (3.14)	0.046 (0.52)
Industry sigma	0.266[a] (5.60)	0.191[a] (4.65)	−0.354[b] (−1.97)	0.016 (0.11)	0.282[a] (6.02)	0.222[a] (5.19)	−0.410[b] (−2.46)	0.065 (0.39)
Market-to-book	0.016[a] (12.79)	0.015[a] (11.46)	0.006 (1.48)	−0.006 (−1.29)	0.016[a] (13.46)	0.015[a] (11.74)	0.009[b] (2.11)	−0.005 (−1.15)
Log firm size	−0.000 (−0.78)	−0.002[a] (−3.20)	0.101[a] (9.45)	0.151[a] (13.77)	−0.000 (−0.25)	−0.003[a] (−4.24)	0.103[a] (9.58)	0.162[a] (15.15)
Capex	−0.262[a] (−16.24)	−0.223[a] (−14.05)	0.225[a] (3.48)	0.315[a] (4.63)	−0.277[a] (−17.78)	−0.231[a] (−14.65)	0.215[a] (3.42)	0.281[a] (4.14)
Leverage	−0.095[a] (−13.06)	−0.052[a] (−6.47)	0.364[a] (15.26)	0.637[a] (19.92)	−0.090[a] (−12.98)	−0.059[a] (−7.70)	0.341[a] (15.65)	0.656[a] (23.63)
Dividend/total assets	−0.076[a] (−5.33)	−0.098[a] (−3.08)			−0.073[a] (−5.73)	−0.089[a] (−3.28)		
R&D/sales	0.235[a] (9.36)	0.262[a] (8.71)			0.249[a] (9.64)	0.275[a] (9.36)		
Acquisition/total assets	−0.392[a] (−21.56)	−0.318[a] (−17.93)	0.368[a] (4.93)	0.182[b] (2.52)	−0.405[a] (−23.00)	−0.339[a] (−20.22)	0.347[a] (4.83)	0.164b (2.30)
Abnormal earnings	0.000 (1.49)	0.000 (0.19)	−0.000 (−0.29)	0.000 (0.22)	0.000[b] (2.10)	0.000 (0.78)	0.000 (0.57)	−0.000 (−0.50)

Table 6 continued

Dependent variables	Two equation system				Three equation system			
	No rated debt (1) Cash	Rated debt (2) Cash	No rated debt (3) ltmature	Rated debt (4) ltmature	No rated debt (1) Cash	Rated debt (2) Cash	No rated debt (3) ltmature	Rated debt (4) ltmature
Term structure	0.001[a] (3.17)	0.002[a] (6.28)	−0.006[a] (−3.97)	−0.002 (−1.20)	0.001[b] (2.46)	0.002[a] (6.11)	−0.007[a] (−4.61)	−0.002 (−1.32)
1990s dummy	−0.001 (−0.64)	0.004[c] (1.89)	0.006 (0.84)	−0.011 (−1.18)	−0.000 (−0.24)	0.004[c] (1.83)	0.005 (0.74)	−0.015[c] (−1.84)
2000s dummy	0.010[a] (6.93)	0.011[a] (8.15)	0.006 (0.99)	−0.033[a] (−6.16)	0.011[a] (6.96)	0.013[a] (8.94)	0.009[c] (1.68)	−0.038[a] (−7.24)
Asset maturity			0.002[a] (3.04)	−0.000 (−0.69)			0.001[a] (2.58)	−0.000 (−0.60)
Log firm size squared			−0.007[a] (−7.75)	−0.008[a] (−10.54)			−0.007[a] (−7.93)	−0.008[a] (−11.52)
Investment tax dummy			0.028[a] (3.82)	0.000 (0.02)			0.032[a] (4.68)	−0.000 (−0.01)
Tax loss carryforward dummy			−0.008 (−1.51)	0.008 (1.58)			−0.005 (−1.04)	0.010[c] (1.91)
Observations	21,592	19,810	20,857	18,762	21,592	19,810	20,857	18,762

Intercept is omitted in the table. The t statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

Table 7 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples, firms who are the top 30 % and bottom 30 % in total assets

Dependent variables	Two equation system				Three equation system			
	Bottom 30 % total assets (1) Cash	Top 30 % total assets (2) Cash	Bottom 30 % total assets (3) ltmature	Top 30 % total assets (4) ltmature	Bottom 30 % total assets (1) Cash	Top 30 % total assets (2) Cash	Bottom 30 % total assets (3) ltmature	Top 30 % total assets (4) ltmature
Lag cash	0.266[a] (7.82)	0.403[a] (12.97)			0.264 (0.56)	0.395[a] (13.29)		
Lag ltmature			0.238[a] (6.98)	0.405[a] (17.88)			0.207 (0.52)	0.400[a] (21.28)
Cash/total assets			0.270[b] (2.28)	0.043 (0.37)			0.222 (0.16)	−0.019 (−0.18)
Fraction of Long-term debt	0.030[b] (2.41)	0.006 (1.00)			0.021 (0.05)	0.002 (0.35)		
Industry sigma	0.205[b] (2.02)	0.172[a] (4.75)	−0.852[a] (−2.82)	0.020 (0.13)	0.199 (1.34)	0.167[a] (4.45)	−0.833 (−0.38)	−0.106 (−0.71)
Market-to-book	0.022[a] (8.96)	0.010[a] (8.94)	−0.003 (−0.41)	−0.005 (−0.96)	0.022[c] (1.66)	0.011[a] (9.48)	−0.001 (−0.01)	−0.004 (−0.91)
Capex	−0.326[a] (−10.35)	−0.172[a] (−13.15)	0.315[a] (2.95)	0.099 (1.31)	−0.323[b] (−2.27)	−0.187[a] (−13.42)	0.289 (0.57)	0.098 (1.34)
Leverage	−0.149[a] (−10.69)	−0.051[a] (−7.90)	0.296[a] (6.64)	0.325[a] (11.47)	−0.147 (−0.68)	−0.052[a] (−7.99)	0.292 (1.05)	0.318[a] (11.96)
Dividend/total assets	−0.055[c] (−1.94)	−0.077[a] (−4.31)			−0.052 (−0.36)	−0.077[a] (−4.27)		
R&D/sale	0.325[a] (6.76)	0.180[a] (6.69)			0.327 (0.89)	0.186[a] (6.76)		
Acquisition/total assets	−0.429[a] (−10.94)	−0.291[a] (−19.36)	0.255[c] (1.74)	0.194[b] (2.46)	−0.430 (−1.12)	−0.311[a] (−20.96)	0.234 (0.30)	0.153[b] (2.06)
Abnormal earnings	−0.000 (−0.37)	0.000 (0.95)	0.000 (1.09)	0.000 (0.13)	−0.000 (−0.09)	0.000 (0.99)	0.000 (0.36)	−0.000 (−0.31)
Term structure	−0.000 (−0.32)	0.002[a] (5.34)	−0.003 (−1.10)	−0.002 (−1.06)	−0.000 (−0.05)	0.002[a] (5.26)	−0.004 (−0.31)	−0.001 (−0.95)
1990s dummy	−0.002 (−0.42)	−0.001 (−0.48)	0.030[b] (2.12)	−0.030[a] (−3.63)	−0.001 (−0.09)	−0.000 (−0.04)	0.039[b] (2.11)	−0.029[a] (−3.77)
2000s dummy	0.009[a] (2.84)	0.008[a] (6.89)	0.045[a] (4.78)	0.009[c] (1.70)	0.010 (0.39)	0.008[a] (7.11)	0.046[b] (2.38)	0.010[b] (2.12)
Asset maturity			0.001[b] (2.16)	0.004[a] (4.73)			0.001 (1.39)	0.004[a] (5.73)
Investment tax credit dummy			0.056[a] (4.29)	0.014[c] (1.95)			0.058[b] (2.14)	0.013[c] (1.89)
Tax loss carryforward dummy			−0.023[b] (−2.32)	0.001 (0.24)			−0.024 (−0.71)	0.005 (1.07)
Observations	5678	15,645	5377	15,303	5678	15,645	5377	15,303

Intercept is omitted in the table. The t statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

assign firms into the top and bottom three deciles of the size distribution.[15] We assume that the smaller firms face financial constraints issues while the larger firms do not. Table 8 presents the results for our set of simultaneous equations for the subsamples based on the ratio of total dividends paid to total assets. We assume that if a firm did not pay any dividends that firm is assigned to the financial constraint group. We assigned the top 30 % dividend payers (as a percentage of total assets) as the group with little or no financial constraints. The structure for Tables 7 and 8 are analogous to that of Table 6.

In Table 7, the results are consistent with our financial constraint story in the two-equation system. When we account for the endogeneity of *leverage*, we lose the statistical significance. In Table 8, we again see the hypothesized differential positive and statistically significant relationship between cash and *debt maturity* for the financially constrained sample. Hence, we generally find support for our hypothesis.

The finance literature has also used various alternative measures of a firm's financial constraints, such as the WW index (Whited and Wu 2006) and the size-age index (Hadlock and Pierce 2010). In Table 9, we re-estimate our previous tables using both the Whited and Wu (2006) index and the Hadlock and Pierce (2010) index as additional proxies for financial constraints. We do not report the regression coefficients for our control variables to conserve space. Like other proxies, financially constrained firms (with high WW/HP index) generally have a positive and statistically significant relation between debt maturity and cash holdings. In contrast, unconstrained firms (with low WW/HP index) (either) have no statistically significant (or in one case, a weak statistically) relation between debt maturity and cash holdings.

3.4 Using an alternative definition for debt maturity

To see if our results are sensitive to the definition of *debt maturity*, we repeat the non-linear GMM analysis using *debt maturity* proxy as the fraction of total debt that matures in more than 4 years and we denote this variable as *ltmature4*. Table 10 reports regression results for the two sub-samples, financially constrained and financially non-constrained firms. Panel A reports the results when we proxy financial constraints by debt ratings or lack thereof. Panel B reports the results when we proxy financial constraints by asset size. Panel C reports the results when we proxy financial constraints by dividends. We do not report the regression coefficients for our control variables to conserve space. When we define financial constraints by debt ratings, we find support for our financial constraint hypothesis. When we define financial constraints by dividend paying status, there is a significantly positive relationship for both the constrained and non-constrained sub-samples. However, the relation is significantly greater for the constrained sample than for the non-constrained sample, hence supporting our hypothesis. Nevertheless, the differences between the constrained versus non-constrained samples are positive but not significantly different from zero.[16]

[15] Note that the actual observations used in the regression sample are not evenly distributed across the size groups since smaller firms are likely to have more missing data on the control variables.

[16] We find weaker results when we proxy debt maturity by *ltmatur5*, but the results are generally supportive of our hypothesis.

Table 8 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples, firms who are the top 30 % in dividends paid and those that do not pay dividends

Dependent variables	Two equation system				Three equation system			
	Firms not paying dividends (1) Cash	Top 30 % total dividend (2) Cash	Firms not paying dividends (3) ltmature	Top 30 % total dividend (4) ltmature	Firms not paying dividends (1) Cash	Top 30 % total dividend (2) Cash	Firms not paying dividends (3) ltmature	Top 30 % total dividend (4) ltmature
Lag cash	0.316[a] (11.63)	0.433[a] (15.06)			0.314[a] (11.93)	0.417[a] (15.27)		
Lag ltmature			0.275[a] (13.41)	0.362[a] (14.65)			0.286[a] (15.52)	0.351[a] (16.14)
Cash/total assets			0.232[a] (2.75)	0.025 (0.19)			0.217[a] (2.85)	−0.034 (−0.27)
Fraction of long-term debt	0.021[b] (2.52)	0.008 (1.36)			0.016[b] (2.26)	0.001 (0.26)		
Industry sigma	0.212[a] (3.90)	0.171[a] (4.15)	0.215 (1.20)	−0.317 (−1.57)	0.216[a] (3.99)	0.184[a] (4.35)	0.182 (1.02)	−0.336[c] (−1.74)
Market-to-book	0.019[a] (13.36)	0.010[a] (9.33)	0.011[b] (2.15)	−0.002 (−0.35)	0.019[a] (13.22)	0.011[a] (10.05)	0.013[a] (3.01)	−0.003 (−0.52)
Log firm size	−0.001 (−0.79)	−0.001[c] (−1.68)	0.112[a] (9.63)	0.119[a] (9.37)	−0.001 (−1.30)	−0.001[c] (−1.80)	0.109[a] (10.17)	0.120[a] (10.16)
Capex	−0.263[a] (−13.48)	−0.238[a] (−15.51)	0.240[a] (3.27)	0.129 (1.24)	−0.267[a] (−14.29)	−0.255[a] (−16.21)	0.218[a] (3.32)	0.136 (1.49)
Leverage	−0.090[a] (−9.92)	−0.070[a] (−9.08)	0.461[a] (17.29)	0.438[a] (12.52)	−0.085[a] (−10.15)	−0.071[a] (−9.44)	0.459[a] (18.85)	0.421[a] (12.41)
R&D/Sale	0.263[a] (10.09)	0.138[a] (4.10)			0.266[a] (9.79)	0.133[a] (3.88)		
Acquisition/total assets	−0.418[a] (−20.30)	−0.319[a] (−18.63)	0.293[a] (3.48)	0.090 (1.00)	−0.422[a] (−20.95)	−0.336[a] (−19.85)	0.299[a] (3.86)	0.112 (1.20)
Abnormal earnings	−0.000 (−0.52)	0.000 (0.59)	0.000 (0.49)	−0.000 (−0.48)	−0.000 (−0.03)	−0.000 (−0.06)	0.000 (0.26)	0.000 (0.06)

Table 8 continued

Dependent variables	Two equation system				Three equation system			
	Firms not paying dividends (1) Cash	Top 30 % total dividend (2) Cash	Firms not paying dividends (3) ltmature	Top 30 % total dividend (4) ltmature	Firms not paying dividends (1) Cash	Top 30 % total dividend (2) Cash	Firms not paying dividends (3) ltmature	Top 30 % total dividend (4) ltmature
Term structure	0.001[b] (2.44)	0.001[a] (3.89)	−0.005[a] (−3.00)	−0.003 (−1.50)	0.001[b] (2.47)	0.001[a] (3.91)	−0.006[a] (−3.07)	−0.002 (−1.37)
1990s dummy	−0.001 (−0.35)	0.004[b] (1.98)	0.016 (1.50)	−0.011 (−1.25)	−0.001 (−0.31)	0.003 (1.40)	0.020[c] (1.87)	−0.014 (−1.51)
2000s dummy	0.010[a] (5.45)	0.010[a] (7.33)	0.003 (0.48)	−0.016[b] (−2.46)	0.012[a] (5.83)	0.010[a] (7.26)	0.005 (0.78)	−0.017[a] (−2.68)
Asset maturity			0.001[b] (2.49)	0.002 (1.64)			0.001[b] (2.50)	0.002[c] (1.90)
Log firm size squared			−0.005[a] (−5.80)	−0.006[a] (−7.85)			−0.005[a] (−6.41)	−0.007[a] (−8.59)
Investment tax credit dummy			0.035[a] (4.59)	0.018[c] (1.94)			0.034[a] (4.50)	0.025[a] (2.76)
Tax loss carryforward dummy			0.002 (0.39)	0.002 (0.26)			0.001 (0.24)	0.002 (0.29)
Observations	16,076	13,970	15,293	13,432	16,076	13,970	15,293	13,432

Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

Table 9 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples of firms

Dependent Variables	Two equation system				Three equation system			
	High WW Index (1) *Cash*	Low WW Index (2) *Cash*	High WW Index (3) *ltmature*	Low WW Index (4) *ltmature*	High WW Index (5) *Cash*	Low WW Index (6) *Cash*	High WW Index (7) *ltmature*	Low WW Index (8) *ltmature*
Panel A: WW Index = − .091 × EBITDA −0.062 × Positive dividend dummy + 0.02 × Long-term debt ratio								
Lag cash	0.356[a] (15.95)	0.461[a] (15.12)			0.336[a] (15.47)	0.445[a] (15.40)		
Lag ltmature			0.366[a] (20.07)	0.392[a] (17.49)			0.362[a] (23.25)	0.377[a] (19.72)
Proportion of long-term (>3 years) debt	0.013[b] (2.21)	0.009[c] (1.72)			0.010[b] (2.19)	0.006 (1.20)		
Cash/total assets			0.210[a] (2.81)	0.188 (1.51)			0.173[b] (2.24)	0.123 (1.05)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25,533	15,869	24,129	15,490	25,533	15,869	24,129	15,490
Panel B: HP Index = − 0.352 × Total assets (log) − 0.025 × age − 0.584 × EBITDA								
Lag cash	0.337[a] (14.92)	0.425[a] (14.02)			0.336[a] (15.35)	0.405[a] (14.02)		
Lag ltmature			0.358[a] (20.90)	0.435[a] (17.82)			0.345[a] (22.67)	0.404[a] (18.21)
Fraction of long-term debt	0.010[c] (1.65)	0.003 (0.63)			0.008 (1.47)	0.005 (1.00)		
Cash/total assets			0.206[b] (2.53)	0.122 (0.95)			0.194[b] (2.42)	0.115 (1.05)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,997	12,565	22,800	12,251	23,997	12,565	22,800	12,251

Panel A dichotomizes the sample into high Whited and Wu (WW) Index and low Whited Wu Index. Panel B dichotomizes sample based on the Hadlock and Pierce Index (HP) into high HP Index and low HP Index Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$

4 Robustness tests and alternative explanations

In this section, we consider alternative explanations for our results. The positive relationship between cash and *debt maturity* may be due to agency problems, the impact of corporate taxes for multinational firms, distressed firms, bank loan covenants, and/or demand for debt by low credit rated firms. We discuss the secular trend of cash holdings and debt maturity in the last subsection.

4.1 Agency costs

The evidence discussed thus far indicates that firms that are more likely to face financial constraints are also more likely to issue long-term debt and hold large *cash holdings*. We have not, however, investigated whether agency problems could also help explain the

Table 10 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples, constrained and non-constrained firms, using an alternative maturity structure proxy defined as the percentage of the total debt maturing in more than 4 years

Dependent variables	Two equation system				Three equation system			
	No rated debt (1) Cash	Rated debt (2) Cash	No rated debt (3) ltmature4	Rated debt (4) ltmature4	No rated debt (1) Cash	Rated debt (2) Cash	No rated debt (3) ltmature4	Rated debt (4) ltmature4
Panel A								
Lag cash	0.371[a] (15.08)	0.336[a] (12.24)			0.374[a] (15.44)	0.326[a] (12.64)		
Lag ltmature			0.314[a] (15.09)	0.334[a] (15.24)			0.306[a] (15.55)	0.329[a] (19.22)
Fraction of long-term debt	0.038[a] (5.58)	−0.001 (−0.16)			0.028[a] (4.48)	0.002 (0.42)		
Cash/total assets			0.572[a] (6.09)	0.115 (1.35)			0.562[a] (5.79)	0.111 (1.25)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,755	19,715	19,759	18,551	20,755	19,715	19,759	18,551
Dependent variables	Bottom 30 % total assets (1) Cash	Top 30 % total assets (2) Cash	Bottom 30 % total assets (3) ltmature4	Top 30 % total assets (4) ltmature4	Bottom 30 % total assets (1) Cash	Top 30 % total assets (2) Cash	Bottom 30 % total assets (3) ltmature4	Top 30 % total assets (4) ltmature4
Panel B								
Lag cash	0.256[a] (7.54)	0.412[a] (14.32)			0.261 (0.06)	0.403[a] (14.54)		
Lag ltmature			0.175[a] (4.40)	0.362[a] (15.46)			0.136 (0.15)	0.352[a] (18.40)
Fraction of long-term debt	0.031[a] (2.97)	0.016[a] (2.61)			0.028 (0.01)	0.011[b] (2.18)		
Cash/total assets			0.383[a] (3.29)	0.238[c] (1.83)			0.405 (0.38)	0.193[c] (1.72)

Table 10 continued

Dependent variables	Bottom 30 % total assets (1) Cash	Top 30 % total assets (2) Cash	Bottom 30 % total assets (3) ltmature4	Top 30 % total assets (4) ltmature4	Bottom 30 % total assets (1) Cash	Top 30 % total assets (2) Cash	Bottom 30 % total assets (3) ltmature4	Top 30 % total assets (4) ltmature4
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5249	15,566	4849	15,180	5249	15,566	4849	15,180
Dependent variables	Firms not paying dividends (1) Cash	Top 30 % total dividend (2) Cash	Firms not paying dividends (3) ltmature4	Top 30 % total dividend (4) ltmature4	Firms not paying dividends (1) Cash	Top 30 % total dividend (2) Cash	Firms not paying dividends (3) ltmature4	Top 30 % total dividend (4) ltmature4
Panel C								
Lag cash	0.318^{a} (12.72)	0.420^{a} (14.71)			0.314^{a} (12.46)	0.405^{a} (14.79)		
Lag ltmature			0.247^{a} (10.70)	0.350^{a} (14.40)			0.242^{a} (11.73)	0.353^{a} (15.73)
Fraction of long-term debt	0.033^{a} (4.47)	0.012^{b} (2.21)			0.028^{a} (4.22)	0.006 (1.28)		
Cash/total assets			0.645^{a} (6.42)	0.272^{b} (2.17)			0.588^{a} (5.91)	0.208^{c} (1.70)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,379	13,834	14,346	13,247	15,379	13,834	14,346	13,247

Summary of the regression coefficients for the control variables are also omitted for brevity. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

positive relation. For example, Jensen (1986) argues that entrenched managers are more likely to hold excess cash. In contrast, Harford et al. (2012) find that firms with weaker governance structures have lower cash reserves. Datta et al. (2005) show that managers may not make optimal debt maturity (or leverage) decisions when their interest is not perfectly aligned with the shareholders. Indeed they find an inverse relation between managerial ownership and *debt maturity*. If indeed entrenched managers are likely to hold more cash and choose longer-term debt to avoid being monitored more frequently (Stulz 1990), then we would expect a positive relation between *cash holdings* and debt maturity, especially among firms with entrenched managers.

We utilize the Entrenchment Index (E Index) and managerial ownership to proxy agency costs. We obtain the E-Index for all the firms followed by the Investor Responsibility Research Center (IRRC) for each year in which the IRRC published data on corporate takeover defenses. The details on the construction of the E Index can be found on Lucian Bebchuk's website. The E Index is a score ranging from 0 to 6, based on the number of anti-takeover provisions (including staggered board, limits to shareholder amendments of the by-laws, supermajority requirements for mergers and charter amendments, poison pills, and golden parachutes) a company has in a given year. Alternatively one can measure agency costs by managerial ownership, as suggested by Datta et al. (2005). They argue that there is an inverse relationship between managerial ownership and *debt maturity*. In particular, managers with a low degree of ownership would prefer long-term *debt maturity* to avoid being monitored more frequently.

In Table 11, we replicate the studies by Datta et al. (2005), Jiraporn and Kitsabunnarat (2007) and Harford et al. (2008a) and examine if adding the E-Index and managerial ownership variables impact our results. In Models (1) through (4), we run the OLS regression like in their papers. In Models (5) through (8), we run the GMM regressions similar to our earlier regressions where cash, debt maturity, and leverage are all endogenized. In Models (9) and (10), we endogenize managerial ownership and Models (11) and (12), we endogenize E-index. We omit reporting the coefficients on the other control variables to save space. We assume that firms have the same E Index as its previous score until a new score is given to the firm. We find a positive relationship between cash holdings and debt maturity in the OLS specification and in the GMM specifications except when we include E-index. One reason for the weaker results in the GMM models where we include E-index is because of lack of variation in E-index, similar to what has been found in fixed-effects models. In addition, we find that managerial ownership is positively related to cash and negatively related to debt maturity in both OLS and GMM specifications. These results are similar to what Datta et al. (2005) and Bates et al. (2009) find. We also find E Index is negatively related to cash and positively related to debt maturity in the OLS specifications. Note that the signs of the coefficients in the GMM models on E-index are similar to the OLS models, but they are not statistically significant. Again, the debt maturity result is similar to that obtained by Jiraporn and Kitsabunnarat (2007) and Harford et al. (2008a).

Thus it is possible that our earlier results on financial constraints could be potentially driven by agency problems. Consequently, we split our sample based upon whether the firm has high E-Index or managerial ownership. We classify firms to have a high E Index if their index is higher than or equal to 4. If indeed agency problems explain the positive relation between *cash holdings* and *debt maturity*, then we would expect that this positive relation to be more significant in the sub-sample of firms with a high E Index. Table 12 reports estimation results for the subsample of high E Index firms and the subsample of low E Index firms using both the two-equation system and the three-equation system. The high E Index sample contains between 2422 and 2556 firm-year observations (depending on

Table 11 The regression coefficients when estimating a system of equations by OLS and non-linear GMM after including the entrenchment index (E-Index) and managerial ownership

	OLS				GMM				GMM (endogenized governance variables)			
	(1) Cash/total assets	(2) ltmature	(3) Cash/total assets	(4) ltmature	(5) Cash/total assets	(6) ltmature	(7) Cash/total assets	(8) ltmature	(9) Cash/total assets	(10) ltmature	(11) Cash/total assets	(12) ltmature
Lag cash					0.373[a] (9.89)		0.446[a] (13.08)		0.366[a] (10.30)		0.422[a] (12.30)	
Lag ltmature						0.471[a] (18.62)		0.414[a] (14.77)		0.437[a] (16.69)		0.384[a] (12.14)
Cash/total assets		0.269[a] (10.25)		0.208[a] (5.37)		0.311[a] (3.00)		0.119 (0.84)		0.287[a] (2.90)		0.130 (0.81)
Fraction of long-term debt	0.026[a] (11.20)		0.011[a] (4.28)		0.039[a] (4.70)		0.006 (0.84)		0.034[a] (4.79)		0.005 (0.65)	
ownpct	0.000[a] (3.86)	−0.001[a] (−5.35)			0.000[c] (1.78)	−0.000[b] (−2.07)			0.000[b] (2.06)	−0.000 (−1.61)		
e_index			−0.003[a] (−5.24)	0.007[a] (3.15)			−0.001 (−1.17)	0.004 (1.35)			−0.001 (−0.42)	0.009 (1.12)
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,873	15,570	9994	9753	15,773	15,491	9939	9720	15,773	15,491	9939	9720

Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

Table 12 The regression coefficients when estimating a system of equations by non-linear GMM after dichotomizing the sample into high E Index and low E Index firms

Dependent Variables	Two equation system				Three equation system			
	High E Index		Low E Index		High E Index		Low E Index	
	(1) *Cash*	(2) *ltmature*	(3) *Cash*	(4) *ltmature*	(1) *Cash*	(2) *ltmature*	(3) *Cash*	(4) *ltmature*
Lag cash	0.421[a] (7.35)		0.350[a] (8.23)		0.395[a] (10.76)		0.338[a] (8.30)	
Lag fraction of long-term debt		0.250[a] (5.55)		0.413[a] (13.06)		0.268[a] (5.02)		0.383[a] (13.90)
Fraction of long-term debt	0.008 (0.57)		0.011 (1.56)		0.012 (0.77)		0.010 (1.44)	
Cash/total assets		0.103 (0.58)		0.157 (1.06)		0.142 (0.60)		0.164 (1.22)
Industry sigma	0.588 (1.60)	−0.359 (−0.77)	0.489[c] (1.76)	0.441 (1.63)	0.509 (0.74)	−0.436 (−0.97)	0.124 (0.51)	0.399[c] (1.66)
Market-to-book		−0.018 (−1.35)		−0.011 (−1.45)		−0.018 (−1.12)		−0.011 (−1.54)
Log firm size	0.001 (0.09)	0.153[a] (2.78)	0.005 (1.09)	0.178[a] (7.15)	0.001 (0.05)	0.151[a] (2.73)	−0.002 (−0.62)	0.172[a] (7.31)
Capex	−0.278 (−1.25)	0.071 (0.37)	−0.150 (−1.22)	0.163 (1.42)	−0.316 (−1.47)	0.097 (0.48)	−0.325[a] (−3.12)	0.203[c] (1.91)
Leverage	−0.114[a] (−2.68)	0.392[a] (5.43)	−0.144[a] (−3.98)	0.386[a] (9.47)	−0.102[b] (−2.26)	0.384[a] (5.27)	−0.094[a] (−4.37)	0.393[a] (10.79)
Dividend/total assets	0.097 (0.67)		−0.107 (−0.59)		0.030 (0.27)		−0.008 (−0.20)	
R&D/sales	0.592[b] (2.27)		0.740[a] (3.90)		0.575[b] (2.48)		0.785[a] (4.43)	
Acquisition/total assets	−0.381[b] (−2.26)	0.368[b] (2.18)	−0.392[a] (−4.21)	0.073 (0.65)	−0.356[a] (−2.72)	0.400[b] (2.36)	−0.378[a] (−5.31)	0.091 (0.82)
Abnormal earnings	−0.000 (−0.10)	0.000 (0.00)	0.000[c] (1.92)	−0.000 (−0.52)	−0.000 (−0.08)	0.000 (0.04)	0.000[c] (1.72)	−0.000 (−0.64)
Term structure	0.004[a] (3.82)	−0.001 (−0.34)	0.002[a] (3.53)	−0.004 (−1.61)	0.004[b] (2.15)	−0.001 (−0.28)	0.002[a] (3.14)	−0.002 (−1.00)
1990s dummy	0.005 (0.60)	0.007 (0.36)	−0.003 (−0.60)	−0.029[b] (−2.50)	0.008 (0.85)	0.007 (0.40)	0.004 (0.91)	−0.026[b] (−2.30)
2000s dummy	0.006 (1.26)	−0.021 (−1.48)	0.006 (1.62)	−0.003 (−0.35)	0.004 (0.64)	−0.021 (−1.55)	0.009[b] (2.55)	−0.004 (−0.50)
Asset maturity		0.005[a] (3.53)		0.004[a] (3.85)		0.005[a] (3.34)		0.004[a] (4.02)
Log firm size square		−0.008[b] (−2.39)		−0.010[a] (−6.63)		−0.008[b] (−2.37)		−0.010[a] (−6.64)
Investment tax dummy		−0.031[b] (−2.00)		0.020[c] (1.78)		−0.032[c] (−1.92)		0.009 (0.80)
Tax loss carryforward		−0.007 (−0.57)		−0.019[b] (−2.39)		−0.008 (−0.61)		−0.017[b] (−2.22)
Observations	2422	2556	7515	7967	2422	2556	7515	7967

Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

using *cash holdings* or *debt maturity* as the dependent variable, whereas the low E Index sample contains between 7515 and 7967 firm-year observations. Interestingly, there is no significant relation between *debt maturity* and *cash holdings* among high E Index firms, whereas for firms with less entrenched managers, cash is significantly positively related to debt maturity when debt maturity is the dependent variable. Hence, we do not find support for an agency explanation for the relationship between *cash holdings* and *debt maturity*.

Table 13 reports estimation results for the subsample of high managerial ownership firms and the subsample of low managerial ownership firms using both the two-equation system and three-equation system.[17] A firm is considered to have high managerial ownership if the total ownership of managers and directors is greater than or equal to the 70th percentile of the sample (25.5 % of the shares). A firm is considered to have a low managerial ownership if the total managerial ownership is less than or equal to the 30th percentile of the sample (5.2 % of the shares). The high managerial ownership sample contains between 4695 and 4812 firm-year observations (depending on using cash or *debt maturity* as the dependent variable, whereas the low managerial sample contains between 4662 and 4745 firm-year observations. Interestingly, there is no significant relation between *cash holdings* and *debt maturity* for the two subsamples. Hence, we again do not find support for an agency explanation for the relationship between *cash holdings* and *debt maturity*.

It is possible that we fail to find support for the agency cost because we are not estimating cash holdings in excess of those needed for operations and investment. Hence we re-estimate Tables 12 and 13 using excess cash holdings as our endogenous variable. We estimated excess cash following Dittmar and Mahrt-Smith (2007), which was based on Opler et al. (1999), Dittmar et al. (2003), and Harford et al. (2008a). We estimate normal cash/total assets as a function of asset size, cash flows, bond ratings, market-to-book ratios, dividend payment, capital expenditures, R&D expenses, year dummies and firm fixed effects. *Excess Cash* is defined as the residual from the above estimation. The results of this new specification are reported in Table 14. We do not report the regression coefficients for our control variables to conserve space. Panel A presents the regression coefficients when estimating a system of equations by non-linear GMM after dichotomizing the sample into High E Index and Low E Index firms. Panel B presents the regression coefficients when estimating a system of equations by non-linear GMM after dichotomizing the sample into High Managerial and Low Managerial firms. We find that there is a positive relationship between excess cash and debt maturity for firms with a low E-Index. This result is contrary to what we expect to find if agency costs is the primary driver for the positive relationship between cash holdings and debt maturity. However, we do find support for the agency cost hypothesis when we proxy agency costs by Managerial Ownership. That is the positive relationship empirically exists by firms with low managerial ownership. But, the relationship between excess cash and debt maturity is also positive (albeit, weaker statistically) for firms with low managerial ownership. We believe that the preponderance of evidence presented in this paper is not consistent with an agency cost explanation.

Finally, it may be the case that the relationship between cash and short maturity is only driven by the recent 2007/2008 financial crisis. We split our sample into crisis period and non-crisis period (i.e., 1985–2006) and find that our results also hold in the non-crisis period.[18]

[17] We obtained the estimates for managerial ownership from Phil Davies of Davies and Taillard (2010).

[18] Results are available upon request. See, for example, Arslan-Ayaydin et al. (2014) who find that Asian based firms that had lower leverage and higher cash holdings were able to invest more during the Global Financial Crisis.

Table 13 The regression coefficients when estimating a system of equations by non-linear GMM after dichotomizing the sample into High Managerial and Low Managerial firms

Dependent variables	Two equation system				Three equation system			
	High managerial ownership		Low managerial ownership		High managerial ownership		Low managerial ownership	
	(1) *Cash*	(2) *ltmature*	(3) *Cash*	(4) *ltmature*	(1) *Cash*	(2) *ltmature*	(3) *Cash*	(4) *ltmature*
Lag cash	0.266[a] (5.72)		0.273[a] (5.20)		0.259[a] (6.17)		0.257[a] (5.60)	
Lag fraction of long-term debt		0.331[a] (8.30)		0.293[a] (7.27)		0.289 (1.42)		0.274[a] (7.80)
Fraction of long-term debt	0.018 (1.31)		0.016 (1.38)		0.016 (1.48)		0.020[c] (1.91)	
Cash/total assets		0.060 (0.48)		0.129 (0.69)		0.124 (0.14)		0.218 (1.33)
Industry sigma	0.131 (1.41)	0.345 (0.96)	0.191[a] (2.79)	−0.344 (−0.93)	0.232[b] (2.13)	0.519 (1.00)	0.239[a] (3.60)	−0.298 (−0.89)
Market-to-book		0.004 (0.45)		−0.016[c] (−1.75)		−0.006 (−0.17)		−0.018[b] (−2.05)
Log firm size	−0.002 (−1.42)	0.046[b] (2.37)	−0.006[a] (−5.67)	0.195[a] (7.31)	−0.003[c] (−1.83)	0.036[c] (1.69)	−0.007[a] (−6.65)	0.198[a] (8.23)
Capex	−0.217[a] (−6.68)	0.258[b] (2.26)	−0.183[a] (−6.23)	0.438[a] (3.19)	−0.218[a] (−6.96)	0.316 (0.84)	−0.187[a] (−6.03)	0.408[a] (3.04)
Leverage	−0.124[a] (−7.82)	0.506[a] (11.23)	−0.090[a] (−7.66)	0.436[a] (8.33)	−0.126[a] (−8.60)	0.506[a] (9.63)	−0.092[a] (−7.29)	0.468[a] (9.43)
Dividend/total assets	−0.028 (−0.65)		−0.075[a] (−2.82)		−0.033 (−0.77)		−0.079[a] (−3.31)	
R&D/sales	0.530[a] (6.51)		0.427[a] (8.14)		0.534[a] (6.35)		0.423[a] (7.93)	
Acquisition/total assets	−0.242[a] (−5.96)	−0.025 (−0.17)	−0.243[a] (−9.13)	−0.130 (−0.84)	−0.257[a] (−6.75)	0.080 (0.24)	−0.254[a] (−9.22)	−0.117 (−0.84)
Abnormal earnings	−0.000 (−0.24)	0.000[b] (2.41)	0.000[c] (1.72)	−0.000 (−0.12)	0.000 (0.12)	0.000[b] (2.31)	0.000[b] (2.11)	−0.000 (−0.54)
Term structure	−0.001 (−1.26)	0.004 (1.41)	0.001 (1.25)	−0.000 (−0.01)	−0.001 (−1.54)	0.004 (1.36)	0.001 (1.41)	0.002 (0.59)
1990s dummy	−0.005 (−1.58)	0.026[c] (1.77)	0.000 (0.15)	−0.011 (−0.92)	−0.007[c] (−1.72)	0.019 (1.28)	0.001 (0.28)	−0.015 (−1.27)
2000s dummy	0.007[b] (2.43)	−0.029[a] (−2.99)	0.016[a] (6.26)	0.003 (0.27)	0.009[a] (2.69)	−0.028[b] (−2.36)	0.019[a] (6.96)	−0.002 (−0.24)
Asset maturity		0.000 (0.58)		0.001 (1.57)		0.000 (0.55)		0.001 (1.47)
Log firm size square		0.001 (0.39)		−0.012[a] (−6.62)		0.001 (0.65)		−0.012[a] (−7.39)
Investment tax dummy		0.019 (1.02)		0.004 (0.33)		0.035[c] (1.81)		0.001 (0.06)
Tax loss carryforward		−0.031[a] (−3.02)		−0.010 (−1.01)		−0.034[a] (−3.14)		−0.013 (−1.35)
Observations	4812	4695	4745	4662	4812	4695	4745	4662

Intercept is omitted in the table. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

Table 14 The regression coefficients when estimating a system of equations by non-linear GMM after dichotomizing the sample into High E Index and Low E Index firms (Panel A) and dichotomizing the sample into High Managerial and Low Managerial firms (Panel B)

Dependent variables	Two equation system				Three equation system			
	High E-Index		Low E-Index		High E-Index		Low E-Index	
	(1) *Excess cash*	(2) *ltmature*	(3) *Excess cash*	(4) *ltmature*	(5) *Excess cash*	(6) *ltmature*	(7) *Excess cash*	(8) *ltmature*
Panel A								
Lag cash	0.348[a] (5.95)		0.329[a] (9.62)		0.313[a] (6.15)		0.314[a] (9.55)	
Lag fraction of long-term debt		0.268[a] (5.48)		0.343[a] (9.71)		0.281[a] (3.74)		0.312[a] (9.92)
Fraction of long-term debt	0.011 (0.56)		0.019[b] (2.06)		0.010 (0.47)		0.014[c] (1.73)	
Excess cash		0.032 (0.22)		0.345[b] (2.11)		0.059 (0.18)		0.331[b] (2.43)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1748	1823	5222	5453	1748	1823	5222	5453

Dependent variables	Two equation system				Three equation system			
	High managerial ownership		Low managerial ownership		High managerial ownership		Low managerial ownership	
	(1) *Excess cash*	(2) *ltmature*	(3) *Excess cash*	(4) *ltmature*	(5) *Excess cash*	(6) *ltmature*	(7) *Excess cash*	(8) *ltmature*
Panel B								
Lag cash	0.206[a] (4.47)		0.251[a] (6.10)		0.189[a] (3.77)		0.219[a] (5.47)	
Lag fraction of long-term debt		0.269[a] (5.93)		0.237[a] (5.51)		0.224[a] (5.21)		0.224[a] (5.80)
Fraction of long-term debt	0.034[b] (2.28)		0.021[c] (1.80)		0.023 (1.15)		0.027[b] (2.56)	

Table 14 continued

Dependent variables	Two equation system				Three equation system			
	High managerial ownership		Low managerial ownership		High managerial ownership		Low managerial ownership	
	(1) *Excess cash*	(2) *ltmature*	(3) *Excess cash*	(4) *ltmature*	(5) *Excess cash*	(6) *ltmature*	(7) *Excess cash*	(8) *ltmature*
Excess cash		0.189 (1.22)		0.382[b] (2.17)		0.271[b] (1.99)		0.502[a] (2.90)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3354	3563	3475	3649	3354	3563	3475	3649

Intercept is omitted in the table. Unlike Tables 10 and 11, we use *excess cash* as our endogenous variable. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

4.2 Taxes

It is widely reported in the media that American corporations hold extensive *cash holdings* overseas due to the increased tax liability the firm would incur if it repatriated the cash back to the United States.[19] For example, Apple has drawn the wrath of the U.S. Senate because of its ability to shift its profits to three subsidiaries in Ireland.[20] Hence, we would expect that the amount of *cash holdings* a company has is related to the extent of business activity conducted by international subsidiaries. In addition, we expect that international business activity affects a firm's financing decisions, as shown by Chen et al. (1997) and Mansi and Reeb (2002). In particular, Lee and Kwok (1988) argue that due to the difficulty in monitoring the management of foreign subsidiaries, multinational corporations have greater agency costs than pure domestic firms, which results in lower leverage. Furthermore, such firms would be more opaque to creditors and therefore might employ a shorter *debt maturity* (Myers 1977; Leland and Toft 1996).

If the relation between debt maturity and cash are driven by the tax treatment of profit repatriations by multinational firms, then we would expect such relation to hold only among the sample of firms with high foreign sales exposure. Bates et al. (2009) create a unitary variable to proxy for international activity. We use a similar proxy that is based on the ratio of the international sales conducted by foreign subsidiaries to the total sales of the firm. We dichotomize our sample based upon the international sales activity of the firm. If a firm has higher than the sample median international sales activity (8.4 % of total sales), then that firm will be part of the high international sales group. Otherwise, the firm belongs to the low international sales group. We obtain level of international sales from the Compustat Business Segment database. Table 15 reports estimation results for the subsample of low international sales firms and the subsample of high international sales firms using both the two-equation system and three-equation system. We find that only the subsample of low international sales have a positive relationship between debt maturity and cash holdings. This may not be surprising since firms with low or no international sales will generally be smaller firms that face financial constraints.

4.3 Default probability

It is possible that our results might be driven by a small sample of firms that are both financially constrained and distressed. To examine this possibility, we separate our sample into firms that face a high/low probability of default and re-estimate our equations. Estimates of default probability are based on Merton's (1974) option pricing model and we obtain these estimates from Professor Yi Tang.[21] A firm is considered to have a high probability of default if the estimated default probability (90th percentile) is equal to or greater than 1.5 % per annum.[22] For this sample, we find no relationship between *cash holdings* and *debt maturity*, which implies that our results are related to financially constrained firms.

[19] For a theoretical discussion of how taxes may affect debt maturity, see Brick and Ravid (1985, 1991) and Lewis (1990).

[20] See, for example, http://www.npr.org/2013/05/21/185688463/ceo-cook-to-defend-apple-before-senate-committee-hearing.

[21] See Allen et al. (2010).

[22] We altered the criteria for high distressed firms and find that our results are not affected.

Table 15 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples, low international sales and high international sales

Dependent variables	Two equation system				Three equation system			
	Low international sales		High international sales		Low international sales		High international sales	
	(1) *Cash*	(2) *Ltmature*	(3) *Cash*	(4) *Ltmature*	(1) *Cash*	(2) *Ltmature*	(3) *Cash*	(4) *Ltmature*
Lag cash	0.303[a] (10.53)		0.423[a] (15.10)		0.297[a] (10.70)		0.406[a] (15.25)	
Lag fraction of long-term debt		0.324[a] (14.51)		0.405[a] (19.54)		0.314[a] (15.87)		0.380[a] (21.27)
Fraction of long-term debt	0.022[a] (3.20)		0.006 (0.99)		0.020[a] (3.47)		0.002 (0.43)	
Cash/total assets		0.246[b] (2.50)		0.045 (0.47)		0.276[a] (3.04)		0.019 (0.22)
Industry sigma	0.321[a] (5.69)	−0.165 (−0.91)	0.112[a] (2.59)	0.097 (0.57)	0.336[a] (5.94)	−0.157 (−0.83)	0.128[a] (3.00)	0.133 (0.83)
Market-to-book	0.015[a] (11.09)	0.003 (0.66)	0.014[a] (11.02)	−0.004 (−0.83)	0.015[a] (10.74)	0.002 (0.43)	0.015[a] (12.28)	−0.004 (−0.80)
Log firm size	−0.003[a] (−3.87)	0.117[a] (11.04)	−0.003[a] (−4.68)	0.132[a] (11.25)	−0.003[a] (−5.10)	0.117[a] (11.16)	−0.003[a] (−4.55)	0.146[a] (13.22)
Capex	−0.236[a] (−12.75)	0.267[a] (3.83)	−0.269[a] (−14.29)	0.296[a] (3.99)	−0.237[a] (−13.18)	0.275[a] (3.95)	−0.270[a] (−14.83)	0.313[a] (4.18)
Leverage	−0.078[a] (−9.56)	0.486[a] (17.11)	−0.082[a] (−9.82)	0.498[a] (15.94)	−0.078[a] (−9.89)	0.493[a] (18.38)	−0.082[a] (−10.16)	0.499[a] (18.46)
Dividend/total assets	−0.038[b] (−2.03)		−0.092[a] (−4.37)		−0.037[b] (−2.02)		−0.097[a] (−4.71)	
R&D/sales	0.318[a] (7.70)		0.185[a] (8.10)		0.319[a] (8.01)		0.192[a] (8.58)	
Acquisition/total assets	−0.333[a] (−16.48)	0.286[a] (3.30)	−0.409[a] (−20.81)	0.236[a] (3.00)	−0.334[a] (−16.74)	0.289[a] (3.59)	−0.423[a] (−22.37)	0.241[a] (3.04)

Table 15 continued

Dependent variables	Two equation system				Three equation system			
	Low international sales		High international sales		Low international sales		High international sales	
	(1) *Cash*	(2) *Ltmature*	(3) *Cash*	(4) *Ltmature*	(1) *Cash*	(2) *Ltmature*	(3) *Cash*	(4) *Ltmature*
Abnormal earnings	0.000[c] (1.70)	−0.000 (−0.54)	0.000 (0.21)	0.000 (1.09)	0.000 (1.58)	−0.000 (−0.25)	−0.000 (−0.36)	0.000 (0.74)
Term structure	0.001[b] (2.18)	−0.004[b] (−2.37)	0.002[a] (6.13)	−0.003[c] (−1.84)	0.001[b] (2.10)	−0.004[b] (−2.53)	0.002[a] (5.70)	−0.004[b] (−2.17)
1990s dummy	0.001 (0.31)	0.001 (0.08)	−0.002 (−0.83)	−0.015[c] (−1.67)	0.001 (0.29)	0.002 (0.21)	−0.002 (−1.01)	−0.022[b] (−2.43)
2000s dummy	0.009[a] (4.91)	−0.028[a] (−4.69)	0.014[a] (8.91)	−0.005 (−0.83)	0.010[a] (5.35)	−0.030[a] (−4.96)	0.015[a] (9.58)	−0.003 (−0.44)
Asset maturity		0.001[b] (2.02)		−0.000 (−0.82)		0.001[c] (1.91)		−0.000 (−0.89)
Log firm size square		−0.006[a] (−7.53)		−0.007[a] (−9.49)		−0.006[a] (−7.70)		−0.008[a] (−11.32)
Investment tax dummy		0.017[c] (1.90)		0.016[b] (2.26)		0.018[b] (2.09)		0.016[b] (2.30)
Tax loss carryforward		0.007 (1.12)		0.006 (1.15)		0.006 (0.97)		0.006 (1.17)
Observations	15,654	14,806	17,341	16,834	15,654	14,806	17,341	16,834

Intercept is omitted in the table. Summary of the regression coefficients for the control variables are also omitted for brevity. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

4.4 Bank loan covenants

Our results may also be driven by the fact that many constrained firms use bank loans as their main source of financing. Many of these loans have liquidity covenants that require firms to hold large cash balances to buffer against potential economic shocks. To test this, we used the database provided by Sufi et al. (2009), which provides the bank loan covenants for a set of firms between 1996 and 2005. We find that there are only 250 firm-year observations of our entire sample have such covenants. Consequently, we ran our analysis for these years by omitting from our sample all firms that have such covenants. We find that the results we obtain are strictly analogous to those that we obtained in Tables 6, 7 and 8, indicating that the concern that financially constrained firms are likely to have liquidity covenants do not affect our results.

4.5 Low credit rating firms and debt maturity

Based on Diamond (1991), risky firms may want to borrow long term to avoid liquidity risk, although long-term creditors will shun them. Hence, we might expect that our results may be partially explained by firms with low credit borrowing short term and holding little cash. To examine this issue, we look at the average *ltmature* for firms without a credit rating and those with a credit rating. We find that the average amount of debt with maturity greater than 3 years as a percentage of the total debt of the firm is 61 % for firms without a credit rating and 49 % for those firms with a credit rating. The average difference is statistically significant, which implies that low credit rating firms tend to borrow intermediate- or long-term debt as opposed to accessing the short-term market. This finding may not be surprising since such firms are typically locked out of the commercial paper market.

4.6 Secular trends

Bates et al. (2009) find that there has been a significant increase in cash holding since 1980. Custódio et al. (2013) find a simultaneous decrease in debt maturity over the same period. Thus one might conclude that cash holdings and debt maturity should be negatively related based upon these secular trends. Note that our tests include year fixed effects and/or time trends which extract the effects of the two secular trends documented by the literature and therefore our results and the secular trend are not in conflict with each other. We also examined the debt maturity characteristics of non-convertible debt issued by corporations using the data available in FISD Mergent. As found by Custódio et al. (2013), the average debt maturity declines from 16 years in 1985 to 7 years in 2006 but rises to almost 10 years by 2010. Except for years 2005, 2006 and 2007, more than 75 % of the debt issued in each year had an original maturity of greater than 5 years, our maximum metric for long term debt. Moreover, during the period of 2005–2007, more than half of the non-convertible bonds issued had an original maturity of greater than 5 years.

4.7 Overconfidence

CEO confidence has been shown theoretically and empirically to explain important corporate decisions (Malmendier and Tate 2005, 2008; Campello et al. 2010, Huang-Meier et al. 2015). We would expect that over confident CEOs would likely to hold less cash since such manager may prefer to hold less cash in order to maximize the return on

Table 16 The regression coefficients when estimating a system of equations by non-linear GMM, for two subsamples, firms with over-confident CEOs and non-over-confident CEOs

	Two equation system				Three equation system			
Over-confidence	Yes	No	Yes	No	Yes	No	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variables	*Cash*	*Cash*	*ltmature*	*ltmature*	*Cash*	*Cash*	*ltmature*	*ltmature*
Panel A: Cash								
Lag cash	0.130[b]	0.349[a]			0.131	0.348[a]		
	(2.50)	(10.47)			(0.21)	(11.02)		
Lag ltmature			0.125[a]	0.346[a]			0.121	0.310[a]
			(2.74)	(12.02)			(0.06)	(12.66)
Proportion of long-term (>3 years) debt	0.001	0.014[b]			−0.004	0.011[c]		
	(0.05)	(2.09)			(−0.02)	(1.81)		
Cash/total assets			0.010	0.154			−0.034	0.172
			(0.02)	(1.12)			(−0.00)	(1.28)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2688	7855	2640	7737	2688	7855	2640	7737
Panel B: Excess cash								
Lag cash	0.175[a]	0.293[a]			0.140[a]	0.270[a]		
	(3.04)	(7.85)			(3.64)	(8.01)		
Lag ltmature			0.034	0.308[a]			0.036	0.278[a]
			(0.16)	(9.51)			(0.37)	(10.32)
Fraction of long-term debt	0.027	0.023[a]			0.017	0.018[a]		
	(0.79)	(3.36)			(1.38)	(2.92)		
Excess cash/total assets			0.332	0.403[a]			0.233	0.456[a]
			(0.27)	(2.60)			(0.57)	(3.26)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1780	5563	1888	5850	1780	5563	1888	5850

Intercept is omitted in the table. Summary of the regression coefficients for the control variables are also omitted for brevity. The *t* statistics are in parentheses and [a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.1$

investment. Similarly, since interest rates are generally lower for short-term debt than for long-term debt, over-confident managers would prefer short term debt to maximize earnings and worry less about refinancing risk. Hence, it is possible that the presence of over-confident managers could drive our results. In Table 16, we formalize this test by splitting the sample into firms with over-confident CEOs and those that are not. Panel A uses cash holdings as the endogenous variable while Panel B uses the excess cash holdings as the endogenous variable. We follow Malmendier and Tate (2005, 2008), Campello et al. (2010) in defining optimistic CEOs as those who hold exercisable stock options that are more than 100 % in the money. Interestingly, we find that the relationship between cash and debt maturity is only significant among the non-over-confident managers.

5 Concluding remarks

The key elements of corporate financial policy include the choice of leverage, debt maturity, and the level of cash. Importantly, these policy choices are jointly determined by management and reflect the firm's characteristics and macroeconomic environment.

However, although prior studies have examined the joint choice of leverage and debt maturity and that of leverage and cash holdings, we are the first to investigate the joint choice of cash holdings and debt maturity of firms while accounting for the endogenous *leverage* decision. We shed light on the debate on cash holdings and debt maturity. Although both cash holdings and debt maturity are important corporate financial policies, they are however jointly determined and should be tested jointly.

Firms that experience information asymmetry would normally finance their operations according to Myers and Majluf's (1984) *pecking order hypothesis*. That is, such firms would use cash and then debt to finance investments before issuing new equity. According to this argument, if firms must borrow, they would issue short-term debt to reduce the underpricing of claimants before relying on long-term debt. In contrast, Acharya et al. (2007) argue that firms that face financial constraints may not want to use their cash reserves for current investments because they may find it difficult to raise external capital to sufficiently fund future investments. Instead, if firms do not have sufficient cash to fund current and future investments, then they may borrow first to fund current investments in order to have the flexibility to fund future investments. In this paper, we argue that firms that face financial constraints would borrow long term debt to build up the firm's cash reserves. This prediction is consistent with the theoretical models of Diamond (1991, 1993) and Sun (2014). This argument resembles the precautionary motive in determining cash level (e.g., Almeida et al. 2004; Bates et al. 2009).

We examine the effect of cash holdings on debt maturity, as well as that of *debt maturity* on *cash holdings*. Our pooled regression results show a significantly positive relationship between *cash holdings* and *debt maturity*. We then estimate simultaneous equation models using GMM to evaluate the endogeneity of cash holdings, debt maturity, and leverage, and we find that our results still hold. Since our predictions are based upon the precautionary motivations for cash holdings, we examine whether or not the positive relationship between cash holdings and debt maturity is stronger among financially constrained firms. We assume that firms that face financial constraints are firms that (1) have debt that is not rated; (2) are small in size as proxied by the level of assets; (3) pay no dividends; above median measure of the Whited-Wu index; and above median measure of the Hadlock and Pierce Index. Our results are consistent with our predictions that the positive relationship between debt maturity and cash holdings is strongest among financial constraint firms. The results are also robust to alternative measures of *debt maturity*.

There is of course an alternative explanation for our finding—firms could hold more cash and long-term debt because of agency problems such as those that might arise from managerial entrenchment. However, agency problems do not appear capable of explaining our evidence. We use both an Entrenchment Index and managerial ownership for the managers and find a positive relationship between cash holdings and debt maturity among firms that have the lowest agency cost.

We conduct additional robustness tests to ascertain if alternative explanations may explain our results. For example, multinational firms may tend to hold large reserves of cash while borrowing long-term to avoid taxes in the United States. In addition, our results may be driven by distressed firms or low credit firms borrowing short-term debt because they do not have access to the long-term credit market and holding low cash reserves. Moreover, capital-constrained firms may rely more on bank loans where such loans may require liquidity reserves, which in turn may explain the positive relationship we find between *cash holdings* and *debt maturity*. We also examine whether confident CEOs drive our results. We show that these alternative explanations do not overturn our results.

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