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Abstract

We investigate the impact of measures of uncertainty on firms' capital investment behavior using a panel of U.S. firms. Increases in firm-specific and *CAPM*-based measures have a significant negative impact on investment spending, while market-based uncertainty has a positive impact.

Keywords: capital investment, asymmetric information, financial frictions, uncertainty, CAPM

JEL: E22, D81, C23

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1 Introduction

Researchers have expended considerable effort in trying to understand the linkages between uncertainty and investment behavior at both firm-specific and aggregate levels.¹

In this paper, we consider the effects of three different forms of uncertainty on firms' investment behavior: *Own* uncertainty, derived from firms' stock returns; *Market* uncertainty, driven by S&P 500 index returns, and the relations between intrinsic and extrinsic uncertainty. To capture the latter effect, we introduce a *covariance* term (our CAPM-based risk measure) and allow the data to determine the differential impact of each of these components on firms' investment.

Early research, using risk measures constructed from stock return data, has shown that uncertainty exerts a strong negative effect on investment. However, researchers also find that the effects of uncertainty on investment generally disappear (see for instance Leahy and Whited (1996)) when Tobin's Q is introduced into the empirical model. In contrast, we show that firm-specific and macroeconomic uncertainty along with their interaction (CAPM based uncertainty) have a significant effect on investment even in the presence of Q , cash flow and the debt ratio.

Below we present our empirical findings. In our analysis we implement a standard investment model which incorporates various measures of uncertainty controlling for firm financial characteristics.

¹See, for example, Brainard, Shoven and Weiss (1980), Ghosal and Loungani (1996), Guiso and Parigi (1999), Beaudry, Caglayan and Schiantarelli (2001), Calcagnini and Saltari (2001) and Henley, Carruth and Dickerson (2003).

2 Empirical findings

2.1 Data

The estimation sample consists of an unbalanced panel of manufacturing firms for the 1984 to 2003 period drawn from Standard and Poor's Industrial Annual COMPUSTAT database. A number of sample selection criteria are applied to the original sample of 20,660 firm-years. We only consider firms who have not undergone substantial changes in their composition during the sample period (e.g., participation in a merger, acquisition or substantial divestment). As these phenomena are not observable in the data, we calculate the growth rate of each firm's real total assets, and trim the annual distribution of this growth rate by the 5th and 95th percentiles to remove firms exhibiting substantial changes in their scale. Values of the investment-to-asset, cash flow-to-asset, debt-to-asset ratios and Tobin's Q outside the 5–95th percentile range are judged implausible. Firms in clear financial distress or those facing substantial liquidity constraints are excluded. One per cent from either end of the annual returns distribution was trimmed. The final data set contains 6,762 firm-years pertaining to 606 firms with complete data for all variables.²

2.2 Generating volatility measures from daily data

We utilize daily stock returns and market index returns to compute intrinsic and extrinsic uncertainty via a method based on Merton (1980) from the intra-annual variations in stock returns and aggregate financial mar-

²Empirical results drawn from the full sample yielded qualitatively similar findings; the screened data were used to reduce the potential impact of outliers upon the parameter estimates.

ket series. This approach provides a more representative measure of the perceived volatility. It avoids such potential problems as high shock persistence when moving average representations are used, and low correlation in volatility when ARCH/GARCH models are applied to quantify volatility in low-frequency series. In that respect, our study improves upon much of the literature in its method of using high-frequency data to quantify volatility evaluated at a lower frequency.^{3,4}

In order to employ the Merton methodology, we must compute the intra-annual volatility of the series from daily data.⁵ We first take the squared first difference of the daily changes in returns (after dividing by the square root of the number of days intervening), which is later defined as the daily contribution to annual volatility:

$$\varsigma_t^d = \left(100 \frac{\Delta x_t}{\sqrt{\Delta \phi_t}} \right)^2 \quad (1)$$

where the denominator expresses the effect of calendar time elapsing between observations on the x process. If data were generated on every calendar day, $\Delta \phi_t = 1, \forall t$, but given that data are not available on weekends and holidays, $\Delta \phi_t \in (1, 5)$. The estimated annual volatility of the return series is defined as $\Phi_t[x_t] = \sqrt{\sum_{t=1}^T \varsigma_t^d}$ where the time index for $\Phi_t[x_t]$ is at the annual frequency.

³Leahy and Whited (1996), Bloom, Bond and Van Reenen (2001), Bond and Cummins (2004) have also utilized daily stock returns to compute firm-level uncertainty. However, the methodology they used to generate a proxy for uncertainty was different from ours.

⁴See Baum, Caglayan and Ozkan (2004) for a more detailed discussion of the Merton procedure along with its merits.

⁵The daily returns series are taken from CRSP. For the market index returns, we use returns on the S&P 500 index, inclusive of dividends.

2.3 Descriptive statistics

Descriptive statistics for the variables used in the analysis are presented in Table 1. The average (median) investment rate for our sample is about 6% (5.4%) and that of Q is about 2.39 (1.57). This value of Q , higher than found in other studies, is due to the use of total assets as a deflator rather than capital stock. We also do not trim the data based on firm specific characteristics such as size of the firm's total assets or cash flow. The last three lines, labeled as η , ε and ν give the basic statistics for the constructed measures of uncertainty obtained from firm stock returns, S&P index returns and the covariance between firm and market returns, respectively.

2.4 The link between uncertainty and capital investment

We employ the dynamic panel data (DPD) approach developed by Arellano and Bond (1991), as implemented in Stata by Roodman (2004). All models are estimated in first difference terms to eliminate the fixed effects using the one-step GMM estimator.

Column 1 of Table 2 presents a standard investment model which contains Q , CF/TA and B/TA along with the lagged dependent variable, $(I/TA)_{t-1}$ as a benchmark. The signs of CF/TA , Q and lagged investment are positive and significant while the sign of B/TA is negative and significant. The J statistic (and the corresponding p -value) is the Hansen–Sargan test statistic and it indicates that the test for overidentifying restrictions is satisfactory (as it is in all reported estimates). Furthermore, we reject the presence of second-order autocorrelation ($AR(2)$) validating the use of suitably lagged endogenous variables as instruments.⁶

⁶The second through fourth lags of $(I/TA)_{t-1}$, Q_t , $(CF/TA)_t$, $(B/TA)_{t-1}$, $(Sales/TA)_{t-1}$ and $Sales_t$ are employed as GMM instruments. In the models includ-

Given satisfactory benchmark results, we introduce our measures of lagged intrinsic and extrinsic uncertainty into this basic model.⁷ Column two of Table 2 provides our results when we introduce the lagged *Own* (intrinsic) uncertainty measure into our basic framework. The magnitude and significance of the coefficients of Q , CF/TA , B/TA and the lagged dependent variable are not altered. The coefficient for *Own* uncertainty is negative and significant at the 1% level. This is an interesting finding as Leahy and Whited (1996) report that uncertainty affects the investment behavior through Q (in their analysis the coefficient on their proxy for uncertainty becomes insignificant with the introduction of Q). In our case, even in the presence of Q , intrinsic uncertainty is significant.

We then add *Market* uncertainty to the original equation (excluding the intrinsic measure) in column three of Table 2; its coefficient is insignificant. Next, we consider a model in which both *Own* and *Market* measures are included in column four of Table 2. When entered jointly, although the coefficient of the *Market* measure becomes positive, it is not significantly different from zero while that of *Own* uncertainty is still negative and significant. This shows that firm-specific uncertainty has a more prominent impact on investment spending than does market-based uncertainty.

To evaluate possible interactions between the two forms of uncertainty, we introduce them along with our measure of CAPM-based uncertainty: $Cov(Own_{ret}, Mkt_{ret})_{i,t-1}$. The results associated with this model are presented in column five of Table 2. This model yields interesting findings. The coefficient on *Own* uncertainty is once again negative and significant, but

ing lagged uncertainty measures, second through fourth lags of those measures were also included as GMM instruments.

⁷Use of contemporaneous uncertainty measures yields similar results.

that of *Market* uncertainty is now positive and significant at the 5% level. We also observe that the CAPM-based uncertainty measure is significant and negative, as theory would suggest. This result is quite interesting supporting the implications of CAPM theory and stands in clear contrast to the findings reported by Leahy and Whited (1996). It also appears that when both market uncertainty and the CAPM uncertainty measure are included in the model, the level of market uncertainty serves as a moderating influence on the effects of the CAPM uncertainty measure. It is perhaps possible that the positive coefficient on market uncertainty is capturing the existence of a real option for managers to invest so that their firm can possess a greater opportunity to expand her presence in that market.

3 Conclusions

In this paper we investigate the analytical and empirical linkages between firms' capital investment behavior and forms of uncertainty. Previous research has found that firm-specific or macro-based measures of uncertainty are insignificant in the presence of Q and that CAPM-based uncertainty measures have no significant impact on investment behavior. In contrast, we show that *Own* uncertainty is operative and has a negative impact on investment in a model incorporating a measure of Tobin's Q , and our measure of CAPM-based uncertainty has a negative effect on investment while *Market* uncertainty has a positive impact.

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Table 1: Descriptive statistics

	<i>p</i> 25	<i>p</i> 50	<i>p</i> 75	mean	std. dev.
<i>I/TA</i>	0.0358	0.0541	0.0800	0.0603	0.0310
<i>Q</i>	0.9861	1.5683	2.8815	2.3920	2.1569
<i>CF/TA</i>	0.0786	0.1098	0.1421	0.1112	0.0465
<i>B/TA</i>	0.1645	0.2520	0.3442	0.2585	0.1242
η	0.4946	0.7548	1.1851	0.9237	0.6165
ε	0.1051	0.1914	0.2983	0.2277	0.1450
ν	0.0226	0.0489	0.0951	0.0672	0.0612
Firm-years	6762				

Notes: *p*25, *p*50, *p*75 are the quartiles of the variables. *I/TA* is the ratio of investment to total assets; *Q* is Tobin's *Q*; *CF/TA* is the ratio of cash flow to total assets; and *B/TA* is the ratio of debt to total assets. The η term is a measure of intrinsic uncertainty, while ε refers to extrinsic uncertainty and ν is the CAPM-based risk measure.

Table 2: Robust GMM estimates of I/TA

	(1)	(2)	(3)	(4)	(5)
$(I/TA)_{t-1}$	0.427*** (0.033)	0.388*** (0.034)	0.438*** (0.033)	0.395*** (0.036)	0.385*** (0.036)
Q_t	0.001 (0.001)	0.001** (0.001)	0.001 (0.001)	0.001* (0.001)	0.002** (0.001)
$(CF/TA)_t$	0.231*** (0.027)	0.234*** (0.026)	0.218*** (0.026)	0.245*** (0.028)	0.246*** (0.028)
$(B/TA)_{t-1}$	-0.070*** (0.013)	-0.062*** (0.012)	-0.066*** (0.012)	-0.056*** (0.012)	-0.055*** (0.012)
η_{t-1}		-0.004*** (0.001)		-0.007*** (0.002)	-0.007*** (0.002)
ε_{t-1}			-0.003 (0.003)	0.006 (0.004)	0.016** (0.007)
ν_{t-1}					-0.032** (0.014)
Firm-years	4327	4323	4327	4323	4323
Firms	606	605	606	605	605
J	276.331	311.088	323.478	337.343	368.193
J pvalue	0.617	0.778	0.606	0.766	0.769
AR(2)	-1.587	-1.740	-1.528	-1.659	-1.734
AR(2) pvalue	0.112	0.082	0.127	0.097	0.083

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: All estimates are generated by Arellano–Bond one-step difference GMM. The instrument set is described in the text. J is the Hansen–Sargan test of overidentifying restrictions, while $AR(2)$ is the Arellano–Bond test of second order autocorrelation in the errors. The η term is a measure of intrinsic uncertainty, while ε refers to extrinsic uncertainty and ν is the CAPM-based risk measure.