The Impact of Real Options on Corporate Cash Holdings

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Abstract

We posit that firms with *valuable* real options have higher demand for liquid assets, particularly cash. Higher cash holdings enable firms to optimally exercise their options without reliance on capital markets, which could reveal the firm's strategic decisions to its competitors. We propose a simple procedure for separating firms with *valuable* real options from other firms. Our procedure assumes that, all else being equal, real options are more valuable when the underlying volatility is high and when managers possess significant flexibility to optimally exercise these options. We propose alternative measures of underlying risk and managerial flexibility. Using a large sample from the Compustat data, we categorize firms as having high (low) volatility and high (low) managerial flexibility. We then study the determinants of demand for cash holdings for each group of firms. We find that firms with valuable real options (high volatility and high managerial flexibility) hold significantly higher cash levels. Moreover, we find that factors that derive demand for liquidity are very different across the two types of firms. Our finding brings new insights to the literature on demand for corporate cash holdings.

The Impact of Real Options on Corporate Cash Holdings

Global cash and near-cash balances are at record levels and continue to grow topping $2.7 trillion for all NYSE and DASDAQ listed companies and growing at 24% annually (Petit et al., 2005). This unprecedented growth in corporate demand for liquidity is puzzling, particularly in light of the recent innovations in the capital markets, which has significantly reduced both the required time and the costs of raising external funds. In this study we investigate whether the preponderance of strategic real options (growth opportunities) that characterize modern firms may have contributed to this rise in cash reserves. We posit that firms with *valuable* real options are likely to hold excess cash, as liquidity facilitates timely and anonymous exercise of such options.[1]

A large body of recent academic literature has attempted to explain the increase in corporate demand for liquidity. The extant literature stresses the importance of transactions costs and precautionary motives as derivers of demand for liquidity and is centered on the main trade-offs in holding cash. For example, liquidity enables firms to invest without recourse to capital markets, thereby avoiding both implicit and explicit transactions costs associated with raising external funds. Likewise, cash reserves reduce the cost of financial distress, as firms with higher reserves are more likely to meet their financial obligations. However, there are significant costs to holding excessive cash reserves, including low rate of return, adverse exposure to taxation, and value destructive abuses of reserves by managers who advance their own pecuniary interests, at the

[1]Cossin and Hricko (2001) consider the relationship between real options and cash holdings in a theoretical model. They measure the benefits of holding cash when raising capital takes time, is costly, and when firms face undervaluation risk when issuing new securities to meet their capital needs.

expense of the shareholders' (Jensen, 1986).

In a world with perfect capital markets (Modigliani and Miller, 1958), the firm optimally carries no liquid assets. With market imperfections, such as informational asymmetry and agency problems, the firm holds an "optimal" level of cash, which enables it to avoid excessive transactions costs, and simultaneously use cash as a strategic tool to capitalize on its growth opportunities. Kim et al. (1998), Harford (1999), Opler et al. (1999), Pinkowitz and Williamson (2001), and others have empirically examined *firm-specific* determinants of the costs and benefits of cash holdings for large cross-section of publicly traded firms.[2] These authors find that cash holdings rise with the firm's investment opportunity set (growth opportunities), cash flow generation, business risk (cash flow volatility), lack of access to capital markets, and high costs of financial distress. On the other hand, cash reserves decline with the availability of other liquid assets, firm size and leverage.

Other authors have considered the influence of *exogenous factors* on corporate liquidity demand. These include the character of legal system and the quality of law enforcement (Ferreira and Vilela, 2002), outside ownership structure and monitoring (Faulkender, 2002; Ozkan and Ozkan,2002), financial constraints (Almeida, et al., 2003), bank (creditors') power (Pinkowitz and Williamson, 2001), and measures of overall corporate governance (Harford, et al. 2004; Kalcheva and Lins, 2003). Yet another strand of this literature investigates how the marginal addition to cash reserves is capitalized into the firm's market value, while controlling for a common set of attributes (Fama and

[2] See also Minton and Schrand (1999), Billette and Garfinkle (2002), Faulkender (2003), Ozkan and Ozkan (2002), Mikkelson and Partch (2002), Dittmar et al. (2002).

French, 1998; Pinkowitz and Williamson, 2002; and Faulkender et al. 2003).

The firm-specific control variables common to these studies include size, leverage, cash flow, working capital, capital expenditures, dividend distributions, bond rating, insider and institutional ownership, measures of business risk (cash flow variability), and proxies for growth opportunities such as the market-to-book ratios (or Tobin's Q), Research and Development (R&D) expenditures, and expenditures on acquisitions.[3]

Depending on the question being addressed, measures of corporate governance, legal system and contract enforcement mechanisms, industry structure, and asymmetric information and agency costs have also been added as determinants of demand for liquidity. Regardless of the focus, however, proxies for growth opportunities (market-to-book ratios, expenditures on R&D and acquisitions, and others) have always been found to be among the most significant predictors of corporate cash holdings.

Despite ample practical and theoretical justifications, the evidence linking the demand for liquidity to the firm's investment opportunity set is indirect and subjective, often measured by variables believed to be good “proxies” for the existence of growth opportunities. To date, no study has attempted to measure this influence directly; a gap the present study aims to fill. In particular, we utilize a simple methodology to separate firms with *valuable* investment opportunities (real options) from the rest of the sample. We then compare cash holdings across the two groups, while using a common set of variables as controls. As we show below, this approach clearly delineates the role real

[3] The rationale for choosing these variables is discussed below and in Opler et al. 1999, Kim et al. 1998, and others.

options play in deriving demand for liquidity, while bringing the role other factors play into sharper focus.

The real options framework has become the preferred "systematic approach" to valuation and strategic management of corporate investment opportunities in recent years.[4] It is now widely recognized that managerial decisions, including holding the "optimal" amount of cash reserves, can create valuable options for the firm. This paper is among the first to empirically link real options and demand for liquidity. In section two we present a procedure for separating firms with *valuable* real options from the rest of the sample. In section three we undertake a comparative analysis, focusing on the distribution of cash holdings and other broad financial attributes of firms in each group. We then rely on multivariate analysis to identify the determinants of cash reserves for each sub-sample. The final section summarizes of our findings and presents directions for future enhancements to this line of research.

[4] See Amram and Kulatilaka (1999), Copeland and Antikarov (2001), and Trigeorgis (1996).

Separating Firms with Valuable Real Options

All modern firms possess a unique portfolio of real options that enable them to operate competitively within their respective industries. These options, however, are not equally valuable, since the compositions of hard assets and the structure of production costs vary widely within and across industries. We posit that firms with valuable real options are more likely to hold excess cash (relative to their peers) primarily because liquid assets can be used to strategically exercise options that are most valuable (in the money).

To evaluate this proposition, one needs to distinguish firms with valuable real options from the rest of the sample. To achieve this objective, we separate firms into two distinct groups; firms with highest or lowest valued real options (see below). We then examine the distribution of cash holdings and compare financial characteristics of firms within each group. Next we estimate the standard time series-cross section regression, linking cash holdings to a common set of conditioning variables identified in this literature (see Opler et al. (1999) and other references cited below).

Two key ingredients that enhance the value of real options are managerial flexibility and the volatility (risk) of the underlying value driver(s).[5] As exhibit 1 shows, one can then think in terms of a two by two matrix with four quadrants, with low option values corresponding to low volatility and limited managerial flexibility and high option values corresponding to high volatility coupled with high level of managerial flexibility. The value of the other two quadrants lies within these two extremes.

[5] See, Copeland and Antikarov (2001)

Exhibit 1: Value of Real Options versus Managerial Flexibility and Uncertainty

Managerial Flexibility	Underlying Uncertainty: Low	Underlying Uncertainty: High
Low	*Low value for real options:* Lack of volatility and managerial flexibility reduces value of real options.	*Moderate (ambiguous):* High option value but lack of discretion to optimally exercise real options.
High	*Ambiguous:* Low option value despite managerial flexibility.	*High Value for real options:* High degree of uncertainty and managerial flexibility enhance value of real options.

Our objective is to assign firms to each quadrant. To this end, we consider a number of proxies for managerial flexibility and the volatility of the underlying risk. The proxies for managerial flexibility are functions of items from the firms' statement of cash flows, including expenditures on investment activity and R&D, deflated by sales or the value of firm's assets (control for size). For measures of underlying risk we consider the volatility of the sales growth rate (5 years quarterly data) as a measure of risk internal to the firm, and total volatility of return on the firm's equity (5 years of monthly data) as a measure of external risk. We further decompose the equity return volatility into systematic and idiosyncratic components using the standard CAPM framework. This decomposition enables us to assess the impact of the firm's idiosyncratic risk on the value of its real options and its demand for liquidity.

The data is taken from the annual Compustat files for the period 1990 through 2000 (11 years) and includes both *active and inactive* firms. Following standard practice, we

exclude data for ADRs, financials, utilities, governmental and unclassifiable, as well as companies with annual net sales, total assets and common equity less than $1 million. Finally, to maximize the size of the data set, outliers (1% percentile cutoffs) and missing values are replaced with the corresponding 4 digit SIC industry averages. The final sample consists of 4251 firms (24141 observations).

We use the median value of our proposed volatility and managerial flexibility measures to assign firms to four distinct quadrants: High flexibility-High volatility (HH), High flexibility-Low volatility (HL), Low flexibility-High volatility (LH), and Low flexibility-Low volatility (LL). To ensure comparability our result with the extant literature, we measure cash holdings as the ratio of cash and equivalent (marketable securities) to *net assets*, defined as the book value of total assets net of cash and cash equivalents. Furthermore, we also consider firms' cash holdings relative to the industry they operate in (see below).

Measures of Managerial Flexibility: Investment cash flow, defined as expenditures on investment activities, is used as a broad proxy for managerial flexibility. Investment cash flow is deflated by sales (**F1**) and net assets (**F2**) to control for size.[6]

Measures of Risk: All else being equal, the value of real options are expected to rise with the volatility of the underlying asset(s). Modern firms possess a variety of real options whose underlying may be different, making it difficult to decide what measure should be used as the "true" underlying risk. For our purposes we use two sets of variables as proxies for the underlying risk. The first are factors that impact the firm's

[6] Investment cash flow measures expenditures on investment activities and is taken from the firm's statement of cash flows.

revenues. To capture these factors, at each point in time (*t*), we calculate volatility for *sales growth rate* (**V1)** and *cash flow growth rate* (**V2)**, using quarterly data from the previous five years. Cash flow is income (after all expenses and taxes but before dividends) plus depreciation. Using the growth rates facilitate comparisons across firms and averaging smoothes the influence of transitory jumps in these variables.

In the real options literature, it is standard to view equity as an option on the assets of the firm, and the total returns volatility as the main underlying risk. Given this rationale, we create two additional volatility measures that are based on firm's equity returns. First we use the firm's *Beta* (**V3)**, to capture uncertainty from the perspective of the "market". For this purpose, at each (*t*), we estimate the firm's Beta using data for S&P-500 (the market index) and the 90-days Treasury Bill yield (risk-free rate) for the past 60 months.[7] Second, we use the residuals of CAPM, as measure of *idiosyncratic risks* (**V4)**, specific to the operations of the firm. The latter measure enables us to separate cash holding decisions in response to firm level risk versus the market risk.

Assigning Firms to Each Quadrant: We are now ready to sort firms into different quadrants of exhibit 1. For each calendar year, the median value of each measure of the managerial flexibility and risk is used to assign firms to the four quadrants. The results are thirty two unique data partitions: **HHViFj**, **HLViFj**, **LHViFj**, **LLViFj**, where **i**=1,2,3,4 and **j**=1,2. As an example, **HHV1F1** is composed of firms with high volatility of sales growth rate and high investment cash flow (relative to sales). Based on the SIC codes, the main industries in each quadrant are as follows. Mining, oil and gas extraction, pharmaceuticals, semiconductor equipment, electronic computers,

[7] We take steps to ensure the consistency of our regression results. For example, correction for first order auto correlation is made when estimating CAPM.

communications, and computer software appear in high volatility-high flexibility quadrant. Chemicals, communications equipment, semiconductors, apparel, miscellaneous retail, and direct mail advertising appear in low volatility-high flexibility quartile. Oil extraction and refining, food, paper, motor vehicles, and air transportation appear in high volatility-low flexibility quartile. Finally, construction, food, newspapers and periodicals, plastic materials and synthetic resins, primary metals, transportation equipment, and merchandize stores appear in low volatility-low flexibility quartile. To get a better sense for each data partition, we first present comparisons of the cash holding and other financial attributes of firms in each quadrant.

The Unconditional Distribution of Cash Holdings: We consider three distinct measures of cash holdings. (1). Cash and equivalents holdings as percent of the firm's net assets (total assets-cash), which is the standard measure considered in the extant literature. We refer to this measure as "cash holdings" hereafter. (2). Relative cash holdings, is calculated by dividing the firm's cash holdings to the average cash holdings for the firms in the same SIC code for that year. (3). Cash difference, is calculated as the difference between the firm's cash holdings and the average cash holdings for the firms in the same SIC code for that year.

Table 1 contains the data on the distributional characteristics of these measures of cash holdings for the entire sample and the quadrants of exhibit 1. The data presented in the table indicates that, regardless of how the data are sorted, firms with high volatility and high managerial flexibility, hold significantly higher cash (at times twice larger). Moreover, for firms in HH quadrant, the distribution of cash holdings is more widely dispersed. As flexibility and risk decline, the value of the firms' real options declines, and

the distribution of cash holdings changes in a manner consistent with the theory posited above; in general firms with less valuable real options tend to hold less cash. Identical conclusions emerge when SIC adjusted cash holdings measures (relative or difference) are considered: firms with low option value hold less cash than their industry average and vice versa. Considering the intermediate cases (LH and HL), we find that increases in managerial flexibility, rather than risk, leads to higher cash holdings.

Figure 1 contains histograms for the logarithm of cash holdings for two different combinations of flexibility-volatility measures. Kernel and normal density plots are superimposed on the histograms to highlight the differences among the distributions of cash holdings for firms in each quartile. Visual inspection of the histograms confirms the distributional differences among quartiles reported in Table 1.

Finally, as both Table 1 and Figure 1 show, the results for different proxies for flexibility and volatility are very similar, as one would expect (e.g., V1F1 versus V2F1). Therefore, to save space, in the remainder of the paper we will focus on the following combinations of flexibility-volatility proxies: **V1F1** (St. Dev. of Sale Growth Rate and Investment Cash Flow deflated by Sales), **V2F2** (St. Dev. of Cash Flow Growth Rate and Investment Cash Flow deflated by Net Assets), **V3F1** (Market Risk (Beta) and Investment Cash Flow deflated by Sales), and **V4F2** (Idiosyncratic Risk and Investment Cash Flow deflated by Net Assets).[8]

[8] These combinations of flexibility-volatility proxies result in greatest differences in the distribution of cash holdings across the quartiles. The results for other combinations are available from the authors upon request.

The Conditional Distribution of Cash Holdings: As noted earlier, previous studies use a common set of firm attributes that have been identified as determinants of corporate demand for liquidity. We construct, to the extent possible, our control variable according to definitions provided by Opler et al. (1999) and subsequently used by other researchers. Table 2 provides a comparison of the *mean* of these attributes for firms in the **HH** and **LL** quadrants under the above four combinations of flexibility-volatility sorting schemes. We consider each block of results in Table 2 separately. While our comparison is focused on the mean, we note that the distribution of these variables (range, variance, and higher moments) is significantly different across the quadrants.

Risk Characteristics: Four measures of risk are reported in table 2; annualized standard deviation of monthly returns, sales growth rate, and cash flows, and a dummy variable that equals one for firms that operate in more than one business segment. The volatility measures proxy for market and revenue risks, while the number of business segments proxies for how diversified are the sources of the firm's revenues. As expected, risk as measured by the standard deviation of monthly returns, sales growth rate, and cash flows is higher for the HH quadrant. Firms in the LL quadrant are more diversified, since a larger fraction of the firms in this quadrant operate in more than one business segment.

We also consider the estimated parameters of CAPM as proxies for risk (not reported in the table to save space). Because each quadrant represents a well-diversified portfolio, the average beta for all data partitions is unity, as expected. The average Jensen alpha is negative for all groups, and generally firms in the HH group under-perform those in the LL group (lower risk adjusted returns). However, the distribution of alpha and beta for firms in HH is far more disperse than that of the LL quadrant.

Operational Flexibility: As described above, we use our proposed proxies for managerial flexibility to sort the firms into the four quadrants. Following the literature, we also use other variables that proxy for flexibility. The market-to-book ratio is used as a proxy for the likelihood that a firm will have valuable investment projects in the future. R&D expenditures (deflated by sales) are believed to correlate with costs of financial distress (Opler et al. 1999) and cause managers to hold higher cash reserves. Harford (1999) has shown that excess cash reserves lead to value destroying acquisitions. We therefore use expenditures on acquisitions (deflated by net assets) as a determinant of liquidity. The ratio of fixed assets to total assets is used as a proxy for operational flexibility: All else being equal, the lower this ratio, the smaller the fraction of the firm's assets tied into property, land and equipment. This is the complement of working capital to total assets. Working capital can be seen as a reserve of liquid asset substitutes. Firms' cash holdings are negatively affected by the amount of liquid asset substitutes (Ferreira and Vilella, 2002). The data in table 2 indicates significant differences in flexibility between the HH and LL quadrants by all these measures.

Firm Size: As in other studies, we use the book value of total assets as a proxy for firm size. The data in table 2 is consistent with those reported in previous studies: Small firms (in HH quadrant) hold more cash than large firms (in the LL quadrant). Under the hypothesis advance in this paper, small firm need the larger cash reserves to finance their more valuable growth options.

Financial Attributes: This group of variables provides a broad picture of a firm's financial status. While firms in the HH quadrant clearly hold larger cash reserves than those in the LL quadrant, it is striking that their net working capital as a percentage of net

assets is much lower. This result suggests a more effective management of the cash conversion cycle by the larger firms. Firms with high managerial flexibility operating in a highly uncertain environment spend more on internal investments (capital expenditures).

Performance Measures: This set of variables is reflective of the firm's operational efficiency. The firms in the LL quadrant hold less cash and accordingly have higher cash turnover ratio. They also tend to pay out more dividends as indicated by the dividend dummy (fraction of firms that pay dividend in each quadrant). The higher dividend payout is a reflection of the lower availability of growth options associated with these more mature firms.

Working Capital and Leverage: This set of accounting ratios measure the long and short term liquidity and leverage. The debt-to-equity ratio is lower for the smaller firms that populate the HH quartile, suggesting that these firms are more likely to rely on equity financing. These results are consistent with Myers' (1993) findings that the debt ratio tends to be lower in high-growth industries, even when the need for external capital may be the greatest. The bond rating dummy (equals one if the firm's bonds are rated and zero otherwise) is a proxy for the firm's access to credit markets. The larger firms (in LL) have better access to the capital markets and accordingly hold less cash.

Market Value: It is common to measure the likelihood that a firm will have positive net present value projects in the future by the ratio of the market value of the firm's assets to the book value of its assets. Since the book value of the firm's assets does not include future growth potentials, it is expected that the market-to-book ratio, will be higher when a firm has a high preponderance of growth opportunities. Given this reasoning, the market-to-book ratio is considered a good proxy for the presence of profitable growth

options. However, the market to book ratio is based on common equity and ignores the preferred stock and long term debt. Following other authors, we calculate Tobin's Q by adding the latter values to common equity and then deflate by the book value of firm's assets.

The "trailing" price-to-earnings (P/E) ratio reported in Table 2 is also indicative of the firm's future growth opportunities and is expected to be higher for firms in HH quadrant. Interestingly, this common wisdom is reversed in our sample, except when market risk (beta) is used to screen firms. That is firms with high beta and high managerial flexibility (F1 or F2) have higher P/E.

Survivor Dummy Variable: Recall that our data includes both active and inactive firms (those that dropped from the sample for a variety of reasons, including bankruptcy, mergers, and alike). To assess to influence of the induced "survivorship bias," we create a dummy variable that equals one for firms with 5 or more years of data. Admittedly this is a "low tech" method of accounting for survivorship bias. However, it does provide an initial indication of this important effect. The larger firms in LL quadrant show a higher survivorship (slower growing, more mature firms) than the faster growing smaller firms in HH quadrant.

The competitive environment within which the firm operates has a significant bearing on demand for liquidity. The degree of concentration within the industry a firm operates in (as for example measured by the Herfindahl Index) can be used to assess the impact of competition on managerial flexibility. Similarly, proxies for internal control such as managerial ownership and representation on the firm's board of directors may be used as measures of managerial flexibility. However, our data does not include such

variables. Instead, we utilize the number of business segment the firm operates in as a proxy that may captures some of these effects.[9]

To summarize, the results in tables 1 and 2 point to a complex and sometimes unexpected relationship between measures of financial performance, real options' value, and demand for liquidity. Overall, it seems reasonable to conclude that the univariate analysis supports the main hypothesis we advanced above, that firms with valuable growth opportunities are likely to hold larger cash reserves. However, we need to pursue this question using multivariate regression analysis, which is the task we turn to next.

Multivariate Analysis: To further investigate our hypothesized relationship, we estimate the standard regression model for the determinants of cash holding. Our main innovation is to control for the existence of the firms' real options. We estimate two distinct specifications using the same set of control variables. First, we use panel data for all firms and include dummy variables signifying different quadrants. Under this specification, each quadrant's dummy coefficient measures the impact of eachs classification on cash holding while the effect of the control variables is forced to be the same across all quadrants.[10] Our model specification has the following form:

$$CH = \mu + \sum_{q=2}^{4} \delta_q D_q + \sum_{y=1990}^{1999} \upsilon_y D_y + \sum_{i=1}^{14} \beta_i C_i + \varepsilon$$

Where

[9] This variable measures the number of different markets in which the firm operates. The variable 1 when the firm operates in one single market, and 10 (max) the firms operates in ten or more distinct markets.

[10] As a second alternative, we estimated the regression model for each quadrant separately. We obtained nearly identical results but will not report them here to save space.

- Vector *CH* represents cash holdings expressed as a percentage of net assets, with each element representing a firm in a particular year (panel data).
- $D_q = 1$ for firms in the *q*-th quadrant of real options' value and zero otherwise (*q*=HH, HL,LH). The coefficient differentiating the quadrants is δ_q. It measures difference in cash holdings across quadrants, after controlling for other factors. Our null hypothesis is that for each data sorting scheme, firms in the HH, HL, and LH quadrants are no different than firms in the LL quadrant: for $\delta_q = 0$ for $q = HH, HL, LH$.
- D_y is a dummy variable for the year. $D_y = 1$ when *y*=1991,…,2000 and zero otherwise. The influence of each year on performance is measured by υ_y. The effect due to 1990 is captured by the intercept.
- C_i is the *i*-th control variable and β_i measures its impact on performance.
- μ is the regression intercept. It measures the conditional mean of the *CH* for the LL quadrant in year 1990.
- ε is the regression error. We assume the residuals are independently and identically distributed (IID). Rationale for this assumption is provided below.

We use this model to investigate the relationship between cash holdings and real options. The control variables were defined above and their distributional characteristics are reported in Table 2. Again, these explanatory variables are common to most studies of demand for corporate cash holding, in particular, Opler et al. (1999) provide detailed

justifications for their use.[11]

To measure the impact of volatility on performance, we use the standard deviation of cash flow growth rate and the idiosyncratic risk. The logarithm of firm's total assets is used as a proxy for firm size. The market-to-book, R&D-to-sales, acquisition-to-net assets, and price-to-earnings ratios represent various measures of corporate flexibility and the existence of growth options (i.e., the likelihood that the firm will have positive net present value projects in the future).

The cash flow (current earnings net of interest, dividends, and taxes, but before depreciation) divided by net assets measures the influence of cash flow level on the performance measure. To distinguish the effect of firms' dividend payouts, we define a dummy variable that equals one in years when the firm pays a dividend and zero otherwise.

As noted, all dollar denominated variables are deflated by the value of net assets. This normalization achieves two important objectives. First, a firm's assets in place rather than its excess short-term cash holdings is an important determinant of its long term performance. Looking at dollar values per unit of net assets is therefore a more appropriate way of comparing firms. Second, deflating by net assets increases the likelihood that the regression residuals have a constant variance. Hence, the assumptions underlying the regression model will not be violated and the results are less likely to be biased.[12]

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[11] We considered over 30 potential explanatory variables that were discussed in the extant literature and selected those with minimum correlation to avoid the biases due to multi-collinearity. The correlation matrix for all variables is available from the authors.

[12] Without this normalization the variance of the regression residual will be a function of firm size. Statistical tests indicate that after this normalization and with the inclusion of size, the residuals become homoscedastic. We also performed other "diagnostic tests" and were not able to reject the standard OLS

Results: The proposed regression model is estimated with panel data procedures using Stata-9. Table 3 and 4 contains the estimated regression coefficients for the above specification. Before focusing on a specific table, we note that the majority of the estimated coefficients are highly statistically significant (above 99% confidence level) and the adjusted R-squared are consistent with those reported in the literature. All regressions include year-dummy variables, which are statistically insignificant and their coefficients are dropped from the tables to save space. The results in these tables are simple to interpret. The first column reports the coefficients for the *fixed effects* (FE) regression, which forces the intercept term and the slope coefficients to be the same across all firms. The FE results are very similar to those reported in the literature and will therefore serves as a reference. For the purpose of our analysis, we focus on regression results from the *Random Effect* (RE) regression, which allows the intercept term to vary by firms but forces the slope coefficients to be the same across all firms. For comparison we also report the *Population Averaged* (PA) regression, which provide parameter estimates based on the average of each firm's dependent and explanatory variables. Some regression coefficients are statistically significant but economically non-significant. In the following, we limit our discussions to those that are both economically and statistically significant.

Table 3 contains the regression results when the dependent variable is the logarithm of cash holdings. Table 4 is identical in every respect except that the dependent variable

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assumptions. Finally, we ran cross-sectional regressions by year and then average the coefficients as suggested by Fama and MacBeth (1973). The results were identical to those reported below.

is the level of cash holdings. In both tables dummy variables distinguish firms in different quadrants. We also estimated these models using our other measures of cash holdings. Given the similarity of the findings we will not consider those regressions to save space.

The results in Tables 3 and 4 can be summarized as follow: Cash holdings are consistently higher for firms in the HH quadrant across all measures of risk (on average 0.73 to 8.94 percent higher than the LL group). Once the controls for growth options are added, other estimated coefficient become similar across the different sorting schemes. In particular, the common proxies for growth options become very similar for all quadrants.

The rest of the control variables confirm the findings in previous studies though the magnitudes of the coefficients are not the same (Opler et al., 1999). In summary, cash reserves rise with business risk, including idiosyncratic risk.[13] Together, these results suggest that firms maintain cash reserves not so much to hedge against market risk but rather as a hedge against internal risk. Firm's diversification, as measured by the number of business segments it operates in, reduces cash holdings.

The impact of firm's investment opportunity (Tobin's Q, fixed to nets assets, R&D and acquisitions) conform to the results in previous studies. In particular, Tobin's Q remain significant even after controlling for the values of real options. R&D expenditure, often viewed as a measure of the potential for financial distress costs, significantly and positively influences cash holdings. The ratio of fixed assets to net assets has a large and negative influence on the level of cash holdings as higher investment in property, plant and equipment lowers the value of real options to the firm. Consequently, capital-intensive firms show significantly lower cash holdings across all measures of volatility.

[13] As Shin and Stulz (2000) and others have shown, the value of a firm's real options is expected to rise with the level of its idiosyncratic risk. Our results confirm this conjecture.

Leverage reduces cash reserves. Not surprisingly, firms with access to capital markets (bond rating) hold less cash. Dividend payouts also result in lower reserves. This is true of firm size as well. Rising cash flows lower reserves and higher net-working capital increase it. As expected, survivor firms (in the sample for at least four years) hold less cash.

Comparing coefficients across the different measures of risk and managerial flexibility, it appears that flexibility, rather than risk, induces corporate demand for liquidity. The rationale may be that firms with high flexibility can better use their cash reserves to capitalize on their options in a timely fashion without signaling competitors through the capital markets.

While the overall results in Tables 3 and 4 conform to those reported in the literature, we find that for firms in the HH quadrant volatility measures (standard deviation of sales growth and stock return), market capitalization and net working capital are not as significant as reported in other studies. However, the proxies for the existence of real options are highly statistically significant at the 99% level or better and have the expected sign and magnitude.

Considering the intermediate cases (HL and LH), we conclude that managerial flexibility rather than volatility is the main driver of corporate cash holdings. The implication is that firms with high managerial flexibility will hold large cash reserves but this may be independent of the need to exercise firm's options in a timely or strategic fashion. Overall, our results are robust across all four flexibility-uncertainty quadrants and shows that "optionality" explains corporate cash holdings.

SUMMARY AND CONCLUSION

A large body of empirical literature has identified the key drivers of corporate cash holdings. The extant literature has hypothesized that existence of real options significantly influences demand for liquidity. The literature has relied on indirect proxies to assess this influence. In this study we provided a direct method for assessing the influence of valuable real options on cash holding. We showed that managerial flexibility and risk enhance the value of the firm's real options. We used a simple methodology to separate firms with valuable real options from the rest of the sample. We then studied how firm characteristics influenced cash reserves. Our approach enabled us to delineate the influence of growth options, while obtaining unbiased estimates of other factors.

Our analysis shows that the existence of real options provides the greatest justifications for corporate cash holdings. While both managerial flexibility and risk influence demand for liquidity, we find that the latter is more important than the former. What may seem as exorbitant cash reserves may be part of a well thought out financial strategy, especially for firms with considerable managerial flexibility and valuable real options.

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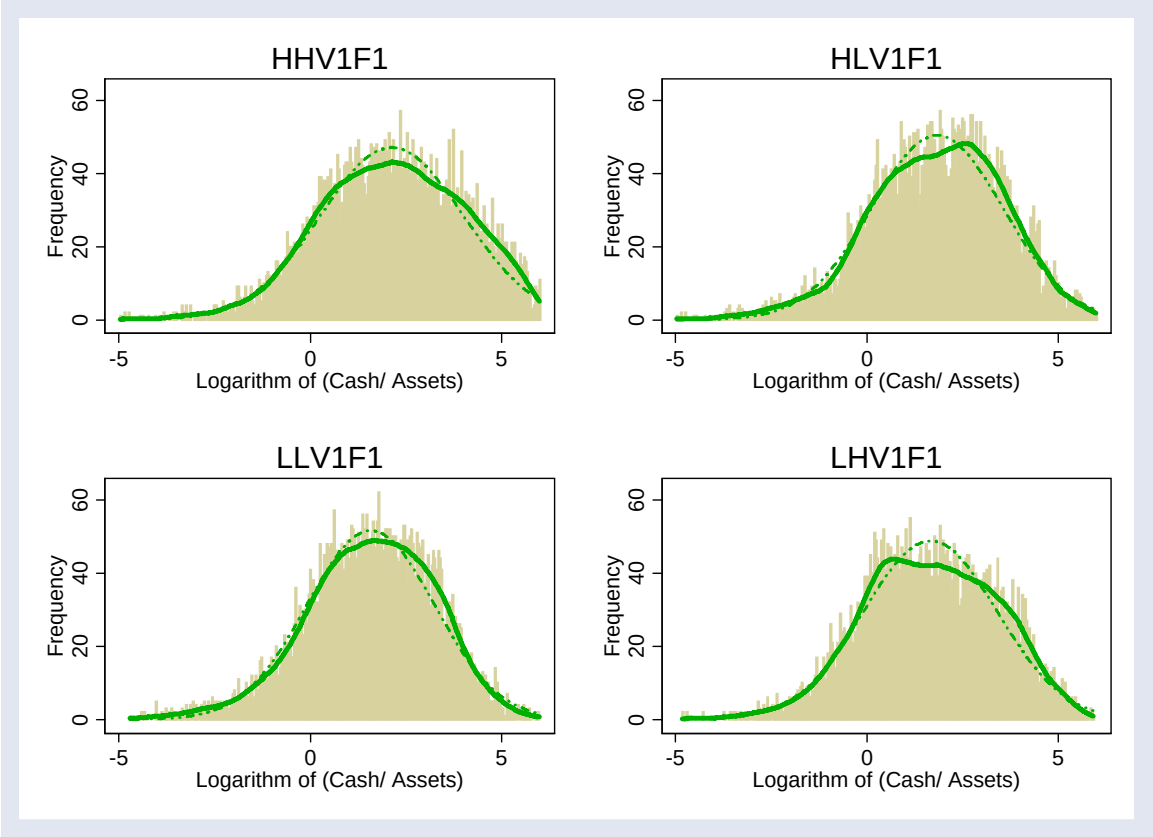

Figure 1: Distribution of the logarithm of cash holding by quadrants of volatility and flexibility (Solid line is a kernel fit and dashed line is the normal density)

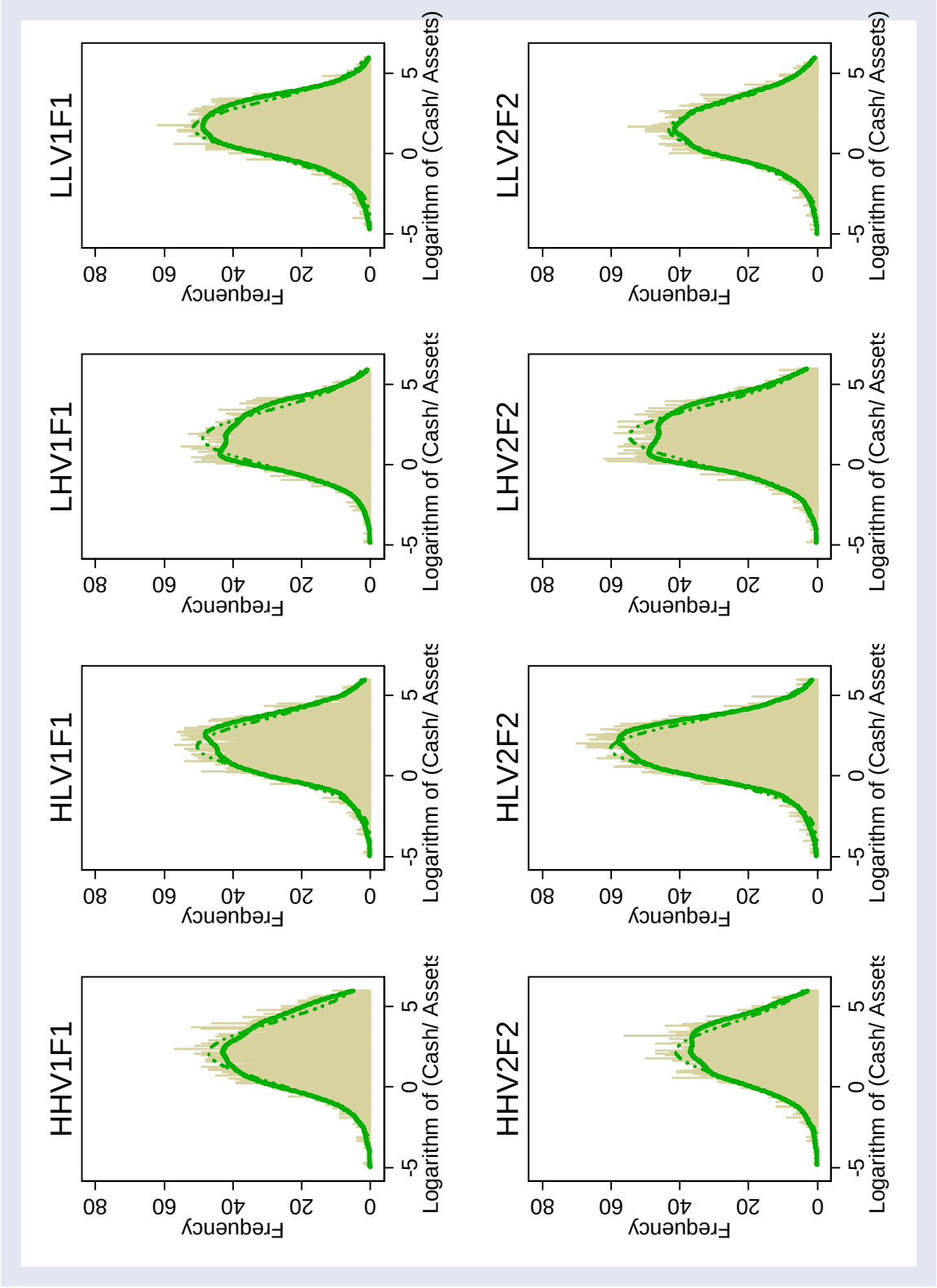

Figure 2: Comparison of the distribution of the logarithm of cash holding by quadrants of volatility and flexibility (Solid line is a kernel fit and dashed line is the normal density)

Table 1: The distribution of measures of cash-holding for firms in quadrants of exhibit 1.

Cash and Equivalent / Net Assets (%)								Relative Cash		Cash Difference	
Name	**Count**	**Mean**	**Mode**	**Lower-25%**	**Upper-75%**	**Skew**	**Kurtosis**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Sample	24141	21.53	6.20	1.76	21.54	3.41	16.04	1.00	1.25	0.00	33.71
LLV1F1	6091	15.01	5.23	1.62	16.28	4.34	27.63	0.96	1.21	-2.33	25.32
LHV1F1	5981	18.45	5.17	1.49	19.59	3.53	18.12	0.90	1.12	-2.44	30.30
HLV1F1	5999	20.43	6.76	1.92	21.23	3.64	18.62	1.03	1.24	-0.23	31.67
HHV1F1	6070	32.18	8.52	2.20	34.28	2.46	8.63	1.11	1.42	4.96	44.09
LLV2F1	5304	17.12	5.33	1.63	17.81	4.03	23.09	1.05	1.27	0.02	27.39
LHV2F1	6769	22.83	5.22	1.46	21.29	3.18	13.80	0.98	1.24	1.32	35.66
HLV2F1	6786	18.16	6.32	1.85	19.11	3.97	22.27	0.95	1.18	-2.31	29.58
HHV2F1	5282	28.61	8.43	2.42	30.81	2.73	10.59	1.03	1.34	1.24	40.93
LLV3F1	5795	13.18	4.69	1.59	14.03	4.53	30.67	1.00	1.22	-1.30	22.37
LHV3F1	6287	14.56	3.86	1.26	13.74	4.39	26.42	0.84	1.10	-3.29	27.04
HLV3F1	6295	21.87	7.46	1.94	24.05	3.49	17.25	0.99	1.23	-1.27	33.42
HHV3F1	5764	37.15	12.52	3.14	44.98	2.20	7.40	1.18	1.44	6.29	46.72
LLV4F1	5726	12.86	4.67	1.60	14.03	4.49	30.83	1.00	1.21	-1.37	21.48
LHV4F1	6346	14.15	3.79	1.26	13.35	4.46	27.54	0.84	1.09	-3.41	26.33
HLV4F1	6364	22.06	7.48	1.94	24.15	3.46	16.90	0.99	1.23	-1.21	33.85
HHV4F1	5705	37.84	13.06	3.23	45.82	2.17	7.22	1.19	1.45	6.51	47.30
LLV1F2	5893	12.63	4.41	1.41	13.31	4.91	35.26	0.87	1.11	-4.20	22.86
LHV1F2	6179	20.61	6.35	1.70	23.54	3.30	16.12	0.99	1.22	-0.65	31.87
HLV1F2	6197	20.41	6.46	1.80	20.41	3.60	17.97	1.01	1.23	-0.80	32.50
HHV1F2	5872	32.60	9.10	2.39	35.36	2.46	8.66	1.14	1.42	5.74	43.72
LLV2F2	5093	15.83	4.67	1.40	14.92	4.23	24.60	0.97	1.18	-1.34	27.01
LHV2F2	6980	23.59	6.04	1.63	23.83	3.14	13.70	1.04	1.30	2.28	35.59
HLV2F2	6997	17.18	5.89	1.76	17.74	4.13	23.77	0.92	1.17	-3.27	29.13
HHV2F2	5071	30.39	9.72	2.64	34.59	2.62	9.96	1.09	1.35	2.72	41.62
LLV3F2	5788	12.09	4.28	1.40	12.22	4.90	34.74	0.93	1.15	-2.54	21.91
LHV3F2	6294	15.56	4.29	1.38	15.59	4.18	24.61	0.91	1.17	-2.15	27.42
HLV3F2	6302	20.77	6.79	1.79	21.69	3.60	18.04	0.95	1.20	-2.38	33.05
HHV3F2	5757	38.36	14.21	3.53	47.25	2.17	7.28	1.23	1.45	7.51	46.80
LLV4F2	5716	11.75	4.27	1.42	12.18	4.87	35.24	0.93	1.13	-2.63	20.89
LHV4F2	6356	15.15	4.15	1.35	15.37	4.24	25.54	0.90	1.17	-2.27	26.78
HLV4F2	6374	20.98	6.80	1.78	21.77	3.57	17.65	0.95	1.21	-2.30	33.53
HHV4F2	5695	39.07	14.73	3.67	48.45	2.13	7.11	1.24	1.46	7.75	47.34

Table 2: Financial Attributes of Firms in HH and LL Quadrants

Variable	Sample	LLV1F1	HHV1F1	LLV2F2	HHV2F2	LLV3F1	HHV3F1	LLV4F2	HHV4F2
RISK									
St. Dev. Monthly Returns (% , Annual)	57.53	51.52	65.74	48.31	65.52	37.58	76.19	34.54	76.39
St. Dev. Sales Growth Rate (% , Annual)	66.99	20.12	140.06	44.23	99.80	39.02	116.84	42.00	103.94
St. Dev. of Quarterly Cash Flow (%$ Mil , Annual)	857.77	769.07	1001.40	144.71	1572.48	715.83	1028.89	723.73	1028.87
Dummy=1 if Number of Bus. Segments > 1	0.25	0.29	0.22	0.31	0.20	0.33	0.19	0.36	0.18
FRIM LEVEL FLEXIBILITY									
Investment Cash Flow / Sales (%, Annual)	1.48	0.19	4.02	0.44	2.96	0.19	3.76	0.37	3.35
Investment Cash Flow / Net Assets (%, Annual)	0.27	0.11	0.47	0.08	0.49	0.11	0.50	0.09	0.54
R&D / Sales (%, Annual)	5.21	2.27	10.35	3.42	8.14	1.47	12.00	1.56	11.62
Fixed Assets (PPE) / Net Assets	1.42	1.19	1.67	1.23	1.55	1.21	1.56	1.29	1.49
Total Assets ($, Millions)	768.84	856.63	525.97	1106.82	515.28	1151.90	285.56	1368.56	209.53
Total Assets net of Cash ($, Millions)	717.00	801.04	488.11	1048.54	467.81	1085.64	248.21	1300.11	174.12
FINANCIAL ATTRIBUTES									
Cash Flow / Net Assets (%)	8.30	8.64	6.89	8.37	7.63	8.46	7.60	7.81	8.34
Net Working Capital / Net Assets (%)	17.23	21.86	11.83	21.65	13.36	22.49	12.85	21.19	14.12
Capital Expenditures / Net Assets (%)	7.77	5.68	9.74	5.47	9.61	5.75	9.95	5.38	10.26
Acquisitions / Net Assets (%)	1.99	1.29	2.67	1.42	2.45	1.48	2.31	1.55	2.28
Shareholder Payout (%, Annual)	0.52	0.63	0.38	0.76	0.35	0.84	0.16	0.88	0.15
Dividend Dummy (1 if Dividend > 0)	0.33	0.41	0.21	0.49	0.19	0.57	0.08	0.60	0.07
Total Debt / Total Equity (%)	77.61	79.29	79.25	76.39	75.60	71.73	72.67	79.39	65.91
Bond Rate Dummy (1 if firm's bonds are rated)	0.10	0.11	0.06	0.16	0.06	0.16	0.01	0.19	0.01
Price-Earnings Ratio	11.50	12.66	8.28	13.58	8.80	13.96	7.57	13.98	8.47
Tobin's Q (Market-to-Book Ratio)	1.90	1.64	2.19	1.70	2.12	1.60	2.31	1.51	2.35
Other Characteristics									
Average Number of Years in the Sample	7.64	8.42	6.58	8.28	6.73	8.48	6.37	8.56	6.37
Average Persistence in the Quartile	------	23.72	23.63	23.98	23.85	21.97	21.88	24.41	24.32
Dummy=1 if Total Debt / Tot Equity < 0	0.04	0.04	0.05	0.03	0.04	0.02	0.06	0.02	0.05
Dummy=1 if Cash Flow / Net Assets < 0	0.22	0.13	0.36	0.12	0.32	0.10	0.38	0.09	0.35
Dummy=1 if Net Working Cap. / Net Assets < 0	0.27	0.17	0.40	0.18	0.36	0.15	0.38	0.16	0.36

Table 3: Determinants of Logarithm of Cash Holdings for the Total Sample for Different Sorting Schemes

	Fixed	V1F1		V2F2		V3F1		V4F2	
	Effect	RE	PA	RE	PA	RE	PA	RE	PA
HH	---	1.43***	1.48***	1.66***	1.75***	1.86***	1.90***	2.17***	2.25***
HL	---	1.15*	1.19**	1.07	1.07	1.23**	1.20*	1.19**	1.20*
LH	---	1.05	1.04	1.27***	1.26***	0.80***	0.77***	0.93	0.94
SDev. of Cash Flow Growth	0.00	0.02***	0.01	0.02**	0.01	0.02***	0.01	0.02***	0.01
SDev. Monthly Returns	0.05	0.16***	0.14***	0.16***	0.15***	0.06	0.02	0.05	0.02
Dummy: #of Bus Segments	-0.20***	-0.05**	-0.08**	-0.05**	-0.07**	-0.05**	-0.07**	-0.05*	-0.07**
Tobin's Q	0.25***	0.34***	0.34***	0.34***	0.33***	0.34***	0.33***	0.34***	0.33***
Fix Assets (PPE) –to-Assets	0.08**	-0.02	0.02	-0.03	0.00	0.00	0.03	-0.01	0.02
R&D / Sales	0.00	0.07***	0.08***	0.07***	0.07***	0.06***	0.07***	0.06***	0.07***
Acquisitions-to-Assets	-0.02***	-0.01***	-0.02***	-0.02***	-0.02***	-0.01***	-0.02***	-0.02***	-0.02***
Total Debt / Total Equity	-0.12***	-0.16***	-0.15***	-0.16***	-0.15***	-0.16***	-0.15***	-0.15***	-0.15***
Bond Rating Dummy	-0.18***	-0.25***	-0.27***	-0.25***	-0.27***	-0.22***	-0.24***	-0.22***	-0.24***
Dividend Dummy	-0.01	-0.10***	-0.10**	-0.09**	-0.09**	-0.04	-0.04	-0.03	-0.03
Market Cap (Log of $, Mil.)	-0.20***	-0.02	-0.05	-0.04	-0.08	0.03	-0.01	0.01	-0.02
Cash Flow-to-Assets	0.12***	0.13***	0.11***	0.12***	0.11***	0.13***	0.11***	0.13***	0.11***
Net Working Cap-to-Assets	0.00	-0.03***	-0.04***	-0.03***	-0.04***	-0.04***	-0.04***	-0.03***	-0.04***
Capital Exp-to-Assets	0.08***	0.10***	0.06***	0.09***	0.05***	0.09***	0.06***	0.09***	0.05***
Dummy: D/E < 0	-1.69***	-2.16***	-2.02***	-2.14***	-2.01***	-2.14***	-2.01***	-2.12***	-1.99***
Dummy: CF/A < 0	1.05***	1.19***	0.99***	1.16***	0.97***	1.20***	1.01***	1.19***	1.00***
Dummy: NWC/A < 0	0.15	-0.01	-0.04	0.01	-0.02	-0.03	-0.06	0.00	-0.04
Constant	4.87***	3.24***	4.18***	3.14***	4.13***	4.32***	6.07***	4.13***	5.70***

The dependent variable is the Logarithm of (Cash and Equivalents / Net Assets).
The Fixed Effect regression excludes quadrant and year dummy variables but includes a dummy variable for each firm.
RE stands for Random Effect regression model.
PA stands for Population Averaged regression model
*** is significance at 99% or better.
** is 95% to 99%,
* is 90% to 95%

Table 4: Determinants of Cash Holding (levels) for the Total Sample for Different Sorting Schemes

	Fixed	V1F1		V2F2		V3F1		V4F2	
	Effect	RE	PA	RE	PA	RE	PA	RE	PA
HH	---	12.05***	10.17***	9.58***	9.41***	17.63***	15.94***	18.59***	17.32***
HL	---	0.89	0.14	-1.35	-1.50	3.50*	2.67*	2.03	1.40
LH	---	3.64**	2.87*	7.57***	5.90***	-1.16	-1.81	-1.57	-1.90
SDev. of Cash Flow Growth	0.00**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
SDev. Monthly Returns	0.04***	0.04***	0.03*	0.04***	0.03**	0.02**	0.00	0.02**	0.00
Dummy: #of Bus Segments	-2.31***	-2.34***	-2.46***	-2.27	-2.31	-2.27	-2.41	-2.22	-2.34
Tobin's Q	1.36***	2.20***	2.52***	2.22***	2.52***	2.18***	2.48***	2.19***	2.48***
Fix Assets (PPE) –to-Assets	-0.42	-3.15***	-3.23***	-3.03***	-3.09***	-2.70***	-2.73***	-2.52***	-2.55***
R&D / Sales	0.25***	0.76***	0.85***	0.77***	0.86***	0.74***	0.83***	0.74***	0.82***
Acquisitions-to-Assets	-0.23***	-0.25***	-0.25***	-0.25***	-0.26***	-0.25***	-0.25***	-0.26***	-0.26***
Total Debt / Total Equity	-0.02***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***
Bond Rating Dummy	-2.73**	-5.19***	-6.24***	-5.17***	-6.17***	-4.68***	-5.64***	-4.58***	-5.50***
Dividend Dummy	1.20	-0.72	-1.77**	-0.87	-1.82**	0.52	-0.17	0.68	0.06
Market Cap (Log of $, Mil.)	0.27	-0.29	-0.41	-0.48**	-0.57**	0.11	-0.03	0.10	-0.05
Cash Flow-to-Assets	0.52***	0.59***	0.55***	0.57***	0.52***	0.59***	0.54***	0.58***	0.54***
Net Working Cap-to-Assets	-0.01	-0.01	-0.03	-0.01	-0.03	-0.01	-0.03	-0.01	-0.03
Capital Exp-to-Assets	0.29***	0.33***	0.31***	0.32***	0.28***	0.32***	0.30***	0.31***	0.28***
Dummy: D/E < 0	-11.63***	-16.29***	-18.29***	-16.16***	-18.04***	-16.18***	-18.19***	-15.97***	-17.82***
Dummy: CF/A < 0	7.00***	9.09***	8.46***	9.22***	8.55***	8.91***	8.25***	8.98***	8.32***
Dummy: NWC/A < 0	5.35***	5.74***	5.50***	5.86***	5.63***	5.73***	5.45***	5.78***	5.52***
Constant	8.53***	8.80***	11.29***	9.74***	11.74***	6.42***	9.42***	6.47***	9.40***

The dependent variable is the level of Cash / Net Assets (%).
The Fixed Effect regression excludes quadrant and year dummy variables but includes a dummy variable for each firm.
RE stands for Random Effect regression model.
PA stands for Population Averaged regression model
*** is significance at 99% or better.
** is 95% to 99%,
* is 90% to 95%