The Impact of Macroeconomic Uncertainty on Non-Financial Firms' Demand for Liquidity

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Abstract

This paper empirically investigates whether changes in macroeconomic volatility affect the efficient allocation of non-financial firms' liquid assets. We argue that higher uncertainty will hamper managers' ability to accurately predict firm-specific information and induce them to implement similar cash management policies. Contrarily, when the macroeconomic environment becomes more tranquil, each manager will have the latitude to behave more idiosyncratically as she can adjust liquid assets based on the specific requirements of the firm, bringing about a more efficient allocation of liquid assets. Our empirical analysis provides support for these predictions.

Keywords: Liquid assets, cash holdings, buffer stock, macroeconomic uncertainty, ARCH, non-financial firms.

JEL: E32, G31, M31.

1 Introduction

Non-financial firms' heavy reliance on liquid assets has presented researchers with a number of interesting questions. Why do these firms hold cash far in excess of transactions needs?[1] How does firms' demand for liquidity differ across categories of firms with similar characteristics? How does firms' liquid asset management respond to variations in broad economic conditions, and uncertainty over the course of the economy? The sizable literature on firms' liquid asset management addresses some of these questions, but has said very little about their interaction with the level and volatility of macroeconomic aggregates. This study seeks to address that deficiency.

Research focusing on the first two questions above has made extensive use of firm-specific characteristics such as leverage, growth opportunities, cash flow, and firm-level cash flow uncertainty.[2] They found that small, non-rated firms, firms with strong investment opportunities, and those facing more volatile cash flows hold more cash. One can interpret these findings to suggest that firms facing a high degree of asymmetric information are likely to hold more liquid assets because of potential difficulties in their access to external financing. In addition to firm-specific variables, macroeconomic aggregates could be an important determinant of firms' cash-holding behavior and one that has received relatively little attention in previous research.

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[1] We use cash and liquid assets synonymously, recognizing that some highly liquid assets are almost indistinguishable from cash in terms of their liquidity.

[2] Papers of this genre include Opler, Pinkowitz, Stulz and Williamson (1999), Faulkender (2002), Ozkan and Ozkan (2004), Almeida, Campello and Weisbach (2004) and Dittmar, Mahrt-Smith and Servaes (2003). Also see Mikkelson and Partch (2003) who investigate linkages between sizable cash holdings and firm performance.

In this paper, we aim to contribute to the literature on corporate liquidity by considering an additional factor which may have important effects on firms' demand for liquidity. We argue that *volatility* in macroeconomic conditions affects managers' determination of the appropriate level of liquid asset holdings and distorts efficient allocation of the firm's resources.[3] In particular, we claim that higher uncertainty will hamper the ability of the managers to accurately predict firm-specific information such as expected future cash flows, inducing managers to behave more homogeneously in terms of their cash management policies. Contrarily, when the macroeconomic environment becomes more tranquil, each manager will have the latitude to behave more idiosyncratically as she can adjust liquid assets based on the specific requirements of the firm to bring about a more efficient allocation of scarce resources. Furthermore, given that managers of firms with differing features (size, growth rate, access to financial markets) will have quite different responses to changes in macroeconomic volatility, we also expect to find variations between groups of firms with respect to the strength of the managerial response to changes in uncertainty. Overall, in this view, greater stability of the macroeconomic environment will favor a more efficient allocation of liquid assets across firms.

The above argument implies that managers' reactions to changes in macroeconomic uncertainty with respect to their demand for liquidity will generate predictable variations in the *cross-sectional distribution* of corporate cash holdings. To test these claims, we investigate whether changes in macroeconomic uncertainty explain the time variation in the cross-sectional dispersion of corporate cash holdings. We expect to find that the cross-sectional disper-

[3]We use the terms macroeconomic volatility and uncertainty interchangeably in this paper.

sion of corporate cash holdings would narrow as increased macroeconomic uncertainty hinders managers' ability to accurately evaluate firm-specific information. Contrarily, a reduction in macroeconomic uncertainty would lead to a more unequal distribution of cash holding behavior across firms as managers take advantage of more accurate expectations of firm-specific information. In other words, macroeconomic tranquility would lead to a widening of the cross-sectional distribution of corporate cash holdings.

An investigation revealing the potential linkages between macroeconomic uncertainty and firms' demand for liquidity not only complements the current literature on firms' liquid asset holdings, but gives us another rationale to promote macroeconomic stability to stimulate the efficient allocation of resources. Beaudry, Caglayan and Schiantarelli (2001) put this claim into close empirical scrutiny by investigating the impact of aggregate price uncertainty on the time-variation in the cross-sectional distribution of capital investment spending at the aggregate and the industry level. Using UK firm level data, they show that the cross-sectional distribution of investment rate narrows during times of uncertainty, implying more homogeneous investment behavior across firms, whereas a reduction in inflation uncertainty leads to a widening of the dispersion as higher-quality information allows firms to invest in projects with differing expected returns. Their findings provide evidence that inflation uncertainty hinders the efficient allocation of firms' capital funds. The approach we follow here is closely related to that of Beaudry et al. as we test for the effects of macroeconomic uncertainty on firms' allocation of liquid assets and argue that firms could forego potential capital spending opportunities due to uncertainty over the macroeconomic environment.

To ascertain the impact of macroeconomic uncertainty on corporate cash

holding behavior, we utilize a dataset obtained from the COMPUSTAT database over the 1970–2000 period which provides us over 125,000 firm-years, with an average of 4,125 non-financial firms per annum. Empirical analysis of these data yields a clear negative relationship between the variance of the cross-sectional distribution of non-financial firms' cash-to-asset ratios and several proxies for uncertainty computed from financial and macroeconomic variables, implying more homogeneous behavior among firms with respect to their cash holdings in times of greater perceived volatility. In our regression analysis, we incorporate several additional variables to gauge the robustness of our findings and guard against potential misspecification of the model and we show that the effects of uncertainty on the dispersion of cash holdings is robust to inclusion of these variables.

In contrast to the more common approach which links the level (or the changes) of individual firms' cash holdings to various firm-specific characteristics and explains the representative firm's demand for liquidity, we provide a method to understand the cash holding behavior of the cohort of firms under scrutiny. In that sense, our approach is unique in the literature as we concentrate on the *distribution* of corporate cash holdings to evaluate the allocation of firms' liquid assets. Yet, we should note that these two methodologies are not contradictory; rather, they are complementary analyses. The rest of the paper is constructed as follows. Section 2 discusses the influence of macroeconomic uncertainty on the optimal cash holdings of non-financial firms. Section 3 describes the data and discusses our results. Finally, Section 4 concludes and gives suggestions for further research.

2 The demand for liquidity under uncertainty

Recent research (for instance, Ozkan and Ozkan (2004) and the references therein) has emphasized the importance of firm-specific characteristics as a determinant of firms' cash-holding behavior. However, the macroeconomic environment within which firms operate could be an equally important determinant of their demand for liquidity. For instance, in March, 2001, *Business Week* reported: "So with the economy stalling and fears of recession rising, executives are becoming more concerned about protecting the cash they've got. 'People are more conservative than they were a year ago,' says Charles G. Ward III, co-head of investment banking at Credit Suisse First Boston. 'CEOs and CFOs are making sure they have bank lines and cash, and they want to make sure capital expenditures don't outstrip their cash-raising capability.' Adds Richard H. Brown, CEO of technology-services giant Electronic Data Systems Corp.: 'Cash is king now.' "[4] This quotation suggests that managers, finding it difficult to gauge their firm's future cash flows in a context of increasing macroeconomic uncertainty, may decide to implement similar cash-management policies, placing a premium on liquidity. Conversely, macroeconomic stability provides managers with the ability to forecast their firms' future cash flows more accurately while giving them the latitude to behave more idiosyncratically.

In their recent study Almeida et al. (2004) show that financially constrained firms' cash flow sensitivity increases during recessions, while financially unconstrained firms' cash flow sensitivity is unaffected by the business cycle. But to our knowledge, there is no study which explicitly considers the

[4]Citation: *Business Week*, 12 March 2001. "In Today's Corporate America, Cash Is King." http://www.businessweek.com/magazine/content/01_11/b3723021.htm.

influence of macroeconomic *uncertainty* on firms' demand for liquid assets across a cohort of firms. In a nutshell, we argue that a non-financial firm's manager would want to adjust her liquid asset holdings to minimize the expected costs of cash management, specifically in anticipation of variations in macroeconomic shocks.[5] However, if the firm's cash flow is subject to macroeconomic shocks, the optimal amount of cash holdings will crucially depend on the manager's perception of firm-specific information through the veil of macroeconomic disturbances. Given that all managers are faced with a similar problem to a greater or lesser degree, adjustments in liquid assets in response to variations in the macroeconomic environment will in turn generate predictable variations in the cross-sectional distribution of corporate cash holdings.[6] In other words, extending the Beaudry et al. (2001) approach to our setting, if managers' perception of expected cash flows crucially depends on the degree of macroeconomic uncertainty, changes in macroeconomic uncertainty will lead to time variations in the cross-sectional distribution of

[5]Our discussion draws upon models developed by Whalen (1966), Schnure (1998), and Frenkel and Jovanovic (1980). Also see Cummins and Nyman (2004) who demonstrate that firms facing a fixed cost of acquiring external finance in an uncertain environment will hold cash as a buffer against the need to borrow in later periods and Graham and Harvey (2001) who emphasize the importance of financial flexibility (having enough internal financing sources) when managers make financing decisions to avoid curtailing their business activities in response to macroeconomic shocks.

[6]Some authors (including Kim, Mauer and Sherman (1998, p. 336); Harford (1999, p.1969)) have suggested that "excess liquidity" may reflect a speculative motive, allowing firms to take advantage of profitable future investment opportunities when these firms face higher costs of external finance.

firms' cash-to-asset ratios: an empirically testable hypothesis.[7]

2.1 Representation of the distribution of firms' demand for liquidity

In this section, we lay out the reduced form relationship that we will employ to link changes in macroeconomic uncertainty to time variation in the cross-sectional distribution of firms' cash-to-total asset ratios. In doing so, our main concern in this paper is not to test a specific model but to document and verify the presence of an empirical relationship. To provide support for the linkages between macroeconomic uncertainty and the cross-sectional distribution of the cash-to-asset ratio, we consider the following reduced form relationship:

$$Disp_t(C_{it}/TA_{it}) = \beta_0 + \beta_1 \tau_t^2 + \epsilon_t, \tag{1}$$

where $Disp_t(C_{it}/TA_{it})$ represents the cross-sectional dispersion of firms' cash-to-asset ratios, measured by the standard deviation of the cross-sectional dispersion of firms' cash-to-asset ratio at time t. τ_t^2 stands for the measure of macroeconomic uncertainty at time t. We claim that the heterogeneity exhibited by non-financial firms' behavior will be negatively related to macroeconomic uncertainty. Hence, we expect to find a negative sign on β_1 using U.S. non-financial firm level data if greater macroeconomic uncertainty were to be associated with a smaller dispersion of firms' cash-to-asset ratios.

Furthermore, this argument should hold for sets of firms with similar characteristics. Given extensive evidence from the finance and economics literature that managers of sets of firms with similar characteristics tend to behave

[7]Appendix C presents a simple partial-equilibrium framework showing how the empirical model may be derived from the optimizing behavior of firms' managers.

similarly to one another, but differently from those with different characteristics, the impact of uncertainty on specific groups could be more pronounced than on others. For instance, managers of those firms with more severe asymmetric information problems might behave more conservatively during times of heightened uncertainty than those with less asymmetric problems, as firms with asymmetric information problems are shown to have limited access to external financing sources. In this context, we conjecture a strong negative response of the cross-sectional dispersion of cash holdings for high-growth firms and financially constrained firms to increases in macroeconomic uncertainty whereas the responses of low-growth firms and unconstrained firms would be less vigorous. Also, managers of capital intensive *vs.* labor intensive manufacturing firms might be expected to behave differently as macroeconomic uncertainty changes over time. We expect to see a stronger reaction when we inspect capital intensive firms' cash holding behavior with respect to that of labor intensive firms due to the greater importance of adjustment costs and irreversible investment in the former group. Hence, we analyze the effect of uncertainty for groups of firms defined by their growth rates, capital intensity in production or their being financially constrained.

2.2 Identifying macroeconomic uncertainty

In order to test our hypothesis of a negative relationship between the cross-sectional variance of firms' cash-to-asset ratios and macroeconomic uncertainty, we must provide a proxy that captures the state of the macroeconomy. To ensure that our empirical findings are not an artifact of a single choice of proxy, we construct four proxies for macroeconomic uncertainty from the conditional variances of real gross domestic product, the index of industrial production, the rate of consumer price inflation and returns on the S&P 500

stockmarket index. Each of these measures captures different elements of the uncertainty perceived by firms' managers relating to the macroeconomic environment. Qualitatively similar findings across each of these proxies lend strength to tests of our hypothesis.

The first proxy employed is the conditional variance of a monthly measure of real gross domestic product as a measure of overall macroeconomic activity. Since GDP is only available at a quarterly frequency, the proxy is derived from quarterly real GDP (International Financial Statistics series $99BRZF$). We generated the monthly GDP series via the proportional Denton procedure *dentonmq* using the index of industrial production (which is available at a monthly frequency) as an interpolating variable (see Baum, 2001).

The second proxy is derived from the monthly index of industrial production itself (International Financial Statistics series $66IZF$). This is a narrrower measure, focusing on industrial activity and omitting the service-sector activity which has become increasingly important to the US economy. The third proxy, designed to pick up uncertainty related to nominal magnitudes, is derived from the monthly rate of consumer price inflation (International Financial Statistics series $64XZF$). The last proxy, focused on financial market uncertainty, is derived from the monthly returns on Standard and Poor's 500 share index (from CRSP Stockmarket Indices).

The conditional variances of each of these variables is estimated with a generalized ARCH (GARCH) model, where the mean equation is a first-order

autoregression, allowing for ARMA errors.[8,9] The specifics of the GARCH models are provided in Appendix B. Each GARCH model's estimated conditional variance series, $\hat{h}_t$, is then employed in a revised version of equation (1),

$$Disp_t(C_{it}/TA_{it}) = \beta_0 + \beta_1 \hat{h}_t + \epsilon_t, \tag{2}$$

where $\hat{h}_t$ denotes the measure of macroeconomic uncertainty captured by the conditional variances of real GDP, industrial production, CPI inflation and S&P 500 returns, respectively, evaluated at time t. The advantage of this approach is that we can relate the behavior of cash holdings directly to a measure of macroeconomic uncertainty.[10]

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[8]Alternatively, some researchers suggest using a moving standard deviation of the macroeconomic series while others propose using survey-based measures based on the dispersion of forecasts. The former approach suffers from substantial serial correlation problems in the constructed series while the latter potentially contains sizable measurement errors.

[9]Following a reviewer's suggestion, we also tested an asymmetric ARCH model; results (available from the authors) were qualitatively similar to those presented here.

[10]Since $\hat{h}_t$ is a generated regressor, potentially measured with error, we employ a generalized method of moments (GMM) instrumental variables estimation technique. Tests of the orthogonality of the generated regressor to the error (the "difference in Hansen J" or "C" statistic: see Baum, Schaffer and Stillman (2003, pp. 20-24)) reject their null hypothesis in almost every case. In contrast, the overidentifying restrictions are generally accepted following the GMM-IV estimation.

3 Empirical findings

3.1 The data

The COMPUSTAT Industrial Annual database of U.S. non-financial firms is used to test our hypothesis. It covers on average 4,125 non-financial firms' annual characteristics from 1970 to 2000. The firms are classified by four-digit Standard Industrial Classification (SIC) code. We consider all firms outside of one-digit codes 6 (finance, insurance and real estate) and 9 (government enterprises), and two-digit code 49 (utilities). We utilize COMPUSTAT data items Cash (*data1*) and Total Assets (*data6*) to construct the Cash-to-Asset ratio. In order to evaluate the severity of firms' financial constraints, we compute the dividend payout ratio as $\frac{data21}{data13-data15-data16}$, where those data items are defined in the Appendix. It is important to note that unlike studies at the level of the individual firm, our analysis is carried out in a panel data context, where the unit of observation is taken to be the one-digit SIC category, observed annually. Thus, the dispersion in the cash-to-asset ratio is computed from the firms within each one-digit SIC category each year, generating a maximum of 196 industry-year observations.

We apply a number of sample selection criteria on our original sample of 173,592 firm-years. First, we marked non-positive values of cash and total assets as missing. Second, we considered that values of the cash-to-asset ratio beyond three standard deviations from the mean were implausible; this only affected 5,352 firm-years, placing an effective upper bound on the cash-to-asset ratio of 0.72. Third, our model should be applied to firms who have not undergone substantial changes in their composition during the sample period (e.g., participation in a merger, acquisition or substantial divestment should be disqualifying). Since we do not directly observe these phenomena,

we calculate the growth rate of each firm's real total assets, and trim the annual distribution of this growth rate by the 10th and 90th percentiles to remove firms exhibiting substantial changes in their scale. Fourth, we wish to exclude firms in clear financial distress or those facing substantial liquidity constraints. We consider two consecutive years of negative cash flows as an indicator of these conditions. Where these appear, we remove them as well as the prior and subsequent cash flows from the sample. These screens collectively reduced the sample to 127,929 firm-years.[11] Descriptive statistics for the annual means of cash-to-asset ratios are presented in Table 1. From the means of the sample we see that firms hold over 10 percent of their total assets in cash.

Note that in our analysis of subsamples of firms, we focus on the applicability of the general model to a group of like firms rather than formally testing for differences between groups of firms, which would necessitate the imposition of constraints across those groups. Furthermore, our groupings are not mutually exhaustive, but designed to identify firms which are strongly classified as, e.g., capital intensive or high-growth firms. Thus, a strategy based on category indicators would not be appropriate, since many firms will not fall in the group defined by either extreme.

We place firms into high-growth and low-growth groups, defining firms as above the 75th percentile and below the 25th percentile of the annual distribution of the growth in real total assets, respectively. As one expects

[11]Empirical results drawn from the full sample yielded qualitatively similar findings; we prefer to use the screened data to reduce the potential impact of outliers upon the parameter estimates. We also carried out the analysis using a longer data set covering the period between 1950–2000. Obtained results were qualitatively similar to those we report in this paper and are available from the authors.

high-growth firms hold, on average, 3.6 percentage points more cash relative to total assets than do low-growth firms.

We analyze the distinction between firms that might be considered financially constrained and those that might be considered financially unconstrained. Following the literature, we used the dividend payout ratio as a measure of financial stringency, defining those firms which lay below the 25th percentile of the annual distribution—or those firms paying zero dividends—to be financially constrained.[12] We defined those firms above the 75th percentile of the annual distribution of the dividend payout ratio to be financially unconstrained. We find that the average cash-to-asset ratios of financially constrained and unconstrained firms differ by 1.3 percentage points, with the latter firms holding more cash.

We classify our manufacturing firms' ($sic2x$ and $sic3x$) factor utilization as capital intensive or labor intensive. Using the NBER and U.S. Census Bureau's Center for Economic Studies (CES) database[13] we classify a four-digit SIC industry CAPITAL intensive if it has an average capital-to-labor ratio above the 75th percentile and LABOR intensive if its average capital-to-labor ratio is below the 25th percentile. The LABOR and CAPITAL categories of firms hold similar amounts of cash relative to total assets, whether measured by mean or median with little variation between each group.

[12]It is possible to use alternative criteria to measure financial constraints as suggested earlier in the literature. Due to space constraints we specifically concentrate on the dividend payout ratio. The idea that financially constrained firms have significantly lower payout ratios follows from Fazzari et al. (1988), among others.

[13]NBER-CES Manufacturing Industry Database, http://www.nber.org/nberces/, June 2000.

3.2 The link between cash holdings and uncertainty

Tables 2–8 present our regression results obtained for equation (2) for all firms and three category splits (low and high growth firms, financially constrained/unconstrained firms, and capital intensive/labor intensive firms, respectively) in a one-digit SIC panel data context over the period between 1970–2000. In those tables, we present GMM (instrumental variables-generalized method of moments) estimation results, where the macroeconomic uncertainty proxies are weighted averages of lagged effects.[14] Instruments employed include the conditional variances of inflation, industrial production, short-term interest rates, money growth and S&P 500 returns as well as a linear time trend, appropriately modified for each proxy.

The four columns of each table present the results for the four proxies for macroeconomic uncertainty (labelled in the column headings) in models augmented with the level of CPI inflation and the three-month LIBOR rate (*LIBOR3mo*) to proxy for the private cost of funds. These level variables are included for robustness purposes to determine whether movements in the cross-sectional distribution of firms' cash-to-asset ratios might be driven by the levels of macroeconomic variables. For each estimated model, we report $\hat{\eta}$, the estimated elasticities of the dispersion of the cash/asset ratio with respect to the macroeconomic uncertainty proxy and the elasticities' estimated standard errors, labelled "*s.e.*". Hansen's J statistic, a test of overidentifying restrictions in the IV-GMM setting, is also reported along with its p-value. Although not reported for brevity, all models contain a constant term and dummies for six of the seven included one-digit SIC categories (*sicIx*) to al-

[14] We imposed an arithmetic lag on the values of the proxy variable for periods $t-1$, $t-2$ and $t-3$, with weights 0.48, 0.34, 0.18, respectively, to capture the combined effect of contemporaneous and lagged uncertainty on cash holding behavior.

low for differential baseline effects of macroeconomic volatility across industry groups.[15]

3.2.1 Results for all firms

Table 2 presents the relationship between the cross-sectional distribution of non-financial firms' cash-to-asset ratio and three proxies for macroeconomic uncertainty for the full sample. In all cases the proxy coefficients are significantly negative at the 5% or 1% level providing support for our hypothesis that periods of heightened uncertainty lead to more homogeneous cash-holdings behavior by firms. The sign of the coefficient and its significance is robust to inclusion of additional regressors which one may consider to have an impact on managers' decision making process. To provide a better insight, we compute the elasticities with respect to the macroeconomic uncertainty measures for each model. We find that for each specification the elasticity has a significant magnitude: a 100% increase in uncertainty will lead to a significant decline in the dispersion of the cash-to-asset ratio, in a range between 9% and 22%. These results bear out that firms will behave much more homogeneously, in terms of their demand for liquid assets, in times of greater uncertainty.

3.2.2 Results for subsamples of firms

Having established the negative impact of uncertainty on the cross-sectional dispersion of the cash-to-asset ratio for the full sample, we next investigate

[15]Recall that we investigate the behavior of the cross-sectional dispersion of the cash-to-asset ratio in an industry-year panel context. Thus, our methodology does not allow for firm-specific characteristics in the estimated equation.

if the strength of the association varies across groups of firms with differing characteristics such as growth rate, financial constraints, and factor intensity.

Low-growth firms (reported in Table 3) are likely to be more mature firms, perhaps those in declining industries. They do not exhibit any significant effects of macroeconomic uncertainty, although the point estimates are uniformly negative for the three proxies. In contrast, the impact of macroeconomic uncertainty on high-growth firms (as reported in Table 4) is uniformly significant and somewhat larger than those of the "all firms" sample in Table 2. The effect of a doubling of uncertainty on the cross-sectional dispersion of the cash-to-asset ratio will be a reduction of approximately 16% for high-growth firms, versus about 14% for all firms. These findings suggest that high-growth firms—likely to be younger firms with substantial uncertainty about their near–term prospects, and facing a high degree of asymmetric information—are more sensitive to macroeconomic factors than the low-growth firms. Recall that the systematic risk associated with a firm's stock is related to growth opportunities, rendering the estimated hurdle rate for capital investment by potential investors inaccurate (see for example Myers and Turnbull (1977)). Hence, it is reasonable to find that fast-growing firms' access to external finance will be limited, requiring them to behave more cautiously, particularly in times of higher macroeconomic uncertainty which further deepens the informational asymmetries. In this context, our results are broadly in line with previous findings; for instance, Harford (1999) finds a positive relation between industry-level market-to-book (MB) ratios and firms' cash-to-asset ratios. He states that MB ratios are proxies for information asymmetry, with high values observed in firms which derive much of their market value from firm growth opportunities and intangibles (p. 1973).

In Tables 5 and 6, we investigate the effects of uncertainty on financially

constrained and unconstrained firms. For the financially constrained firms, the effects of macroeconomic uncertainty are substantial, with significant estimated elasticities, whereas for the unconstrained firms macroeconomic uncertainty does not appear to have any significant effect (although the point estimates are uniformly negative). A 100% increase in uncertainty leads to about a 13% reduction in the cross-sectional cash-to-asset ratio dispersion for the financially constrained firms *versus* 7% for the unconstrained firms. This result is also quite intuitive. As Almeida et al. (2004) indicate, financially unconstrained firms have no reason to hold extra cash; their cash holding policies are indeterminate. Hence, an increase in uncertainty should not have a significant effect on the cross-sectional distribution of these firms' cash-to-asset ratios as the managers will react idiosyncratically to any change in the macroeconomic environment. In contrast, for financially constrained firms, any change in the level of uncertainty which can affect managers' ability to predict their cash flows should cause them act more conservatively in concert leading to a narrowing of the dispersion of their cash-to-asset ratios.

In summary, our findings suggest that constrained firms are more sensitive to the impact of macroeconomic innovations in comparison to unconstrained firms: a point also noted by Almeida et al. (2004) in section D of their analysis.[16]

Low-growth firms, as noted above, are likely to be more mature, established firms which may enjoy freedom from financial constraints. Thus, we

[16]Almeida et al. (2004) specifically investigate the sensitivity of cash holdings to cash flows while carrying out their analysis in levels, i.e. first moments. In contrast, we investigate the impact of different uncertainty measures on the cross-sectional dispersion of cash holdings (second moments), and we do not specifically concentrate on the role of financial constraints.

might consider the combination of these factors in our sample.[17] However, since our sample splits are not mutually exhaustive, very few firm-year observations are generated by firms with these combined characteristics. Of the 154,344 firm-years in our sample, 29,710 (19.25%) are associated with low-growth firms, while 35,782 firm-years (23.2%) are associated with financially unconstrained firms.[18] Only 7,563 firm-years (4.9% of the sample) are associated with low-growth, financially-unconstrained firms. Thus, it is evident that our growth and financial constraint classifications are measuring different characteristics of these non-financial firms.

Finally, we report how capital-intensive *vs.* labor-intensive manufacturing firms' cash-to-asset ratio dispersion responds to macroeconomic uncertainty in Tables 7 and 8, respectively.[19] Similar to the previous set of results, we obtain significant and negative effects for both firm classifications. For each specification reported in Table 7, the computed elasticities for capital-intensive firms are substantially larger than those of labor-intensive firms. While a 100% increase in uncertainty leads to an average 26% reduction in the dispersion of the cash-to-asset ratio for capital-intensive firms, it only causes a 17% decline in dispersion for labor-intensive firms (slightly larger than the value for the "all firms" sample). This finding may indicate that capital-intensive firms may not be as flexible as labor-intensive firms due to costs of adjustment of their capital stock. Contrarily, it may be easier for

[17]We are grateful to an anonymous reviewer for this suggestion.

[18]These percentages differ from 25% due to screening applied to generate the estimation sample.

[19]Recall that the data employed for this classification utilize manufacturing firms (*sic2x* and *sic3x*) only, for a total of 56 industry-year observations and a single one-digit industry dummy.

labor-intensive firms to adjust their operating costs in response to a cash flow shock.

3.2.3 Summary findings

In summary, these results support our claims that changes in macroeconomic uncertainty lead to significant time variations in the cross-sectional distribution of non-financial firms' liquid asset holdings, measured by their cash-to-asset ratios over and above the level effect of macroeconomic variables. These results are robust to the use of four different measures of macroeconomic uncertainty signalling increased uncertainty hampers efficient use of resources. Our results also carry to subsamples: the effects of macroeconomic uncertainty on firms' liquidity are more pronounced for some categories of firms than others while the relationship is always negative. Firms experiencing rapid growth, firms that might be considered financially constrained and capital-intensive firms are also found to be quite sensitive to macroeconomic uncertainty. Firms that are paying sizable dividends exhibit a lower sensitivity to these macro effects, while capital-intensive firms' sensitivity is somewhat greater than that of labor-intensive firms. The overall message of our analysis is that macroeconomic uncertainty is an important determinant of corporate liquidity behavior, and the strength of that effect systematically differs with respect to firm-specific characteristics, distorting the efficient use of liquid assets.

4 Conclusions

In this paper we focus on the link between the dispersion of firms' liquid asset holdings and macroeconomic uncertainty using a panel of U.S. non-financial

firms drawn from the COMPUSTAT database over the period 1970–2000. We argue that uncertainty about economic conditions should have clear effects on firms' liquid asset management over and above the movements of macroeconomic aggregates and would distort the efficient allocation of firm-specific resources. To that end, we investigate whether the presence of greater macroeconomic uncertainty leads to a narrowing of the cross-sectional dispersion of firms' cash-to-asset ratios, and conversely whether economic tranquility would provide firms with the latitude to behave more idiosyncratically, leading to a widening of that dispersion.

To test this claim, we estimate a simple reduced-form equation using an annual data set summarizing individual firms' behavior at the industry level and four proxies for macroeconomic uncertainty derived from GARCH models fitted to monthly macroeconomic and financial data. On the basis of our empirical analysis, there is clear evidence that changes in macroeconomic uncertainty leads to time variation in the cross-sectional distribution of firms' cash-to-asset ratios. Furthermore, we find similar results when we investigate subsamples while the total effects of uncertainty are more pronounced for some categories of firms than others in accordance with our priors. Overall, we show that a doubling of uncertainty (depending on firm characteristics) would lead to an 8% to 40% reduction in the dispersion of non-financial firms' cash-to-asset ratios. These figures are most extraordinary. Last but not least, our results are robust to the inclusion of macroeconomic factors that capture the state of the economy.

Taking the current evidence along with the findings reported by Beaudry, Caglayan and Schiantarelli (2001) and Baum, Caglayan and Ozkan (2004) who document that an increase in macroeconomic uncertainty could lead to a significant reduction in the cross-sectional dispersion of the investment

rate and banks' loan-to-asset ratios, respectively, it is clear that macroeconomic uncertainty leads to significant distortions in the efficient allocation of firms' resources between capital spending and short-term liquidity needs. Our paper, along with many others, strongly implies that the overall impact of reducing macroeconomic uncertainty would be quite beneficial to the economy and that the second moments of macroeconomic aggregates should be of key concern to economic policymakers.

Appendix A

Construction of cash holdings and uncertainty measures

The following variables are used in the empirical study.

From Standard and Poor's COMPUSTAT database:
DNUM: Industry Classification Code
DATA1: Cash Holdings
DATA6: Total Assets
DATA13: Operating Income before Depreciation
DATA15: Interest Expense
DATA16: Income Taxes-Total
DATA21: Dividends-Common

From IMF International Financial Statistics:
66IZF: Industrial Production monthly
64XZF: Consumer Price Inflation
99BRZF: GDP at 1996 prices
60EAZF: Three-month LIBOR

From CRSP Stock Market Indices:
S&P 500 Monthly Returns

Appendix B

GARCH proxies for macroeconomic uncertainty[20]

	log(*Real GDP*)	log(*IndProdn*)	*CPI Inflation*	*S&P* 500
Lagged dep.var.	0.986	0.981	0.989	
	(0.01)***	(0.00)***	(0.00)***	
Constant	0.000	0.001	0.000	0.007
	(0.00)	(0.00)	(0.00)	(0.00)***
AR(1)	-0.981	0.808	0.285	0.907
	(0.01)***	(0.07)***	(0.04)***	(0.07)***
AR(2)				-0.918
				(0.07)***
MA(1)	1.001	-0.590		-0.941
	(0.00)***	(0.10)***		(0.08)***
MA(2)				0.907
				(0.07)***
ARCH(1)	0.123	0.292	0.089	0.019
	(0.03)***	(0.05)***	(0.02)***	(0.01)***
ARCH(2)	0.126	-0.204		
	(0.03)***	(0.05)***		
GARCH(1)	-0.187	0.889	0.872	1.805
	(0.05)***	(0.03)***	(0.03)***	(0.01)***
GARCH(2)	0.814			-0.839
	(0.05)***			(0.04)***
Constant	0.000	0.000	0.000	0.000
	(0.00)***	(0.00)**	(0.00)***	(0.00)***
Loglikelihood	1937.89	1860.48	2809.59	897.58
Observations	535	535	641	504

OPG standard errors in parentheses

Models are fit to detrended log(Real GDP), detrended log(IndProdn), CPI inflation and S&P 500 returns.

** significant at 5%; *** significant at 1%

[20]Unsurprisingly, the initial model for stock returns did not contain a statistically significant autoregressive term, so it was reestimated without a lagged dependent variable.

Appendix C
A simple cash buffer-stock model

Below we provide a one period model, which is a variant of the island model used by Lucas (1973), highlighting the manager's cash holding decision as a signal extraction problem.

Each period, firm i receives an uncertain amount of net cash flow between time t and $t+1$, drawn from a uniform distribution with an upper bound H and a lower bound, $L = -H$. The manager of the firm would want to hold an optimal amount of cash buffer at a cost of r_1 percent for precautionary reasons. A negative cash flow shock that exceeds current cash holdings requires the firm to borrow from an external source to meet its obligations at a higher interest rate of r_2 percent. We assume that $r_2 > r_1$, and possibly $r_2 >> r_1$ due to financial frictions. A firm holding a cash buffer of C_i faces the following three possible outcomes.

i) With probability $P_1 = \frac{H}{2H} = \frac{1}{2}$, the net cash flow of the firm could be positive; the firm merely incurs the opportunity cost of holding C_i[1]

$$COST_1 = C_i r_1. \tag{C.1}$$

ii) The firm could face a negative cash shock (CF_i) of a magnitude up to C_i with probability of $P_2 = \frac{C_i}{2H}$, rendering the cost of replenishment as well as cost of holding the cash buffer:

$$COST_2 = C_i r_1 - E(CF_i | -C_i < CF_i < 0) = C_i r_1 - \frac{-C_i}{2}. \tag{C.2}$$

iii) To remain solvent, a negative shock greater than C_i, may force the firm to borrow from an external source at the gross interest rate $(1 + r_2)$ with a probability of $P_3 = \frac{H - C_i}{2H}$:

$$\begin{aligned} COST_3 &= C_i r_1 + C_i - (E(CF_i | -H < CF_i < -C_i) + C_i)(1 + r_2) = \\ &= C_i r_1 + C_i + \left(\frac{H - C_i}{2}\right)(1 + r_2). \end{aligned} \tag{C.3}$$

[1] Any unused cash is assumed to be distributed back to the shareholders.

Given all scenarios expressed in equations (C.1–C.3), the manager minimizes total expected cost, $ECOST = COST_1P_1 + COST_2P_2 + COST_3P_3$, and obtains the optimal cash buffer as:

$$C_i = \frac{H}{r_2}(r_2 - 2r_1). \tag{C.4}$$

Provided that $r_2 > 2r_1$, the firm will have positive cash holdings. However, if the bounds of the distribution were to be hit by a random shock $\epsilon_{i,t}$ representing an uncertainty of the net disbursements that each firm faces where $\epsilon_{i,t} \sim N(0, \sigma^2_{\epsilon,t})$ then the managers' perception of the expected cash flows that will prevail becomes important. Assume that the manager of each firm observes a noisy signal in the form of $S_{i,t} = \epsilon_{i,t} + \nu_t$, where $\nu_t \sim N(0, \sigma^2_{\nu,t})$ and independent of $\epsilon_{i,t}$. In this context the noise in the signal, ν_t, reflects macroeconomic uncertainty.

Conditioning upon the signal $S_{i,t}$, the manager forms an optimal forecast of net disbursements as $E_t(\epsilon_{i,t}|S_{i,t}) = \lambda_t S_{i,t}$, where $\lambda_t = \frac{\sigma^2_{\epsilon,t}}{\sigma^2_{\epsilon,t}+\sigma^2_{\nu,t}}$. We assume that the firm manager cannot observe $\sigma^2_{\nu,t}$, but rather that she may form an optimal forecast of that quantity. Therefore, substituting for $E_t(H_{i,t}|S_{i,t}) = H + \lambda_t S_{i,t}$, we can modify equation (C.4) as:

$$E(C_{i,t}|S_{i,t}) = (H + \lambda_t S_{i,t})(\frac{r_2 - 2r_1}{r_2}) = kH + k\lambda_t S_{i,t}, \tag{C.5}$$

where $k = (\frac{r_2 - 2r_1}{r_2})$. As the impact of macroeconomic uncertainty $(\sigma^2_{\nu,t})$ increases, the manager's ability to predict cash flow will diminish, affecting the optimal level of cash holdings.

Finally, using equation (C.5) we may examine the cross-sectional distribution of cash holdings for each period,

$$Var(C_{i,t}|S_{i,t}) = \frac{k^2\sigma^6_{\epsilon,t}}{\sigma^4_{\epsilon,t} + \sigma^4_{\nu,t}}, \tag{C.6}$$

and as hypothesized in the text obtain

$$\frac{\partial Var(C_{i,t}|S_{i,t})}{\partial \sigma^2_{\nu,t}} = -2\frac{k^2\sigma^6_{\epsilon,t}\sigma^2_{\nu,t}}{(\sigma^4_{\epsilon,t} + \sigma^4_{\nu,t})^2} < 0. \tag{C.7}$$

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Table 1: Annual Cash/Asset ratios: Descriptive statistics, 1970–2000

	μ	σ	$p25$	$p50$	$p75$	N
All firms	0.105	0.014	0.091	0.107	0.117	127,302
Low–growth firms	0.085	0.008	0.078	0.084	0.090	25,923
High–growth firms	0.121	0.025	0.099	0.125	0.147	25,871
Financially constrained firms	0.107	0.018	0.088	0.112	0.122	64,546
Unconstrained firms	0.094	0.008	0.089	0.093	0.101	29,869
Capital–intensive firms	0.102	0.110	0.026	0.062	0.138	38,113
Labor–intensive firms	0.102	0.115	0.025	0.059	0.138	32,428

Note: $p25$, $p50$ and $p75$ represent the quartiles of the distribution, while μ and σ represent its mean and standard deviation. N refers to the number of firm–years of data in each category which have been collapsed into 196 observations, identified by year and one–digit SIC category (56 observations for capital– and labor–intensive categories).

Table 2: Dispersion of Cash/Asset ratio for all firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-40.860**	-19.620***	-92.381*	-115.218**
	(12.919)	(5.842)	(36.935)	(35.144)
Inflation	-0.005***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.298***	0.217***	0.158**	0.139*
	(0.073)	(0.060)	(0.057)	(0.055)
Ind–years	196	196	196	196
$\hat{\eta}$	-0.171	-0.114	-0.089	-0.221
s.e.	0.054	0.034	0.036	0.067
J	9.237	8.095	9.421	6.743
J pvalue	0.100	0.088	0.051	0.150

HAC IV-GMM estimates, based on 127302 firm-year obs.
$*$ <10%, **<5%, ***< 1%

Table 3: Dispersion of Cash/Asset ratio for low–growth firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-31.870	-11.763	-30.011	-40.675
	(16.666)	(7.973)	(49.839)	(40.255)
Inflation	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.202*	0.131	0.104	0.086
	(0.095)	(0.082)	(0.081)	(0.081)
Ind–years	196	196	196	196
$\hat{\eta}$	-0.157	-0.080	-0.034	-0.092
s.e.	0.082	0.055	0.057	0.092
J	5.898	7.146	7.242	4.312
J pvalue	0.316	0.128	0.124	0.365

HAC IV-GMM estimates, based on 25923 firm-year obs.
$*$ <10%, **<5%, ***< 1%

Table 4: Dispersion of Cash/Asset ratio for high–growth firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-50.828**	-24.455**	-138.271**	-96.542*
	(16.511)	(7.758)	(49.626)	(45.148)
Inflation	-0.005***	-0.005***	-0.004***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.272**	0.193**	0.102	0.104
	(0.085)	(0.075)	(0.075)	(0.066)
Ind–years	196	196	196	196
$\hat{\eta}$	-0.207	-0.138	-0.130	-0.182
s.e.	0.066	0.044	0.046	0.084
J	7.979	6.250	6.968	9.858
J pvalue	0.157	0.181	0.138	0.043

HAC IV-GMM estimates, based on 25871 firm-year obs.
$*$ <10%, **<5%, ***< 1%

Table 5: Dispersion of Cash/Asset ratio for fin. constr. firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-31.971*	-15.410*	-81.423	-119.982**
	(15.726)	(7.077)	(44.646)	(43.218)
Inflation	-0.006***	-0.006***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.438***	0.377***	0.318***	0.304***
	(0.090)	(0.080)	(0.078)	(0.075)
Ind–years	196	196	196	196
$\hat{\eta}$	-0.130	-0.087	-0.076	-0.222
s.e.	0.064	0.040	0.042	0.080
J	11.473	10.828	11.006	6.408
J pvalue	0.043	0.029	0.026	0.171

HAC IV-GMM estimates, based on 64546 firm-year obs.
$*$ <10%, **<5%, ***< 1%

Table 6: Dispersion of Cash/Asset ratio for fin. unconstr. firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-17.432	-6.140	-40.742	-58.947
	(12.459)	(5.689)	(33.922)	(35.613)
Inflation	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.036	-0.005	-0.027	-0.022
	(0.067)	(0.065)	(0.069)	(0.068)
Ind–years	196	196	196	196
$\hat{\eta}$	-0.078	-0.038	-0.042	-0.121
s.e.	0.056	0.035	0.035	0.073
J	1.331	0.745	1.328	0.296
J pvalue	0.932	0.946	0.857	0.990

HAC IV-GMM estimates, based on 29869 firm-year obs.
$*$ <10%, **<5%, ***< 1%

Table 7: Dispersion of Cash/Asset ratio for capital–intensive firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-66.183***	-31.444***	-168.341**	-183.774**
	(19.809)	(8.516)	(62.195)	(60.982)
Inflation	-0.005***	-0.005***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.330**	0.183	0.094	0.032
	(0.119)	(0.099)	(0.101)	(0.098)
Ind–years	56	56	56	56
$\hat{\eta}$	-0.312	-0.203	-0.181	-0.392
s.e.	0.094	0.055	0.068	0.128
J	4.821	3.588	3.144	3.874
J pvalue	0.438	0.465	0.534	0.423

HAC IV-GMM estimates, based on 38113 firm-year obs.
$*$ <10%, **<5%, ***< 1%

Table 8: Dispersion of Cash/Asset ratio for labor–intensive firms 1970–2000

	GDP	IndProdn	Infl	SPRetn
uncert	-42.877*	-21.330*	-86.476	-148.665*
	(21.119)	(8.775)	(63.613)	(61.529)
Inflation	-0.006***	-0.006***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
LIBOR3mo	0.414**	0.334**	0.283*	0.241*
	(0.126)	(0.118)	(0.125)	(0.115)
Ind–years	56	56	56	56
$\hat{\eta}$	-0.195	-0.132	-0.090	-0.303
s.e.	0.096	0.054	0.066	0.123
J	4.920	4.196	4.616	1.848
J pvalue	0.426	0.380	0.329	0.764

HAC IV-GMM estimates, based on 32428 firm-year obs.
$*$ <10%, **<5%, ***< 1%