# The Impact of Uncertainty on Investment:

# Empirical Evidence from Manufacturing Firms in Korea

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Abstract

This paper investigates the empirical relationship between investment and uncertainty using the firm-level data from the Korean manufacturing sector. The empirical results show that uncertainty is negatively correlated with investment only for the post-crisis sample period. In particular, the negative effect of uncertainty on investment is more significant for firms with low interest coverage ratio, high debt-to-asset ratio, and small size. The findings are consistent with the claim that firms tend to act (invest) in a more risk-averse manner following the financial crisis.

## I. Introduction

Since the financial crisis in 1997, fixed investment in the Korean economy has been relatively stagnated: the fixed investment in the national income account grew 64.3% from 1990 to 1997, but only 3.4% from 1997 to 2004. The role of uncertainty has received particular attention by those seeking to explain the low investment growth. For example, the Korea Development Institute (KDI) takes the view that the stagnation of investment may be due to a lack of sufficient confidence in the future business environment in general and the emergence of uncertainty amid the structural reform process following the financial crisis in particular (KDI Economic Outlook, 2004).

The impact of uncertainty on investment has attracted attention of academics as well as policy makers. There are extensive theoretical studies exploring the relationship between uncertainty and investment, but different theories predict different signs of the relationship. The difference mainly stems from the underlying assumptions on whether the marginal revenue product of capital is convex or concave with respect to a random variable that generates uncertainty. The relationship is positive if the marginal revenue product is convex, while it is negative if the marginal revenue product is concave. Hartman (1972) and Abel (1983) argue that an increase in uncertainty raises an incentive to invest as the marginal revenue product of capital is convex in output price. An increase in the variance of output price without a change in the mean raises expected profitability of capital, which leads to an increase in investment.[1] With flexibility of labor relative to capital, firms can adjust labor to price fluctuation leading to a change in labor-capital ratio and thus causing the marginal revenue product of capital to change by

[1] Mean preserving spread in the sense of Rothschild and Stiglitz (1970).

more than the movement in price.[2] In contrast, models of irreversible investment predict a concave marginal revenue product and thus a negative uncertainty-investment relationship at least in the short run. Irreversibility implies that decreasing capital stock is more costly than increasing investment due to the asymmetry of adjustment cost. Therefore, firms that face high uncertainty tend to postpone capital expenditure until they have more information.[3]

The influence of the irreversible investment theory is evident in the U.S. Economic Report of the President (2004), in which the negative effect of uncertainty on investment is described as follows: “increased uncertainty likely also had direct effects on business decisions about investment and hiring: uncertainty may cause firms to wait until they have more information before committing to an investment. In this case, firm managers hesitate to respond to a change in demand." (p.38)

The objective of this paper is to provide empirical evidence on the uncertainty-investment relationship using firm level data from the Korean manufacturing sector. In particular, I investigate whether the sluggish investment growth subsequent to the 1997 financial crisis in Korea is due to increase uncertainty.

To compare the impacts of uncertainty on investment before and after the financial crisis, I split the sample into the pre-crisis sample and the post-crisis sample. I find that the uncertainty-investment relationship is negative only for the post-crisis sample. The findings suggest that Korean firms over-invested without sufficient risk consideration

[2] Hartman(1972) assumes that a firm, which maximizes the expected value of the sum of discounted cash flows, decides how much capital to rent before output price and wage are determined and then chooses the amount of labor to hire.

[3] Dixit and Pindyck (1994) and Caballero (1999) provide comprehensive surveys on the topic of irreversible investment.

before the financial crisis. In particular, several studies on the Korean financial crisis argue that an implicit loss protection by the government prevailing in the pre-crisis period is responsible for the over-investment. For instance, using a sample of Korean firms before the crisis, Han (1999) finds that the uncertainty-investment relationship is not significant, but he finds a positive relationship for a sample of five chaebols (Korean industrial conglomerates). He argues that chaebols over-invested in risky projects relying on the government's implicit loss protection.

In contrast, in the post-crisis sample, I find a negative correlation between uncertainty and investment, but the correlation is statistically significant only for the firms with weak balance sheet conditions, such as low interest coverage ratio, high debt to asset ratio, and small firm size, suggesting that financially constrained firms are more likely to act in a risk averse manner. Other things being equal, a weaker balance sheet condition implies a higher probability of default, and thus firms with weak balance sheet conditions would be more cautious in investment decision. Consequently, the uncertainty-investment relationship is expected to be stronger in a sample of firms with weak balance sheet conditions.

The paper is organized as follows. Section II discusses empirical specifications. Section III describes the data and provides summary statistics. Section IV presents empirical results and Section V concludes.

## II. Empirical Specification

One of the standard models of investment in empirical research using firm-level data takes the form in which investment spending is a function of Tobin’s q and cash flow. I augment this standard specification with a proxy for uncertainty, and test whether a measure of uncertainty has a marginal explanatory power for investment, controlling for Tobin’s q and cash flow.

The q theory of investment states that q is a sufficient statistic for summarizing all the information relevant to a firm's investment decision. Empirical research typically rearranges the theoretical first order condition as a linear regression under the assumption of quadratic adjustment costs, and then uses the observable Tobin's q as a proxy for marginal q. Hayashi (1982) shows that, under the assumptions of constant returns to scale and perfect competition, marginal q is equal to average q, which is the ratio of the manager's valuation of the firm's existing capital stock and its replacement cost. If the financial market is efficient, the average q should be equal to the ratio of market valuation to replacement cost, which is Tobin's q. In theory, as Abel (1983) argues, any information about uncertainty should also be summarized by q because q is a sufficient statistic for investment. However, Tobin's q may differ from its theoretical counterpart due to measurement errors in q and/or any violation of the underlying theoretical assumptions (Erickson and Whited (2000)). If this is the case, it is possible to detect a significant correlation between uncertainty and investment even after controlling for Tobin’s q.

Bond and Cummins (2004) also employ the q model of investment to examine whether uncertainty marginally affects investment decisions using the sample of publicly traded U.S. firms between 1982 and 1999. They find a significantly negative effect of uncertainty on capital accumulation controlling for expected profitability by Tobin's q. In contrast, Leahy and Whited (1996) find that the relationship is insignificant when they control for q.[4]

Following Bond and Cummins (2004), Bloom, Bond, and Van Reenen (2001), and Leahy and Whited (1996), I specify two slightly different equations as follows:

$$(1) \quad (I/K)_{it} = \mu_i + \mu_t + \alpha\, q_{it} + \beta\, CF_{it} + \gamma\, \sigma_{it} + e_{it}\,,$$

$$(2) \quad (I/K)_{it} = \mu_i + \mu_t + (\alpha_0 + \alpha_1\, \sigma_{it})\, q_{it} + \beta\, CF_{it} + e_{it}\,,$$

where $(I/K)_{it}$ is firm $i$'s investment in time $t$ divided by the capital stock in time $t$ and $q_{it}$ is the Tobin's q at the beginning of time $t$. $\sigma_{it}$ is a proxy for uncertainty and $CF_{it}$ is a measure of cash flow defined by the ratio of earnings before interest and taxes (EBIT) to capital stock. $\mu_i$ denotes the individual firm effect to control for different elasticity of demand or relative price across firms. $\mu_t$ represents the time effect which can control changes in the cost of capital over the business cycle.

In equation (1), uncertainty is assumed to directly affect investment. In equation (2), the influence of uncertainty on investment operates through the sensitivity of investment to q. Bloom, Bond, and Van Reenen (2001) and Bond and Cummins (2004) argue that a higher level of uncertainty reduces the responsiveness of investment to demand shock or profitability. To the extent that q represents the expected profitability of investment, the coefficient on the interaction term between uncertainty and q can be interpreted as

[4] However, Leahy and Whited (1996) find a significantly negative relationship when q is not included in the regression.

an impact of uncertainty on the investment sensitivity to expected profitability. If the adjustment cost of capital stock is a quadratic function, then the coefficient on q becomes a speed of adjustment. In this case, the coefficient on the interaction term measures the impact of uncertainty on the speed of adjustment. Bond and Cummins argue that a negative coefficient on the interaction term provides supporting evidence for the theory of irreversible investment.

Theories of asymmetric information in capital markets predict that external financing is more costly than internally generated funds. Motivated by these theories, Fazzari, Hubbard, and Petersen (1988) and subsequent empirical works on corporate investment study the relationship between investment and cash flow to test for the presence of financing constraints. These studies split a sample of firms according to some a priori measures of financial constraints and compare the investment-cash flow sensitivities across the (relatively) constrained and unconstrained samples. However, there has been much debate, notably between Kaplan and Zingales (1997, 2000) and Fazzari, Hubbard and Petersen (1988, 2000), whether investment-cash flow sensitivity reflects the degree of financial constraints. Fazzari, Hubbard and Petersen contend that firms with larger coefficient estimates on cash flows are likely to be more financially constrained. On the other hand, Kaplan and Zingales argue that investment-cash flow sensitivity is not a good measure of financial constraints. According to Kaplan and Zingales, if the sensitivities do not increase monotonically with the degree of financial constraints, a lower sensitivity does not necessarily imply a lower degree of financial constraint.

## III. Data

### A. Measuring Uncertainty

Despite a large body of theoretical studies, relatively few empirical works have been done on the relationship between uncertainty and investment.[5] The sluggish progress in empirical research is in part due to the difficulty in measuring uncertainty. Because uncertainty can take many forms including uncertainty about future demand, cost of production, consumers' preference as well as government policies and institutional changes, it is difficult to obtain a precise and encompassing measure of uncertainty faced by firms. Also, since uncertainty concerns what might happen in the future, a measure of uncertainty should be a forward-looking variable.[6]

I obtain a measure of uncertainty from the volatility of individual daily stock returns.[7] Each year, I calculate the standard deviation of daily stock returns for each individual firm and divide it by the standard deviation of the returns on the market index to control for the variation over business cycle. Given that uncertainty is related to dispersion of future random variables that might affect firm value, the volatility of stock returns is a natural candidate as a measure uncertainty. Stock prices reflect the

5 Choi (1999) finds a negative correlation between volatility in foreign exchange rate and investment in time series regression.

6 Han (1999) investigates investment behavior of Korean firms in the pre-crisis period of 1992-97. He uses the coefficient of variation of operating profit in the previous five years. This approach can directly link uncertainty to the changes in profitability. However, it is noteworthy to mention that using historic figures may not offer any insight on the future uncertainty faced by firms at the time of investment decision.

7 Standard deviations of weakly stock returns do not bring about qualitative changes.

expectation on the future environment, taking into account all information in the market. In fact, standard deviation of stock returns and its variants have been used in Leahy and White (1996), Bloom, Bond, and Van Reenen (2001) and Bond and Cummins (2004) for measuring uncertainty.[8] However, this approach has a disadvantage if fluctuations in stock prices reflect bubbles, fads, or noises which are not relevant to investment decisions.

### B. Sample Splits and Descriptive Statistics

To examine whether the effect of uncertainty has changed since the financial crisis, I split the sample into two sub-samples: a pre-crisis sample (1991-1997) and a post-crisis sample (1999-2004).[9] For each sub-sample, I classify firms according to the interest coverage ratio to test the hypothesis on the differential effect of uncertainty on investment between financially constrained and unconstrained firms. Each year during the sample period, firms are ranked based on their interest coverage ratio and classified as constrained (unconstrained) firms if their interest coverage ratio is below (above) the median.

Table 1 presents summary statistics on various firm characteristics used in the regression for high interest coverage ratio firms and low interest coverage ratio firms in

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[8] Bond and Cummins (2004) construct two alternative measure of uncertainty. One is based on the disagreement among securities analysts forecasting future profits and the other is based on the variance of the errors made by securities analysts in forecasting the firm's profits in recent past.

[9] The observations in 1998 are not included in both sub-samples to preclude the possibility that the empirical results are dominated by a direct consequence of financial crisis.

each of the pre-crisis and the post-crisis sample. Comparing the pre-crisis and the post-crisis samples, a clear pattern emerges in investment ratio (I/K) and cash flow. The average investment ratio decreased significantly after the crisis: in the pre-crisis period (1991-1997), the investment ratio is 21.6% on average, but in the post-crisis period (1999-2003), it is merely 7.8%. Not surprisingly, cash flow also fell substantially after the crisis. Tobin's q and the normalized standard deviation of stock returns are also lower in the post-crisis sample, but the differences are relatively small compared to the investment ratio.

Although investment ratio and cash flow fell after the financial crisis on average, a different pattern is found across high and low interest coverage ratio firms. The decrease in investment ratio is more substantial for the low interest coverage group: the average investment ratio is only 3.1% in 1998-2003 periods. In the post-crisis period, the average cash flow of low interest coverage ratio firms turns out to be negative. In contrast, the average cash flow did not change much for high interest coverage ratio firms: 43.6% before the crisis and 40.4% after the crisis.

Another interesting finding from Table 1 is the changes in stock return volatility after the crisis. In the pre-crisis period, the standard deviations of stock returns do not show a large difference between high and low interest coverage ratio firms. In the post-crisis period, however, the standard deviations of stock returns show a clear difference between the two groups. The volatility of stock returns for the low interest coverage ratio group increased after the crisis while the volatility for the high interest coverage ratio group did not change much in the post-crisis period. Accordingly, the gap between the two groups in terms of stock return volatility has widened.

## Ⅳ. Empirical Results

### A. Results from the Full Sample

This section presents the estimation results of investment equations for the two specifications. Before testing differential impacts of uncertainty across time and across groups, I present the estimation results from the full sample. I use a fixed effect model, and Huber-White's robust standard error to test for the significance of the coefficient estimates.[10]

Table 2 reports the estimation results from the full sample. Model I and Model II refer to the specification (1) and specification (2), respectively. The results from Model I in which the proxy for uncertainty, the standard deviation of stock returns, is an independent explanatory variable are reported in the second column and the third column. The result in the second column shows that the coefficient estimates on the proxy for uncertainty is negative and statistically significant suggesting that uncertainty adversely affects investment. The result in the third column, in which cash flow is included in the regression, is qualitatively the same. The estimation results from Model II show the same finding in that the coefficients on the interaction term between Tobin's q and the proxy for uncertainty are negative and statistically significant.

The estimation results from the full sample are broadly consistent with Bond and Cummins (2004). In particular, the results from Model II are consistent with the prediction that uncertainty reduces the responsiveness to future expected profitability represented by Tobin's q. Given the same future profitability of investment, the results

[10] A dynamic panel model by Arellano and Bond (1991) yields qualitatively same results.

suggest that firms facing a higher level of uncertainty respond less sensitively to the expected profit opportunities. If interpreted in terms of the irreversible investment story, a higher level of uncertainty is likely to lead firms to become more passive to increasing investment because the committed investment cannot be reversed when the business environment turns out to be unfavorable.

### B. Sample Splits: Pre-crisis Sample vs. Post-crisis Sample

The empirical results from the full sample uncover the sign of uncertainty-investment relationship. This sub-section examines if there are differences in the effects of uncertainty between the pre-crisis sample (1991-1997) and post-crisis sample (1999-2004). Table 3 reports the estimation results for the two sub-samples.

Comparison of the results in Table 3 shows that the relationship between uncertainty and investment is negative and statistically significant for the post-crisis sample, but the relationship appears to be insignificant for the pre-crisis sample. In the pre-crisis sample, both Model I and Model II yield statistically insignificant coefficient estimates on the proxy for uncertainty. In contrast, they are negative and highly significant in the post-crisis sample, implying that the negative uncertainty-investment relationship found in the full sample is mainly from the post-crisis period. [11]

Of course, one may argue that measurement problems of the data may account for the insignificant relationship in the pre-crisis sample. For example, if Tobin's q has

[11] Excluding outliers form the sample does not change the results qualitatively. Re-estimating Model II after excluding upper 5% and bottom 5% of investment ratio gives the coefficient estimates on uncertainty -0.011 (*t*-value -0.27) in the pre-crisis period and -0.022 (*t*-value -3.33) in the post-crisis period.

complete information about uncertainty, it may be possible that no meaningful relationship between uncertainty and investment is estimated in the regression. Furthermore, the insignificant relationship may result from non-fundamental factors in stock prices such as bubbles and noise. However, there is no specific reason as to why these potential factors exist only before the financial crisis.

A more convincing story for the change in the uncertainty-investment relationship is that some of the important factors in the investment decisions made by the Korean manufacturing firms in the pre-crisis sample period are not adequately considered in the regression. Korean firms' investment decisions prior to the crisis are generally viewed to have taken an aggressive approach toward quantitative expansion without proper risk considerations. For instance, if there is a strategic incentive, increasing investment could be more profitable in spite of uncertainty. That is, if firms decide to postpone investment due to uncertainty, then there is a potential risk that other firms increase market shares in advance or that a new firm is seeking to enter the market. Before the crisis, it could be the case that many firms judged that these kinds of potential costs were larger than the benefits of delaying investment. Furthermore, before the financial crisis, firms had a belief on government's implicit loss protection or a belief on "too big to fail," which may have led to over-investment and a lower sensitivity to uncertainty.

On the other hand, after the financial crisis, corporate restructuring may have led firms to act in a more risk-averse manner so that risk considerations dominated the strategic incentives. At the same time, a belief on the implicit guarantee by the government disappears in the process of corporate restructuring. Accordingly, firms become more sensitive to uncertainty in investment decisions.

While the effect of uncertainty is detected only in the post-crisis sample, the coefficient estimates on cash flow are statistically significant only in the pre-crisis sample. Table 3 reports that the cash flow sensitivity is economically and statistically significant both in Model I and Model II in the pre-crisis sample, but not in the post-crisis sample. From the standpoint of Fazzari, Hubbard, and Petersen (1988), the results suggest that, on average, Korean firms were financially constrained before the financial crisis, but not constrained after the crisis. However, as argued by Kaplan and Zingales (1997) among others, cash flow sensitivities may not be monotone in the degree of financial constraints. I discuss the cash flow sensitivity in more detail in the next sub-section.

### C. Sample Splits: Financial Constraints

To test the hypothesis that financially constrained firms are more likely to be sensitive to uncertainty in investment decisions, I run the regressions separately for the sample of high interest coverage firms and low interest coverage firms in the pre- and post-crisis period. Table 4 reports the estimation results. “High” and “Low” denote the high and low interest coverage firms, respectively.

In the pre-crisis period, the coefficient estimates on the proxy for uncertainty are not statistically significant regardless of whether the interest coverage ratio is high or low. In particular, the coefficient is positive, though not statistically significant, for the high interest coverage ratio firms. In contrast, the cash flow sensitivity is estimated significantly for both high and low interest coverage ratio firms. The results, therefore, indicate that the effects of uncertainty are not different across the two samples split according to interest coverage ratio in the pre-crisis period.

In the post-crisis period, on the other hand, a clear pattern emerges in terms of the statistical significance of the coefficient estimates. The coefficients are estimated negatively for both high and low interest coverage ratio firms, but the coefficients are statistically significant only for low interest coverage ratio firms. Interestingly, the coefficients on cash flow are not statistically significant for both samples.[12] The results for the post-crisis period suggest that the effect of uncertainty on investment is conditional depending on a firm's financial condition. As firms with weak balance sheet condition are more likely to act in a risk-averse manner, their investment becomes more sensitive to uncertainty.[13]

One may ask whether the uncertainty-investment relationship is correlated with cash flow sensitivity. In the pre-crisis sample, the uncertainty sensitivity is not significant whereas the cash flow sensitivity is significant. In the post-crisis sample, in contrast, the uncertainty sensitivity is estimated significantly while the cash-flow sensitivity is not. However, excluding the cash flow term from the regression does not change the

[12] So far, the regressions are run separately for different samples and results are compared across the samples. This approach implicitly assumes that the error structures are different across the samples. Alternatively, if the true error structure is identical across the samples, it is more appropriate to estimate a model using dummy variables with the full sample data. To do this, I set up four dummy variables for High/pre-crisis, Low/pre-crisis, High/post-crisis, and Low/post-crisis and generate interaction terms between the proxy for uncertainty and these dummy variables. Then I include the interaction terms in the regression and test the coefficients on the interaction terms. The estimation results do not change qualitatively (See Table 7).

[13] Excluding outliers of upper and lower 5% of the variables does not change the results qualitatively. For instance, during the post-crisis period, the coefficient on the proxy for uncertainty is estimated by -0.016 (*t*-value -2.07) for the low interest coverage ratio sample.

estimated uncertainty sensitivity qualitatively and excluding the uncertainty term from the regression does not change the statistical significance of the cash flow sensitivity. These exercises suggest that the presence of financial constraints is captured more strongly by the uncertainty sensitivity rather than the cash flow sensitivity in Korea.

Although the interest coverage ratio has been one of the most widely used measures of the degree of financial constraints, the results from splitting the sample by a single measure can be open to dispute. In fact, since no measure is supposed to capture perfectly the degree of financial constraints, previous literature usually uses several a priori measures to classify firms and compare the results from different samples classified by different criteria. Accordingly, I use the debt-to-asset ratio and firm size as alternative classification criteria for a robustness check.

Table 5 presents the estimation results from the samples classified by the debt-to-asset ratio. Since high debt-to-asset ratio firms are more likely to be vulnerable to changes in macroeconomic conditions such as changes in interest rates, their investment could be more strongly affected by uncertainty. In the post-crisis sample, the coefficient estimate on the proxy for uncertainty is negative and statistically significant for high debt-to-asset ratio firms, but it is not the case for low debt-to-asset ratio firms. In the pre-crisis sample, however, no significant coefficients are estimated regardless of whether the debt-to-asset ratio is high or low. In contrast, the coefficient estimates on cash flow are statistically significant in the pre-crisis sample, but not in the post-crisis sample. The results in Table 5 are broadly consistent with the results in Table 4 in that uncertainty affects investment only for firms with weak financial conditions and only in the post-crisis sample.

In principle, there should be no direct link between a firm's size and its financial soundness, but in fact, large firms have advantages to finance investment compared to small firms. Since large firms have more assets to put up as collateral, their borrowing costs are likely to be lower. Further, compared to small firms, large firms have a longer operating history and thus they are expected to have accumulated a longer credit history in relation to financial institutions or capital markets. Moreover, firm size as a classification criterion has an advantage as it can be viewed as more exogenous than the interest coverage and debt-to-asset ratio.

Table 6 reports the estimation results when firms are classified according to size.[14] The results in Table 6 show that the coefficient estimates on the proxy for uncertainty are statistically significant for small firms in the post-crisis sample.[15] For large firms, no significant effect of uncertainty is estimated both in the pre-crisis sample and post-crisis sample. The coefficients on cash flow are estimated significantly only in the pre-crisis period, consistent with Table 3, Table 4, and Table 5. The results suggest that there is a possible link between firm size and financial soundness in the post-crisis period. Following the crisis, large firms are generally viewed to have improved substantially their balance sheet conditions after massive restructuring, but small firms in comparison have yet to undergo such extensive restructuring.[16]

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[14] For a robustness check, I include interest coverage ratio, debt to asset ratio, and firm size in the regression and estimate the models for the sample of pre-crisis period and post-crisis period. The results are qualitatively the same.

[15] However, a significant coefficient is estimated only in Model II.

[16] The standard deviation of stock returns as a proxy for uncertainty may depend on firm characteristics. In general, the volatility of stock returns is increasing in the debt-to-asset ratio and decreasing in firm size. Since the debt-to-asset ratio and firm size are the classification criteria to split samples, it could be the case that the negative correlation between uncertainty

## Ⅴ. Conclusion

The findings in this paper show that uncertainty is negatively correlated with investment in the post-crisis sample, but not in the pre-crisis sample, suggesting that Korean economy experienced a structural break where firms started to act in a more risk-averse manner after the financial crisis. In the pre-crisis period, firms pursued quantitative expansion without taking risk into account. This finding is consistent with the view that strategic incentives were more important than risk management in investment decisions. It is also consistent with the existence of the government's implicit loss protection before the crisis. Another main finding of the paper is that, even in the post-crisis period, uncertainty affects investment of financially constrained firms such as low interest coverage ratio firms and high debt to asset ratio firms. This finding suggests that enhancing financial soundness by corporate restructuring could reduce the negative uncertainty-investment relationship.

The results are consistent with the theory of irreversible investment in which firms reduce or postpone investment in response to an increase in uncertainty. At the same time, firms may raise savings in the form of short-term liquidity to prepare for the potential situation of deterioration in future business conditions. Considering this aspect

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and investment in the high debt-to-asset ratio sample and in the small firm sample simply reflects high volatility of returns in the sample. To examine this possibility, standard deviations of returns are regressed on the debt-to-asset ratio, firm size, and interest coverage ratio to obtain residuals orthogonal to these firm characteristics. Then I estimate the investment equation using the residuals as a proxy for uncertainty. The results are not qualitatively different (not reported). In addition, instead of splitting the sample, I include these firm characteristics in the regression and estimate the models. The results do not change qualitatively (not reported).

of precautionary corporate saving, investigating the relationship between uncertainty and short-term liquidity holdings, such as cash and current asset, is another important direction for future research.[17]

[17] Preliminary results from regressing short-term liquidity on Tobin's q, cash flow and the proxy for uncertainty show that uncertainty is positively correlated with corporate saving.

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<Table 1> Summary Statistics

| | 1991~2003 | | | 1991~1997 | | | 1999~2003 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | High | Low | Total | High | Low | Total | High | Low |
| $I/K$ | 0.165 | 0.202 | 0.127 | 0.216 | 0.242 | 0.189 | 0.078 | 0.125 | 0.031 |
| | (0.619) | (0.513) | (0.71) | (0.734) | (0.551) | (0.880) | (0.428) | (0.433) | (0.418) |
| $q$ | 0.85 | 0.837 | 0.862 | 0.919 | 0.941 | 0.899 | 0.777 | 0.720 | 0.831 |
| | (0.392) | (0.35) | (0.427) | (0.305) | (0.292) | (0.314) | (0.455) | (0.339) | (0.539) |
| $\sigma$ | 2.097 | 1.863 | 2.318 | 2.148 | 2.06 | 2.228 | 2.078 | 1.675 | 2.467 |
| | (0.983) | (0.548) | (1.221) | (0.639) | (0.556) | (0.698) | (1.313) | (0.494) | (1.687) |
| $CF/K$ | 0.269 | 0.424 | 0.113 | 0.344 | 0.436 | 0.251 | 0.183 | 0.404 | -0.037 |
| | (0.82) | (0.567) | (0.987) | (0.731) | (0.503) | (0.894) | (0.889) | (0.654) | (1.028) |

Notes: High (Low) denotes high (low) interest coverage firms

Numbers in parentheses are standard deviations.

<Table 2> Estimation Results: Full Sample

| | Model I | | Model II | | Model I + Model II | |
|---|---|---|---|---|---|---|
| Constant | 0.085 | 0.025 | -0.111 | -0.143 | -0.076 | -0.144 |
| | (0.55) | (0.14) | (-0.45) | (-0.60) | (-0.30) | (-0.54) |
| $q$ | 0.35 | 0.306* | 0.511 | 0.460* | 0.497 | 0.460* |
| | (1.58) | (1.84) | (1.62) | (1.89) | (1.56) | (1.81) |
| $\sigma$ | -0.076** | -0.058** | | | -0.02 | 0.000 |
| | (-2.08) | (-2.40) | | | (-1.29) | (0.02) |
| $q \times \sigma$ | | | -0.048* | -0.043** | -0.041 | -0.043 |
| | | | (-1.68) | (-1.96) | (-1.40) | (-1.58) |
| $CF/K$ | | 0.214 | | 0.216 | | 0.216 |
| | | (1.37) | | (1.41) | | (1.40) |
| $R^2$ | 0.124 | 0.176 | 0.132 | 0.185 | 0.132 | 0.185 |
| $F$ statistic | 14.94 | 12.67 | 14.87 | 12.30 | 13.82 | 11.56 |
| No. obs | 4,562 | 4,539 | 4,562 | 4,539 | 4,562 | 4,539 |
| No. firms | 417 | 416 | 417 | 416 | 417 | 416 |

Notes: Numbers in parentheses are t-values.

*, **, *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

<Table 3> Estimation Results: Pre-crisis Sample vs. Post-crisis Sample

| | 1991~1997 | | 1999~2003 | |
|---|---|---|---|---|
| | Model I | Model II | Model I | Model II |
| Constant | -0.553*** | -0.544*** | 0.075 | -0.04 |
| | (-3.15) | (-3.46) | (1.32) | (-0.88) |
| $q$ | 0.476*** | 0.555*** | 0.163*** | 0.289*** |
| | (4.23) | (4.02) | (2.92) | (4.78) |
| $\sigma$ | 0.005 | | -0.023** | |
| | (0.16) | | (-2.28) | |
| $q \times \sigma$ | | -0.053 | | -0.022*** |
| | | (-1.51) | | (-5.28) |
| $CF / K$ | 1.198*** | 1.196*** | -0.025 | -0.022 |
| | (5.44) | (5.49) | (-0.94) | (-0.84) |
| $R^2$ | 0.590 | 0.591 | 0.221 | 0.231 |
| $F$ statistic | 5.85 | 5.71 | 12.17 | 14.01 |
| No. obs | 2,218 | 2,218 | 1,948 | 1,948 |
| No. firms | 358 | 358 | 415 | 415 |

Notes: Numbers in parentheses are t-values.

*, **, *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

<Table 4> Estimation Results:
High interest coverage ratio sample vs. Low interest coverage ratio sample

| | 1991~1997 | | 1999~2003 | |
|---|---|---|---|---|
| | High | Low | High | Low |
| < Model I > | | | | |
| Constant | 0.065 | -0.887*** | -0.091 | -0.08 |
| | (0.37) | (-3.97) | (-0.73) | (-1.43) |
| $q$ | 0.059 | 0.734*** | 0.360*** | 0.137** |
| | (0.53) | (4.41) | (3.87) | (2.35) |
| $\sigma$ | 0.008 | 0.025 | -0.029 | -0.015* |
| | (0.12) | (0.55) | (-0.66) | (-1.67) |
| $CF/K$ | 0.535*** | 1.288*** | 0.065 | -0.057 |
| | (2.96) | (7.65) | (1.36) | (-1.46) |
| $R^2$ | 0.35 | 0.741 | 0.414 | 0.303 |
| $F$ statistic | 2.64 | 8.43 | 6.29 | 3.79 |
| No. obs | 1,054 | 1,164 | 943 | 1,005 |
| No. firms | 282 | 275 | 307 | 317 |
| < Model II > | | | | |
| Constant | -0.118 | -0.782*** | -0.143* | -0.148*** |
| | (-0.83) | (-4.45) | (-1.67) | (-2.63) |
| $q$ | 0.02 | 0.747*** | 0.385*** | 0.220*** |
| | (0.14) | (3.99) | (2.62) | (2.89) |
| $q \times \sigma$ | 0.021 | -0.015 | -0.014 | -0.013*** |
| | (0.36) | (-0.31) | (-0.27) | (-3.00) |
| $CF/K$ | 0.535*** | 1.288*** | 0.065 | -0.052 |
| | (2.98) | (7.64) | (1.36) | (-1.37) |
| $R^2$ | 0.351 | 0.741 | 0.413 | 0.308 |
| $F$ statistic | 2.48 | 8.55 | 5.98 | 5.03 |
| No. obs | 1,054 | 1,164 | 943 | 1,005 |
| No. firms | 282 | 275 | 307 | 317 |

Notes: Numbers in parentheses are t-values.
*, **, *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

<Table 5> Estimation Results:

High debt to asset ratio sample vs. Low debt to asset ratio sample

| | 1991~1997 | | 1999~2003 | |
|---|---|---|---|---|
| | High | Low | High | Low |
| < Model I > | | | | |
| Constant | -0.638*** | -0.199 | 0.115 | -0.150*** |
| | (-3.22) | (-1.05) | (1.43) | (-2.94) |
| $q$ | 0.589*** | 0.162* | 0.095 | 0.257*** |
| | (4.99) | (1.84) | (1.17) | (4.67) |
| $\sigma$ | -0.033 | 0.03 | -0.026** | 0.016 |
| | (-0.73) | (0.66) | (-2.20) | (0.84) |
| $CF / K$ | 1.348*** | 0.305*** | -0.031 | 0.018 |
| | (9.81) | (3.14) | (-1.05) | (0.61) |
| $R^2$ | 0.778 | 0.447 | 0.505 | 0.297 |
| $F$ statistic | 12.63 | 2.29 | 4.13 | 8.16 |
| No. obs | 1073 | 1145 | 977 | 971 |
| No. firms | 234 | 255 | 281 | 279 |
| <Model II > | | | | |
| Constant | -0.636*** | -0.147 | -0.052* | -0.122*** |
| | (-4.10) | (-1.33) | (-0.57) | (-3.35) |
| $q$ | 0.660*** | 0.081 | 0.268** | 0.193** |
| | (5.03) | (0.77) | (2.34) | (2.11) |
| $q \times \sigma$ | -0.061 | 0.041 | -0.021*** | 0.035 |
| | (-1.46) | (1.03) | (-3.06) | (0.82) |
| $CF / K$ | 1.351*** | 0.304*** | -0.031 | 0.02 |
| | (9.86) | (3.17) | (-1.08) | (0.64) |
| $R^2$ | 0.779 | 0.448 | 0.513 | 0.297 |
| $F$ statistic | 12.93 | 2.26 | 5.32 | 8.20 |
| No. obs | 1,073 | 1,145 | 977 | 971 |
| No. firms | 234 | 255 | 281 | 279 |

Notes: High (Low) denotes high debt to asset ratio firms

Numbers in parentheses are t-values.

*, **, *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

<Table 6> Estimation Results:
Large firms vs. Small firms

| | 1991~1997 | | 1999~2003 | |
|---|---|---|---|---|
| | Large | Small | Large | Small |
| < Model I > | | | | |
| Constant | -0.151 | -1.106*** | -0.153*** | 0.098 |
| | (-1.01) | (-3.34) | (-2.75) | (1.39) |
| $q$ | 0.341** | 0.460** | 0.274*** | 0.137* |
| | (2.55) | (2.10) | (4.01) | (1.90) |
| $\sigma$ | -0.022 | 0.111 | -0.016 | -0.017 |
| | (-0.56) | (1.43) | (-1.25) | (-1.40) |
| $CF/K$ | 0.430*** | 1.458*** | 0.063** | -0.049 |
| | (2.65) | (12.1) | (1.91) | (-1.46) |
| $R^2$ | 0.242 | 0.858 | 0.257 | 0.231 |
| $F$ statistic | 3.95 | 26.19 | 9.17 | 4.23 |
| No. obs | 1691 | 523 | 1231 | 714 |
| No. firms | 291 | 118 | 288 | 175 |
| < Model II > | | | | |
| Constant | -0.194* | -0.534** | -0.188*** | 0.006 |
| | (-1.70) | (-2.43) | (-3.74) | (0.08) |
| $q$ | 0.378*** | 0.460* | 0.321*** | 0.233** |
| | (2.65) | (1.76) | (4.00) | (2.31) |
| $q \times \sigma$ | -0.017 | 0.001 | -0.02 | -0.015*** |
| | (-0.38) | (0.01) | (-1.35) | (-2.75) |
| $CF/K$ | 0.431*** | 1.448*** | 0.063* | -0.046 |
| | (2.67) | (11.53) | (1.91) | (-1.40) |
| $R^2$ | 0.242 | 0.857 | 0.258 | 0.236 |
| $F$ statistic | 3.81 | 25.28 | 9.05 | 4.98 |
| No. obs | 1,691 | 523 | 1,231 | 714 |
| No. firms | 291 | 118 | 288 | 175 |

Notes: Large (Small) denotes large firms with more than 300 employees.
Numbers in parentheses are t-values.
*, **, *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

<Table 7> Estimation Results: Dummy variables

| | Interest Coverage Ratio | | Debt to Asset Ratio | |
|---|---|---|---|---|
| | Model I | Model II | Model I | Model II |
| Constant | 0.058 | -0.03 | -0.062 | -0.076 |
| | (0.57) | (-0.46) | (-0.66) | (-1.26) |
| $q \times D_{11}$ | 0.088 | 0.15 | 0.631*** | 0.760*** |
| | (1.31) | (1.53) | (4.39) | (3.84) |
| $q \times D_{12}$ | 0.630*** | 0.719*** | 0.170*** | 0.184** |
| | (4.65) | (3.97) | (2.84) | (2.15) |
| $q \times D_{21}$ | 0.173*** | 0.206* | 0.094* | 0.168** |
| | (2.76) | (1.82) | (1.69) | (2.00) |
| $q \times D_{22}$ | 0.089*** | 0.142** | 0.149*** | 0.130* |
| | (2.04) | (2.42) | (3.69) | (1.68) |
| $(q\times)\sigma \times D_{11}$ | -0.045 | -0.031 | -0.057** | -0.065** |
| | (-1.44) | (-1.22) | (-2.09) | (-2.01) |
| $(q\times)\sigma \times D_{12}$ | -0.018 | -0.047 | -0.009 | -0.009 |
| | (-0.72) | (-1.38) | (-0.33) | (-0.33) |
| $(q\times)\sigma \times D_{21}$ | -0.023 | -0.019 | -0.046*** | -0.018*** |
| | (-0.67) | (-0.41) | (-3.84) | (-2.60) |
| $(q\times)\sigma \times D_{22}$ | -0.031*** | -0.014*** | 0.009 | 0.009 |
| | (-3.27) | (-2.80) | (0.42) | (0.27) |
| $CF / K \times D_{11}$ | 0.395*** | 0.393*** | 1.232*** | 1.225*** |
| | (2.96) | (2.95) | (6.35) | (6.38) |
| $CF / K \times D_{12}$ | 1.222*** | 1.213*** | 0.224*** | 0.223*** |
| | (5.57) | (5.57) | (2.76) | (2.75) |
| $CF / K \times D_{21}$ | 0.149*** | 0.145*** | 0.009 | 0.012 |
| | (3.18) | (3.14) | (0.35) | (0.46) |
| $CF / K \times D_{22}$ | -0.009 | -0.001 | 0.066*** | 0.064*** |
| | (-0.86) | (-0.73) | (3.06) | (2.94) |
| $R^2$ | 0.425 | 0.426 | 0.428 | 0.428 |
| $F$ statistic | 12.00 | 12.09 | 11.48 | 11.72 |
| No. obs | 4,539 | 4,539 | 4,539 | 4,539 |
| No. firms | 416 | 416 | 416 | 416 |

Notes: Numbers in parentheses are t-values.

*, **, *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.