The Effects of Uncertainty on the Leverage of Non-Financial Firms*

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Abstract

The paper investigates the link between the optimal level of non-financial firms' short-term leverage and macroeconomic and idiosyncratic sources of uncertainty. We develop a structural model of a firm's value maximization problem that predicts a negative relationship between uncertainty and optimal level of borrowing. This proposition is tested using a panel of non-financial US firms drawn from the COMPUSTAT quarterly database covering the period 1993–2003. The estimates confirm that as either form of uncertainty increases firms decrease their levels of short-term leverage. This effect is stronger for macroeconomic uncertainty than for idiosyncratic uncertainty.

Keywords: leverage, uncertainty, non-financial firms, panel data.

JEL classification: C23, D8, D92, G32.

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1 Introduction

The determinants of capital structure have always attracted considerable attention in the literature. In their seminal work, Modigliani and Miller (1958) derive the theoretical result that under the assumption of perfect capital markets, financial and real decisions are separable so that the firm's leverage has no effect on the market value of the firm, nor on its capital investment plans. However, recent empirical research provides contrary evidence. For instance, a vast number of studies show a positive relationship between liquid asset holdings and firms' investment decisions.[1] Other studies show that firm leverage depends on firm-specific characteristics such as cash holdings, total assets, and the investment-to-capital ratio.[2] Furthermore, empirical evidence on the interaction of macroeconomic uncertainty and capital structure indicators is rather scarce. As an exception, Baum, Caglayan, Ozkan and Talavera (2006) find a negative relationship between macroeconomic uncertainty and the cross-sectional dispersion of cash-to-asset ratios for US non-financial firms. Hence, their study supports the view that macroeconomic uncertainty is an important factor in firms' decision-making. By furthering this idea, we intend to contribute to the literature on corporate debt by analyzing the impact of macroeconomic and idiosyncratic uncertainty on the optimal level of non-financial firms' leverage.

We formulate a dynamic stochastic partial equilibrium model of a representative firm's value optimization problem. The model is based upon an empirically testable hypothesis regarding the association between the optimal level of debt and uncertainty arising from macroeconomic or idiosyncratic sources. The model predicts that an increase in either type of uncertainty leads to a decrease in leverage.

[1] See for example Gilchrist and Himmelberg (1998); Fazzari, Hubbard and Petersen (1988).
[2] See Shuetrim, Lowe and Morling (1993); Auerbach (1985); Weill (2001).

To test the model's predictions, we apply the System GMM estimator (Blundell and Bond, 1998) to a panel of US non-financial firms obtained from the quarterly COMPUSTAT database over the 1993–2002 period. After some screening procedures it includes more than 31,000 manufacturing firm-quarter observations, with about 950 firms per quarter. As the impact of uncertainty may differ across categories of firms, we also consider four sample splits. Our main findings can be summarized as follows. We find evidence of a negative association between the optimal level of debt and macroeconomic uncertainty as proxied by the conditional variance of the index of leading indicators. When the macroeconomic environment becomes more uncertain, companies behave more cautious and borrow less, even when they might expect to face decreased revenues and potential cash flow shortages. Furthermore, idiosyncratic uncertainty also has a negative and significant effect on firms' use of leverage. These results are robust to the inclusion of macroeconomic factors summarized by the index of leading indicators.

These results provide useful insights into corporate capital structure decisions. Changes in macroeconomic uncertainty, partially influenced by monetary policy, will not only affect firms' leverage but also their costs of obtaining external finance and in turn their investment dynamics. Moreover, monetary policy will have an effect on the discount rates of investment projects. Therefore, our results suggest that the transmission mechanism of monetary policy is much more complicated than formulated in standard models which ignore the interaction of real and financial variables' first and second moments.

The remainder of the paper is structured as follows. Section 2 presents a simple value maximization model for a representative firm. Section 3 describes the data and discusses our results. Finally, Section 4 concludes and gives suggestions for further research.

2 The Q Model of Firm Value Optimization

2.1 Model Setup

The theoretical model proposed in this paper is based on the firm value optimization problem and represents a generalization of the standard Q models of investment by Whited (1992) and Hubbard and Kashyap (1992). The present value of the firm is equated to the expected discounted stream of D_t, dividends paid to shareholders, where β is the discount factor.

$$V_t(K_t) = \max_{\{I_{t+s},B_{t+s}\}_{s=0}^{\infty}} D_t + E_t\left[\sum_{s=1}^{\infty} \beta^s D_{t+s}\right], \tag{1}$$

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{2}$$

$$D_t = \Pi(K_t, \phi_t) - C(I_t, K_t) - I_t + B_t - B_{t-1}R(\tau_t)\eta(B_{t-1}, K_t, \xi_t), \tag{3}$$

$$D_t \geq 0, \tag{4}$$

$$\lim_{T\to\infty}\left[\prod_{j=t}^{T-1}\beta_j\right] B_T = 0, \forall t \tag{5}$$

The firm maximizes equation (1) subject to three constraints. The first is the capital stock accounting identity $K_{t+1} = (1-\delta)K_t + I_t$, where K_t is the beginning-of-period capital stock, I_t is investment expenditures, and δ is the rate of capital depreciation. The second constraint defines firm dividends, where $\Pi(K_t, \phi_t)$ denotes the maximized value of current profits taking as given the beginning-of-period capital stock, which is affected by a measure of idiosyncratic uncertainty, ϕ_{t-1}. Finally, $C(I_t, K_t)$ is the real cost of adjusting I_t units of capital.

At time t, all present values are known with certainty while all future variables are stochastic. In order to isolate the role of debt financing we assume, following "pecking order" theory, that equity financing is too expensive and firms exhibit a strict preference for debt financing.[3] Financial liabilities of the firm are denoted by B_t. Furthermore, managers are assumed to have rational expectations. We incorporate financial frictions assuming that risk-neutral shareholders require an external premium, $\eta(B_{t-1}, K_t, \xi_t)$, which depends on firm-specific characteristics such as debt and capital stock as well as a stochastic shock ξ_t. Similar to Gilchrist and Himmelberg (1998), we also assume $\partial\eta/\partial B_{t-1} > 0$: i.e., highly indebted firms must pay an additional premium to compensate debt-holders for additional costs because of monitoring or hazard problems. Moreover, $\partial\eta/\partial K_t < 0$: i.e., large firms enjoy a lower risk premium. Hence, the gross interest rate is equal to $R(\tau_t)\eta(B_{t-1}, K_t, \xi_t)$ where $R(\tau_t)$ is the base rate of return, which depends on the macroeconomic environment, but not on firm-specific characteristics.

Financial frictions are also introduced through the non-negativity constraint for dividends, $D_t \geq 0$ and the corresponding Lagrange multiplier λ_t. The λ_t can be interpreted as the shadow cost of internally generated funds. Equation (5) is the transversality condition which prevents the firm from borrowing an infinite amount and paying it out as dividends.

Solving the optimization problem we derive the following Euler equation for investment:

$$C_{I,t} + 1 = E_t \left[\beta\Theta_t \left(\Pi_{K,t+1} + (1-\delta)\left(C_{I,t+1} + 1\right) - R_{t+1}\eta_{K,t+1}B_t\right)\right] \quad (6)$$

Note that $\Theta_t = \frac{(1+\lambda_{t+1})}{(1+\lambda_t)}$. Expression $\beta\Theta_t$ may serve as a stochastic time-varying discount

[3] This is in line with the stylized fact—particularly for large US publicly-traded firms–that equity finance is a rarely-considered option. "The net equity issuances by the US non-financial corporate sector have been negative since the 1980s." Frank and Goyal (2005), p. 32. To a first approximation, ignoring equity finance would seem to be largely in line with observed practice.

factor which is equal to β in the absence of financial constraints ($\lambda_{t+1} = \lambda_t$).[4]

From the first-order conditions for debt we derive:

$$E_t\left[\beta\Theta_t R_{t+1}\left(\eta_{t+1} + \eta_{B_{t+1}} B_t\right)\right] = 1. \tag{7}$$

In the steady state $\beta E_t\{(R(\tau_{t+1}))\Theta_t\} = \beta E\{R(\tau_{t+1})\} = 1$, which implies that $\eta_{B_{t+1}} B_t = 1 - \eta_{t+1}$. Since we assume $\eta_{B_{t+1}} > 0$, B_t is guaranteed to be positive only if $\eta_{t+1} \leq 1$. Gilchrist and Himmelberg (1998) suggest that the risk premium may be negative if η_{t+1} is considered as net of tax advantages or agency benefits.

Combining the first order conditions we derive the optimal level for borrowing

$$B_t = \frac{E_t\{\Pi_{K,t+1}\Theta_t\} + (1-\delta)E_t\{\Theta_t C_{I,t+1}\} - E_t\{\Theta_t \eta_{t+1} R(\tau_{t+1})\} - 1/\beta C_{I,t}}{\eta_B E_t\{\Theta_t R(\tau_{t+1})\} + \eta_K E\{R(\tau_{t+1})\}} \tag{8}$$

which allows us to derive

$$\frac{\partial B_t}{\partial \tau_{t+1}} = \frac{\partial B_t}{\partial E_t\{R(\tau_{t+1})\}} \frac{\partial E_t\{R(\tau_{t+1})\}}{\partial \tau_{t+1}} < 0 \tag{9}$$

Similarly, we construct the relationship between idiosyncratic uncertainty and firm lending. Equation (8) provides a positive relationship between expected profitability and leverage. The negative relationship between profitability and uncertainty is justified in Batra and Ullah (1994):

$$\frac{\partial B_t}{\partial \phi_{t+1}} = \frac{\partial B_t}{\partial E_t\{\Pi(\phi_{t+1})\}} \frac{\partial E_t\{\Pi(\phi_{t+1})\}}{\partial \phi_{t+1}} < 0 \tag{10}$$

[4] For simplicity, we ignore the derivative of the investment adjustment cost function with respect to the capital stock, $C_{K,t}$. In our data the mean of I_t/K_t=0.04, and the squared term will be 0.0016 given that $C_{K,t} = (I_t/K_t)^2$. Therefore, its effect is negligible.

Compared to a certainty equivalent economy, the firm facing higher costs of external financing caused by an increase in macroeconomic or idiosyncratic volatility decreases its level of debt.

2.2 Econometric Specification

We test the hypothesis that uncertainty affects firms' debt decisions based directly on the Euler equation (6). It relates the optimal level of debt, B_t, with the marginal profit of capital, $\Pi_{K,t+1}$ which is a function of idiosyncratic uncertainty ϕ_{t+1}, the marginal adjustment cost of investment, $C_{I,t}$, the expected marginal adjustment cost, $E_t\{C_{I,t+1}\}$, the relative shadow cost of external financing, Θ_t, and the expected base interest rate, a function of macroeconomic uncertainty, $R(\tau_{t+1})$.

In order to implement Euler equation estimation we linearize the product of β_t, Θ_t and A_t, where $A_t = \Pi_{K,t+1} + (1-\delta)\left(C_{I,t+1}+1\right) - R(\tau_{t+1})\eta_{K,t+1}B_{t+1}$. We utilize a first–order Taylor approximation around the means. Ignoring constant terms, the approximation is equal to:[5]

$$\beta_t \Theta_t A_t = \overline{\beta}\gamma\Theta_t + \overline{\beta}A_t + \gamma\beta_t$$

where $\overline{\beta}$ is the average discount factor and γ denotes the unconditional mean of A_t.

As in Chirinko (1987) and Hayashi (1982), we utilize a traditional adjustment cost function given by $C(I_t, K_t) = \frac{\alpha}{2}\left(I_t/K_t - \nu_i\right)^2 K_t$.[6] The parameter ν_i might be interpreted as a firm-specific optimal level of investment. The marginal adjustment cost of

[5] See also Love (2003).

[6] We acknowledge that there is support in the literature for potentially non-linear adjustment cost functions (e.g., Abel and Eberly (2002). As this feature is not the focus of our study, we make the standard assumption of quadratic adjustment costs.

investment of a firm i at time t is given by:

$$C_{I,it} = \alpha \left(\frac{I_{it}}{TA_{it}} - \nu_i \right) \tag{11}$$

where TA_{it}, a proxy for capital K_{it}, measures total assets of firm i at time t. Similarly, the expected marginal adjustment cost of a firm i at time t is:

$$E_t \left\{ C_{I,it+1} \right\} = \alpha \left(E_t \left\{ \frac{I_{it+1}}{TA_{it+1}} \right\} - \nu_i \right) \tag{12}$$

The marginal profit of capital is parameterized using a sales-based measure[7]

$$\Pi_{K,it+1} = \theta_1 \frac{S_{it}}{TA_{it}} + \theta_2 \phi_{i,t} \tag{13}$$

where S is the firm's sales, TA is total assets, $\theta_1 = \alpha_k / \mu$, α_k is the capital share in the Cobb–Douglas production function specification and μ is the markup (defined as $1/(1+\kappa^{-1})$, where κ is the firm-level price elasticity of demand). Note that expected profitability is parameterized as a linear function of idiosyncratic uncertainty, $\phi_{i,t}$.

The level of financing constraint for a representative firm i at time t, Θ_{it}, is a function of their stock of cash and level of debt:

$$\Theta_{it} = a_{0i} + a_1 Cash_{it} + a_2 B_{i,t-1} \tag{14}$$

where $Cash_{it}$ is the cash and cash equivalent, B_{it} is the level of debt and a_{0i} is a firm-specific measure of financial constraints. Debt generates interest and principal

[7] The discussion in Gilchrist and Himmelberg (1998) suggests that a sales-based measure of the marginal profit of capital is more desirable comparing to operating income measure.

obligations and increases the probability of financial distress, while the availability of liquid assets relaxes the external finance constraint (see also Hubbard, Kashyap and Whited (1995); Almeida, Campello and Weisbach (2004); Gilchrist and Himmelberg (1998)).

Finally, the base interest rate $R(\tau_t)$ is assumed to be a linear function of macroeconomic uncertainty and the index of leading indicators, a proxy of the state of the macroeconomy:

$$R(\tau_t) = \omega_1 \tau_t + \omega_2 Leading_t \tag{15}$$

The resulting empirical specification is:[8]

$$\begin{aligned} \frac{B_{it}}{TA_{it}} &= \beta_0 + \beta_1 \frac{B_{it-1}}{TA_{it-1}} + \beta_2 \frac{Cash_{it}}{TA_{it}} + \beta_3 \frac{S_{it}}{TA_{it}} + \beta_4 \frac{I_{it+1}}{TA_{it+1}} + \beta_5 \frac{I_{it}}{TA_{it}} \\ &+ \beta_6 \tau_{t-1} + \beta_7 \phi_{i,t-1} + \beta_8 Leadinc_{t-1} + f_i + Ind_i + e_{it} \end{aligned} \tag{16}$$

As COMPUSTAT gives end-of-period values for firms, we include lagged proxies for the uncertainty measures and macroeconomic conditions in the regressions rather than contemporaneous proxies, so that recently-experienced volatility will affect firms' behavior. We control for industry-specific effects using industry dummies Ind_i. The main hypotheses of our paper can be stated as:

$$H_0 : \beta_6 < 0 \tag{17}$$

$$H_0 : \beta_7 < 0 \tag{18}$$

[8]All stock and flow variables are scaled by total assets in order to decrease the effect of heteroskedasticity.

That is, macroeconomic and idiosyncratic uncertainties affect the optimal level of leverage and these effects have negative signs. When firms experience higher idiosyncratic uncertainty or greater uncertainty over the course of the macroeconomy they make less use of debt. Our model specification also predicts that $\beta_3 < 0$ and $\beta_4 < 0$. The optimal level of firm leverage increases in response to a decrease in liquid assets or sales. Moreover, given the existence of multi-period liabilities, we expect to find persistence in the leverage ratio, $\beta_1 > 0$.

The main aim of our study is to investigate whether robust results are obtained for these hypotheses relating to uncertainty measures and not to identify the coefficients of the structural model.[9]

2.3 Identifying Uncertainty

The macroeconomic uncertainty identification approach resembles that of Baum et al. (2006). Firms' debt decisions depend on anticipation of future profits and investment. The difficulty of evaluating the optimal amount of debt issuing increases with the level of macroeconomic uncertainty.

The literature suggests various methods to obtain a proxy for macroeconomic uncertainty. In our investigation, as in Driver, Temple and Urga (2005) and Byrne and Davis (2005), we use a GARCH model to proxy for macroeconomic uncertainty. We believe that this approach is more appropriate compared to alternatives such as proxies obtained from moving standard deviations of the macroeconomic series (e.g., Ghosal and Loungani (2000)) or survey-based measures based on the dispersion of forecasts (e.g., Graham and Harvey (2001), Schmukler, Mehrez and Kaufmann (1999)). While the

[9] It is possible to show that all βs are functions of model parameters, but it is not possible to identify every parameter of the structural model with reasonable assumptions.

former approach suffers from substantial serial correlation problems in the constructed series the latter potentially contains sizable measurement errors.

We construct a proxy for macroeconomic uncertainty from the conditional variance of the index of leading indicators (DRI-McGraw Hill Basic Economics series $DLEAD$) as a measure of overall macroeconomic activity. The conditional variance of the index of leading indicators is estimated with a generalized ARCH (GARCH) model, where the mean equation is a first-order autoregression allowing for ARMA errors. The specifics of the GARCH model are provided in Table 1. The estimated conditional variance series is then employed in a revised version of equation (16).

One can employ different proxies to capture firm-specific risk. For instance, Bo and Lensink (2005) use three measures: stock price volatility, estimated as the difference between the highest and the lowest stock price normalized by the lowest price; volatility of sales measured by the coefficient of variation of sales over a seven–year window; and the volatility of number of employees estimated similarly to volatility of sales. Bo (2002) employs a slightly different approach, setting up the forecasting AR(1) equation for the underlying uncertainty variable driven by sales and interest rates. The unpredictable part of the fluctuations, the estimated residuals, are obtained from that equation and their three-year moving average standard deviation is computed.

In contrast to the studies cited above, we proxy the idiosyncratic uncertainty by computing the the standard deviation of the closing price for the firm's shares over the last nine months, scaled by the mean of those price quotes. This measure is calculated using COMPUSTAT items $data12$, 1st month of quarter close price; $data13$, 2nd month of quarter close price; $data14$, 3rd month of quarter close price and their first and second lags. We believe that volatility of stock prices reflects not only sales or cost uncertainty but also captures other idiosyncratic risks. Scaling the volatility measure by the mean price reduces the heterogeneity caused by stockmarket bubbles as well as that related to differences in firms' average share prices.

3 Empirical Implementation

3.1 Dataset

We work with the Quarterly Industrial COMPUSTAT database of U.S. firms. The initial dataset includes 201,552 firm-quarters over 1993–2003. The firms are classified by two-digit Standard Industrial Classification (SIC). The main advantage of the dataset is that it contains detailed balance sheet information.

We apply sample selection criteria to the original sample. First, we set all negative values for all variables in the sample as missing. Second, we set observations as missing if the values of ratio variables are lower than the 1st percentile or higher than the 99th percentile. We decided to use the screened data to reduce the potential impact of outliers upon the parameter estimates. After the screening and including only manufacturing sector firms we obtain about 950 firms' quarterly characteristics.

Table 2 provides descriptive statistics of the firms and the macroeconomic uncertainty proxy. All firm-specific variables are taken from COMPUSTAT and are measured at the fiscal quarter-end. The leverage ratio (B/TA) is defined as the ratio of Short-term Debt (item $data45$) to Total Assets (item $data6$). The Cash-to-Asset ratio (C/TA), the Investment-to-Asset ratio (I/TA) and the Sales-to-Asset ratio (S/TA) are defined as using Cash and Short-Term Investments (item $data1$), Capital Expenditures (item $data90$) and Sales (item $data12$), respectively.

In our analysis of subsamples of firms, we focus on the applicability of the general model to a group of firms having similar characteristics instead of 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., large or high-leverage 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.

Table 3 breaks down the data across different groups of firms. First, we subdivide the manufacturing-sector firms (two-digit SIC 20–39) into producers of durable goods and producers of non–durable goods on the basis of firms' primary SIC codes. A firm is considered durable if its primary two-digit SIC is 24, 25, 32–39.[10] SIC classifications for non–durable industries are 20–23 and 26–31.[11] The characteristics of durable and non-durable goods producers are similar, but the former have a higher average liquidity ratio.

We categorize firms into high-liquidity and low-liquidity categories, defining firms as above the 75th percentile and below the 25th percentile of the quarterly distribution of the liquidity ratio, respectively. Low-liquidity firms have higher leverage and sales-to-assets ratios compared to their high-liquidity counterparts.

Finally, we define firms as high-leverage (large) and low leverage (small) if their leverage ratio (total assets) is above the 75th percentile and below the 25th percentile, respectively. Small firms and low leverage firms hold twice as many liquid assets as do large firms and high leverage firms, respectively.

[10]These industries include lumber and wood products, furniture, stone, clay, and glass products, primary and fabricated metal products, industrial machinery, electronic equipment, transportation equipment, instruments, and miscellaneous manufacturing industries.

[11]These industries include food, tobacco, textiles, apparel, paper products, printing and publishing, chemicals, petroleum and coal products, rubber and plastics, and leather products makers.

3.2 Empirical results

We estimate Equation (17) using the lagged conditional variance of the index of leading indicators as the proxy for macroeconomic uncertainty. Results for all manufacturing firms are given in Table 4. These specifications represent the Blundell and Bond (1998) one-step System GMM estimator employing the first differences transformation.[12] As instruments we use B/TA_{t-3} to B/TA_{t-5}, $CASH/TA_{t-2}$ to $CASH/TA_{t-5}$, I/TA_{t-2} to I/TA_{t-5}, and S/TA_{t-2} to S/TA_{t-5} for the equations in differences and $\Delta S/TA_{t-1}$, $\Delta CASH/TA_{t-1}$, and $\Delta I/TA_{t-1}$ for the equations in levels.

Our main finding is that there is a negative and significant relationship between leverage and both idiosyncratic and macroeconomic uncertainty. Although both forms of uncertainty have significant coefficients, that for macroeconomic uncertainty is considerably larger. The table reports the elasticities of the leverage ratio with respect to each measure: the elasticity for macroeconomic uncertainty is about 3.7 times larger than that for idiosyncratic uncertainty.

There is a negative and significant relationship between short-term leverage and the liquidity ratio. This finding is evidence that firms increase internal financing when external funds are less accessible or affordable. Firms also decrease leverage when marginal profitability, proxied by the $Sales/TA$ ratio, increases. Higher profitability assures higher cash flow, which could be also a proxy for the availability of internal finance. Finally, overall economic conditions, as captured by the index of leading indicators, do not have a meaningful effect at the margin.

Table 5 presents the coefficients for idiosyncratic and macroeconomic uncertainty for the same equation estimated over the eight subsamples of our data. Both non-

[12] To check robustness of our results we also employed an orthogonal deviations transformation and received similar results.

durable and durable manufacturers are sensitive to macroeconomic uncertainty, while only the latter are affected by idiosyncratic factors. On the other hand, when we consider firms with low and high levels of liquidity, we find that both groups are responsive to macroeconomic uncertainty, but the low-liquidity firms are almost twice as sensitive. This may reflect low-liquidity firms' greater likelihood of being liquidity constrained.

When we consider those firms with low or high levels of leverage, we find the highly levered firms to be over three times as sensitive to macroeconomic uncertainty, and almost twice as sensitive to idiosyncratic uncertainty. The predictions of our analytical model appear to be strongly borne out for those firms with high leverage. Firm size also seems to be a meaningful factor. Both small and large firms are sensitive to macroeconomic uncertainty, while only small firms exhibit a sensitivity to idiosyncratic uncertainty. The latter effect is considerably smaller than the effect of macroeconomic uncertainty.

In summary, these subsamples provide additional support to the hypotheses of our model. Macroeconomic uncertainty has a negative and significant effect on leverage for all eight subsamples, while idiosyncratic uncertainty has negative and significant effects in five of the eight cases. Importantly, both forms of uncertainty appear to have distinguishable effects in most subsamples, indicating the importance of both external and firm-specific uncertainty factors in firm behavior.

In summary, we find strong support for the hypotheses of Equation (17) and (18). Firms decrease their borrowing in more uncertain times. When the macroeconomic environment becomes more uncertain, companies become more cautious and borrow less, even when they might expect to face decreased revenues and potential cash flow shortages. Note that these results confirm the results regarding the impact of uncertainty on investment reported in Bloom, Bond and Van Reenen (2001).

4 Conclusions

This paper investigates the relationship between leverage of manufacturing firms and macroeconomic uncertainty using quarterly COMPUSTAT data. We have developed an empirical model of the optimal leverage ratio based on the Euler equation of the standard neoclassical model of capital accumulation subject to adjustment costs. The firm faces high costs of external financing when it is more heavily leveraged. Based on the model's predictions we anticipate that firms decrease their use of debt when macroeconomic uncertainty or idiosyncratic uncertainty increases. In order to empirically test our model we employ dynamic panel data methodology. The results suggest negative and significant effects of uncertainty measures on leverage for US non-financial firms during 1993–2003.

There are significant differences in the results for different firms' subsamples. High-liquidity and low-leverage firms exhibit a larger sensitivity to macroeconomic uncertainty reflected by financial markets than do their low-liquidity or high-leverage counterparts. Durable goods makers, high-liquidity firms, highly leveraged firms and small firms also exhibit sensitivity to firm-specific volatility.

From the policy perspective, we suggest that macroeconomic uncertainty has an effect on nonfinancial firms' capital structure which in turn affects their dynamics of investment. Other studies (see Bernanke and Gertler (1989)) have shown that balance sheet shocks may affect the amplitude of investment cycles in a simple neoclassical model. Moreover, in many countries monetary policy tends to be persistent in the direction of change of the monetary instrument, with rare reversals (perhaps reflecting central banks' interest rate smoothing objectives). Therefore, firms' sensitivity to macroeconomic uncertainty should be taken into account if more activist monetary policies are contemplated.

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Appendix A:

Construction of macroeconomic and firm specific measures

The following variables are used in the empirical study.

From the Quarterly Industrial COMPUSTAT database:

DATA1: Cash and Short-Term Investments

DATA6: Total Assets

DATA12: Sales

DATA90: Capital Expenditures

DATA45: Long-Term Debt

From the DRI–McGraw Hill Basic Economics database:

DLEAD: index of leading indicators

Table 1: GARCH(1,1) model of macroeconomic uncertainty, 1959m1-2004m6.

Lagged dep.var.	0.899
	(0.14)***
Constant	0.080
	(0.13)
AR(1)	0.909
	(0.14)***
MA(1)	-0.608
	(0.06)***
ARCH(1)	0.063
	(0.02)***
GARCH(1)	0.901
	(0.01)***
Constant	0.007
	(0.00)
Loglikelihood	1937.89
Observations	545

Note: Model is fit to the detrended index of leading indicators. OPG standard errors in parentheses.
** significant at 5%; *** significant at 1%

Table 2: Descriptive Statistics

All firms	μ	σ^2	$p25$	$p50$	$p75$
Short Term Debt/Total Assets	0.0485	0.0676	0.0034	0.0234	0.0638
Investment/Total Assets	0.0324	0.0319	0.0108	0.0228	0.0430
Sales/Total Assets	0.2901	0.1432	0.1973	0.2695	0.3595
Cash/Total Assets	0.1172	0.1588	0.0154	0.0475	0.1527
Idiosyncratic Uncertainty	1.4360	0.9611	0.7654	1.1517	1.8230
Macroeconomic Uncertainty	0.4940	0.0852	0.4193	0.4712	0.5598

Note: Number of observations is 31,404. p25, p50 and p75 represent the quartiles of the distribution, while μ and σ^2 represent mean and variance respectively.

Table 3: Descriptive Statistics by subsample

	Durable (N=18,608)		*Non-durable (N=12,796)*	
	μ	σ	μ	σ
Short Term Debt/Total Assets	0.05	0.07	0.05	0.07
Investment/Total Assets	0.03	0.03	0.03	0.03
Sales/Total Assets	0.29	0.14	0.29	0.15
Cash/Total Assets	0.11	0.16	0.11	0.16
Idiosyncratic Uncertainty	1.54	0.99	1.29	0.90
	Low leverage (N=7,770)		*High leverage (N=6,815)*	
	μ	σ	μ	σ
Short Term Debt/Total Assets	0.03	0.06	0.09	0.09
Investment/Total Assets	0.03	0.03	0.03	0.03
Sales/Total Assets	0.28	0.15	0.31	0.16
Cash/Total Assets	0.17	0.19	0.09	0.14
Idiosyncratic Uncertainty	1.52	1.05	1.40	0.95
	Low liquidity (N=8,583)		*High liquidity (N=7,340)*	
	μ	σ	μ	σ
Short Term Debt/Total Assets	0.06	0.07	0.03	0.06
Investment/Total Assets	0.03	0.03	0.03	0.04
Sales/Total Assets	0.30	0.13	0.25	0.15
Cash/Total Assets	0.05	0.12	0.25	0.20
Idiosyncratic Uncertainty	1.31	0.84	1.71	1.11
	Small (N=7,635)		*Large (N=6,532)*	
	μ	σ	μ	σ
Short Term Debt/Total Assets	0.06	0.09	0.06	0.07
Investment/Total Assets	0.03	0.03	0.03	0.03
Sales/Total Assets	0.30	0.17	0.25	0.09
Cash/Total Assets	0.18	0.21	0.06	0.09
Idiosyncratic Uncertainty	1.76	1.13	1.17	0.82

Note: μ and σ^2 represent mean and variance respectively.

Table 4: Determinants of Leverage: All Firms

Short Term Debt/Total Assets$_{t-1}$	0.6325***
	(0.0341)
Sales/Total Assets$_t$	-0.0463***
	(0.0134)
Cash/Total Assets$_t$	-0.0295***
	(0.0106)
Investment/Total Assets$_{t+1}$	0.0470***
	(0.0117)
Investment/Total Assets$_t$	-0.0622***
	(0.0114)
Macroeconomic Uncertainty$_{t-1}$	-0.0176***
	(0.0031)
Idiosyncratic Uncertainty$_{t-1}$	-0.0016***
	(0.0006)
Index of Leading Indicators$_{t-1}$	-0.0002
	(0.0002)
$\eta_{Macroeconomic}$	-0.1796
$\eta_{Idiosyncratic}$	-0.0483
N	31,404
Sargan	0.162
AR(1)	-11.70***
AR(2)	-0.10

Note: The equation includes constant and industry dummy variables. Macroeconomic uncertainty is measured as the conditional variance of the detrended index of leading indicators. Asymptotic robust standard errors are reported in the brackets. Estimation by one-step System GMM using `xtabond2` for Stata. Sargan is the Sargan–Hansen test of overidentifying restrictions (p-value reported). AR(k) is the test for k-th order autocorrelation. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Determinants of Leverage: Sample splits

Uncertainty	Non-Durable	Durable	Low Liquidity	High Liquidity
Macroeconomic$_{t-1}$	-0.0169***	-0.0173***	-0.0216***	-0.0117**
	(0.4802)	(0.3840)	(0.5462)	(0.5767)
Idiosyncratic$_{t-1}$	-0.0006	-0.0017**	-0.0011	-0.0023*
	(0.0010)	(0.0007)	(0.0011)	(0.0014)
Uncertainty	**Low Leverage**	**High Leverage**	**Small**	**Large**
Macroeconomic$_{t-1}$	-0.0113**	-0.0427***	-0.0240***	-0.0196***
	(0.5506)	(0.751)	(0.7650)	(0.6447)
Idiosyncratic$_{t-1}$	-0.0020*	-0.0036**	-0.0036***	0.0005
	(0.0010)	(0.001)	(0.0012)	(0.000)

Note: Every equation includes constant, lagged short term leverage, sales-to-assets ratio, liquidity ratio, current and leading investment-to-assets ratio, the index of leading indicators and industry dummy variables. Macroeconomic uncertainty is measured as the conditional variance of the detrended index of leading indicators. Asymptotic robust standard errors are reported in the brackets. Estimation by one-step System GMM using `xtabond2` for Stata. * significant at 10%; ** significant at 5%; *** significant at 1%.