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Investment, Cash Flow, and Uncertainty: Evidence for the Netherlands

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Preliminary version, comments welcome

Abstract

We contribute to the debate on the interpretation of investment-cash flow sensitivities by including uncertainty measures in both a simple theoretical investment model and an empirical illustration for Dutch firm-level data. Using a slightly modified version of the Kaplan-Zingales (1997) model we show that it is likely that firms facing high uncertainty rely more on cash flow. Next we illustrate this result using an investment panel data model of Dutch listed firms. Using a threshold estimator we determine the critical level of stock price, sales, and employment uncertainty. Next we apply a GMM-estimator to correct for the endogeneity of the regressors. The empirical results confirm the notion that higher uncertainty intensifies the use of cash flow.

1. Introduction

The recent literature on investment modeling emphasizes the role of both (real and financial) imperfections and uncertainty in investment decisions. There is attention for adjustment costs and (ir)reversibilities, imperfect competition on product markets, a lack of information on financial markets, all possibly combined with the presence of uncertainty of the selling price, sales itself, stock prices, etc. Both the theoretical literature and the empirical equivalent argue that at least some of the relations seem to be nonlinear. One can think of the lumpy adjustment cost functions (see Hamermesh and Pfann, 1996), the impact of uncertainty on irreversible investment (Sarkar, 2000), the differential impact of financial constraints on investment (Whited, 1992), etc. The complexity of the nonlinearities, however, prevents widespread empirical research. Here one can think of the rather problematic empirical implementation of the nowadays popular real options model (see Dixit and Pindyck, 1994).

Our paper investigates a very simple investment model, inspired by the financial market imperfection literature. We analyze the historical investment-cash flow model, wherein the major notion is the upward sloping supply curve of financial means with internal resources as the cheapest funds (see Duesenberry, 1958). This model is popularized by Fazzari, Hubbard, and Petersen (1988) using micro-economic data. Since 1988 many empirical studies analyzed the cash-flow sensitivity of investment (see Lensink et al, 2001 for a review) and many others have criticized both the theoretical notions as well as the empirical findings (see Kaplan and Zingales, 1997). In this paper we certainly do not pretend to solve all the problems related to investment-cash flow models. In fact one might argue that we add even a few more. Our main contribution to the literature is the inclusion of uncertainty in investment-cash flow models and a preliminary analysis of the impact uncertainty is believed to have. Including uncertainty in investment-cash flow models is very much inspired by the real options literature. Our approach however is far more eclectic and loose than the rather prescriptive option valuation models. We start from a few very simple descriptive observations, where we show that firms that face higher uncertainty (no matter what the source of the uncertainty might be) experience higher cash-flow uncertainty elasticity's (see Figure 1 as a first clue). Our main concern

therefore is whether we come up with a consistent theoretical explanation of this finding. And if so, whether we can go a little further than pure descriptive statistics in analyzing this rather unexplored phenomenon.

Why would firms that face large uncertainty be more cash-flow dependent? In line with FHP it is easy to point at financial distress. Firms that face a large demand uncertainty could be confronted with a large external financing premium, such that they are constrained in obtaining external funds and are forced to rely on internal wealth. This might as well be untrue however, because unconstrained firms might use their cash flow rightaway for seemingly profitable investment projects knowing that they are able to attract external funds at any time (this is an argument in line with Cleary, 1999). Almeida and Campello (2001) argue that if current investment is seen as collateral for future borrowing and shocks to internal wealth affect current investment, firms that are less constrained will borrow more. So less constrained firms are more sensitive to cash flow through the amplification affect of collateral. It might also be true that management demonstrates risk averse decisions in using internally generated funds instead of asking the bank for a new loan, without being a firm that would be financially constrained. Hines and Thaler (1995) suggest that non-optimizing behavior by managers might also lead to a higher degree of cash flow sensitivity of investment. If management behaves relatively less-optimizing for high uncertainties, it might use more cash flow for financing investment. So there are multiple explanations of the same empirical phenomenon we are presenting.

How do we proceed? First we start with a simple theoretical model of the investment-cash flow relation. Our model is a simple extension of the Kaplan-Zingales (1997) model. We add two types of uncertainty to the KZ-model: uncertainty with respect to Return on Investment (ROI) and the wedge between the costs of external and internal funds. We analyze this model under risk aversion of managers (with risk neutrality as a simple benchmark case). In fact we analyze whether we can find clues for the two main arguments in this discussion: the financial imperfections (or FHP-) hypothesis, or the risk attitude of managers. We show that the KZ-model that allows for uncertainty indeed hints

at a higher cash-flow sensitivity for firms that have a more risk averse management, or a firm that faces higher uncertainty. These results don't provide any serious tools in identifying empirical relations, but do suggest that looking for the role of uncertainty in models like this is justified.

Next we proceed to analyze the impact of uncertainty empirically. We use data on 96 Dutch listed firms during the sample 1985-1997. We propose to estimate a simple threshold model, where the threshold variable is implemented by uncertainty measures. Following Hansen (1999) we indeed find that high uncertainty leads to larger cash-flow elasticities. The major advantage of the Hansen-approach is that the estimates of the thresholds are conditional on the model specification as a whole. The major disadvantage is that the Hansen-procedure in fact resembles a simple Least Squares strategy, not allowing for endogeneity of the regressors. Since this seems a too restrictive assumption we analyze the results further using a Generalized Methods of Moments (GMM) estimator. The results obtained here again confirm the existence of different regimes of uncertainty affecting the cash-flow sensitivity of investment. We summarize and conclude at the end.

2. A Simpel Investment Model for a Risk-Averse and a Risk-Neutral Manager[1]

What type of models are known to analyze the impact of financial variables on investment decisions? As Chirinko (1993) argues one might use q-models or estimate the Euler-conditions directly. Fazzari et al. (1988) estimate a q-model and add cash-flow, while Whited (1992) estimates an Euler-condition and adds debt constraints. In this paper we analyze the former class taking the very simple one-period Kaplan-Zingales (1997) model. The Kaplan-Zingales model assumes a deterministic setting (so the risk attitude of the decision-maker is unimportant). They show that the FHP-conclusions on the interpretation of cash-flow sensitivities can't be based on this simple one-period model. The monotonicty of the marginal investment-internal wealth relation, implicitly assumed to be negative by FHP, can't be assumed in general terms. We depart from the Kaplan-Zingales model by assuming a stochastic world and risk aversion of the decision-maker.

There are many reasons to believe that a manager will behave risk averse, but probably the fear of losing the job is the most prominent one.

We have a manager that derives utility of making profits (Π) according to the exponential utility function $U(\Pi) = e^{\alpha \Pi}$. The coefficient of absolute risk aversion (CARA) is $R_A = -\alpha$ (and $\alpha > 0$, risk neutrality corresponds to $\alpha = 0$). The manager will maximize the certainty equivalent of expected utility:

$$E\left[\Pi - \frac{\alpha}{2}\sigma_\Pi^2\right]$$

where σ_Π^2 is the variance of profits. We model profits by

$$\Pi = F(\lambda I) - C(I - W, \mu k) - I$$

The profit function is similar to the one used by Kaplan-Zingales (1997). The difference is that we have added a stochastic term λ in the production function F and a stochastic term μ in the cost function C. λ represents the uncertainty in real returns on investment; μ represents the stochastic nature of the costs of attracting external funds. We assume:

A. 1: $E[\lambda] = E[\mu] = 1$ and $\sigma = E[\lambda^2]$ and $\rho = E[\mu^2]$

Note that we use the property that the variance of λ is equal to the variance of the simple deterministic transformation $\lambda + 1$. I is investment. In line with the original Kaplan-Zingales model, it is assumed that:

A. 2: $F_1 > 0$, $F_{11} < 0$

Investment can be financed with internal funds W or external funds E. This implies that $I = W + E$. The opportunity cost of internal funds is the cost of capital R, which is assume

to be equal to 1. The additional costs of external funds is given by a function $C(E, \mu k)$, where k is a measure of a firm's wedge between the internal and external cost of funds. Because of information or agency problems the use of external funds generates a deadweight cost, which is borne by the issuing firm. The total cost of raising external funds increases with the amount of funds raised and in the extent of agency or information problem. We assume:

A. 3: $C_1 > 0$; $C_2 > 0$; $C_{11} > 0$ and $C_{22} > 0$.

For ease of computation, we assume that we can write:

A. 4: $F(\lambda I) = \lambda F(I)$ and $C(I - W, \mu k) = \mu C(I - W, k)$.

Assumption **A. 4** implies that we can disembed uncertainty. In case both uncertainty terms are uncorrelated ($E[\lambda \mu] = 0$) we can derive the variance of profits:

$$\sigma_\Pi^2 = E[\lambda^2] F(I)^2 + E[\mu^2] C(I - W, k)^2 = \sigma F(I)^2 + \rho C(I - W, k)^2$$

For reasons of convenience, we define $A = \dfrac{1 - \alpha \sigma}{1 + \alpha \rho}$. We make the following assumption:

A. 5 $A > \dfrac{C_{11}}{F_{11}}$

Proposition 1: *Under A.1 –A. 5 investments are positively related to an increase in internal wealth. This holds for a risk-averse manager and a risk neutral manager.*

Proof:

The first-order condition for optimal investment reads:

$$E\left[(\lambda - \alpha\sigma)F_1(I)\right] = 1 + E(\mu + \alpha\rho)\left[C_1(I - W, k)\right]$$

Total differentiation of this condition, ignoring *dk*, gives:

$$E\left[(\lambda - \alpha\sigma)F_{11}dI\right] = E(\mu + \alpha\rho)C_{11}\left[dI - dW\right]$$

The sensitivity of investment to internal wealth, for given k (note that

$E[\lambda] = E[\mu] = 1$) is

$$\frac{dI}{dW} = \frac{(1 + \alpha\rho)C_{11}}{(1 + \alpha\rho)C_{11} - (1 - \alpha\sigma)F_{11}}$$

We can rewrite this into:

$$\frac{dI}{dW} = \frac{C_{11}}{\left(C_{11} - AF_{11}\right)}$$

In the case of perfect capital markets $dI/dW = 0$, because $C(.) = 0$. But, with imperfect capital markets, and using **A.5**, $dI/dW > 0$. Note that this holds for a risk-averse and a risk neutral manager ($\alpha > 0$ and $\alpha = 0$, respectively).

   QED

The result of proposition 1 shows that for either low risk aversion (small α) or relatively small uncertainty with respect to the real returns on investment (small σ) we find the familiar positive relation between investment and internal wealth. For rather large risk aversion and/or relatively large real returns uncertainty this relation might become negative. Although interesting the *dI/dW*-relation is not of real importance in itself. We are interested in the sensitivity of this relation with respect to changes in uncertainty and in the monotonicity over changes in internal wealth.

Proposition 2: *Under A. 1 –A. 4 an increase in uncertainty leads to a higher sensitivity of investment to internal wealth for a risk-averse manager. For a risk-neutral manager, an increase in uncertainty does not affect the sensitivity of investment to internal wealth.*

<u>Proof</u>

The effect of an increase in return on investment uncertainty and external cost uncertainty are, respectively, given by

$$\frac{d^2I}{dWd\sigma} = \frac{-\alpha(1 + \alpha\rho)C_{11}F_{11}}{\left((1 + \alpha\rho)C_{11} - (1 - \alpha\sigma)F_{11}\right)^2} > 0$$

$$\frac{d^2 I}{dW d\rho} = \frac{-\alpha C_{11} F_{11}}{\left((1+\alpha\rho)(C_{11} - (1-\alpha\sigma)F_{11})\right)^2} > 0$$

It is immediate clear that for the risk-neutral manager ($\alpha = 0$) both derivatives are 0.

QED

The result of proposition 2 is rather crucial to explain our empirical findings in Figure 1. Indeed, risk averse managers tend to rely more on internal wealth, no matter what the initial relation between investment and internal wealth was, if uncertainty (either return on investment or cost uncertainty) increases. Proposition 2 also shows that uncertainty with respect to external financing costs will increase the marginal impact of return uncertainty. If firms have a rather high external cost uncertainty it is likely that also the mean costs of external finance will be high. This indeed leads to the FHP-hypothesis: firms that are likely to be affected by new finance restrictions will rely more on internal finance.

Kaplan and Zingales remark that the usual practice of comparing the investment-cash flow sensitivities across groups of firms corresponds to looking at differences in *dI/dW* as a function of internal wealth *W*. This approach is only useful if the sensitivity of investment to cash flow (*dI/dW*) decreases when a firm's availability of internal wealth increases. In other words $d^2 I/dW^2$ should be negative. Kaplan and Zingales, using their deterministic one period model, argue that for a quadratic cost function and a production function with a positive third derivative this is not the case. Hence, when financial constraints become more severe, the sensitivity to cash flow does not necessarily increase. In this way, they severely criticize the FHP-methodology of comparing various subgroups of firms and the differential role cash flow plays. The question now is whether the Kaplan-Zingales critique also holds for a risk-averse manager in a stochastic setting. In stead of **A. 5** we now assume:

A. 6: $\dfrac{C_{11}}{F_{11}} < A < 0$

In addition, we assume:

A. 7: $F_{111} \geq 0$ and $C_{111} \geq 0$

Proposition 3: *Under A.1- A. 4, A. 6 and A. 7* $\dfrac{d^2 I}{dW^2} < 0$.

<u>Proof</u>

In order to calculate $d^2 I/dW^2$, we make use of the result that if H(W,I)=0 and I=f(W) is a

solution, $f_{11}(W)$ is given by: $f_{11} = -\dfrac{H_{11}(H_2)^2 - 2H_{12}H_1 H_2 + H_{22}(H_{})^2}{(H_2)^3}$

H(W,I)=0 corresponds to $E[(\lambda - \alpha\sigma)F_1(I)] - E(\mu + \alpha\rho)[C_1(I - W, k)] - 1 = 0$, so

$H_1 = E(\mu + \alpha\rho)C_{11}$; $H_2 = E(\lambda - \alpha\sigma)F_{11} - E(\mu + \alpha\rho)C_{11}$; $H_{11} = -E(\mu + \alpha\rho)C_{111}$;

$H_{12} = E(\mu + \alpha\rho)C_{111}$ and $H_{22} = E(\lambda - \alpha\sigma)F_{111} - E(\mu + \alpha\rho)C_{111}$

It can now be calculated that:

$$\frac{d^2 I}{dW^2} = \left(\frac{F_{111}}{F_{11}^2} - A\frac{C_{111}}{C_{11}^2} \right) \frac{AC_{11}^2 F_{11}^2}{(C_{11} - AF_{11})^3}$$

So it is clear that for a negative *A* (that is $\alpha\sigma > 1$) the first term between brackets can turn positive. In that case the numerator of the second term is negative. The denominator will be negative for not too negative values of A, which gives the upper bound.   *QED*

Note that under risk neutrality, *A=1* and we get the original Kaplan-Zingales case. Note also that, in line with Kaplan and Zingales, we need to make assumptions regarding the production function and the cost function in order to justify the FHP analysis. Kaplan and Zingales show that for $F_{111} > 0$ and $C_{111} = 0$, the monotonicity does not hold anymore. In our case, using **A. 6.** the FHP analysis still holds even if $F_{111} > 0$ and $C_{111} = 0$.

So proposition 3 tells us that in case of large uncertainty and especially relatively large cost uncertainty combined with return on investment uncertainty we get the monotonicity

of the $\dfrac{d^2 I}{dW^2}$. We can show this effect in another way as well. How does the $\dfrac{d^2 I}{dW^2}$ change

if return on investment uncertainty σ or cost of external funds uncertainty ρ increase? Is

it likely that $\dfrac{d^2 I}{dW^2}$ will become more negative for increases in uncertainty?

Proposition 4: *Under A.1- A. 4, A. 6 and A. 7* $\dfrac{d^3 I}{dW^2 / d\sigma} < 0$, *but* $\dfrac{d^3 I}{dW^2 / d\rho} > 0$.

Proof:

$$\frac{d^2 I}{dW^2} = \frac{A C_{11}^2 F_{111}}{(C_{11} - A F_{11})^3} - \frac{A^2 F_{11}^2 C_{111}}{(C_{11} - A F_{11})^3}$$

Take the derivatives of the first and second term with respect to A:

$$\frac{d^3 I}{dW^2 dA} = \frac{\{C_{11} F_{111}(C_{11} - A F_{11}) + 3A C_{11}^2 F_{111} F_{11}\}}{(C_{11} - A F_{11})^4} - \frac{\{2A F_{11}^2 C_{111}(C_{11} - A F_{11}) + 3A^2 F_{11}^3 C_{111}\}}{(C_{11} - A F_{11})^4}$$

$$= \frac{\{C_{11}^2 F_{111}(1 + 2A F_{11}) - A F_{11}^2 C_{111}(2C_{11} + A F_{11})\}}{(C_{11} - A F_{11})^4}$$

If A<0 all the terms in the numerator will be positive. It is easy to see that

$$\frac{\partial A}{\partial \sigma} = \frac{-\alpha}{(1 + \alpha \rho)} < 0$$

$$\frac{\partial A}{\partial \rho} = \frac{-\alpha(1 - \alpha \sigma)}{(1 + \alpha \rho)^2} > 0$$

QED

So an increase in σ is likely to favor the monotonicity, but an increase in ρ will do the reverse.

Concluding, in this section we obtained the following results. First, for a risk-averse manager, an increase in (both return on investment and cost) uncertainty leads to an increase in the internal funds sensitivity of investment. Second, a stochastic version of the Kaplan-Zingales model does not give general insights regarding the monotonicity of the derivative *dI/dW*. But we are able to characterize cases, where the monotonicity is likely to exist: the cases of large risk aversion combined with relatively large cost uncertainty.

In the remainder of the paper we will empirically test whether firms that face higher degrees of uncertainty indeed display higher internal funds sensitivities. The second conclusion reminds us on the fact that by comparing internal funds sensitivities of different groups of firms may not automatically be explained in terms of external financial constraints. Before explaining the estimation technique, the next section describes the data we have used.

3.   **Data**

During the period 1990 up to and including 1997 about 150 firms were listed on the Amsterdam Stock Exchange. From these firms we take the non-financial firms and remove some firms that have exceptional accounting systems (like Royal Dutch Shell, which publishes its accounts both in the United Kingdom and the Netherlands). This gives a raw set of 112 firms for the period 1985-2000. The coverage of the data for the starting years of the sample and the most recent years is not complete. Moreover, we use a moving average for some variables. Finally we need a balanced set of data in one of our regression models. This confines the final data to 96 firms over 1990-1997. This set is representative for the Dutch non-financial manufacturing sector. It is good to note that Dutch listed firms are known for their international orientation (the major reason being the Dutch economy a very open relatively small economy).

The data are taken from the source REACH, which is operated by the Belgian company Bureau Van Dijk. Bureau van Dijk publishes a European equivalent AMADEUS, which holds information on both listed and non-listed firms. REACH is the Dutch subset of AMADEUS and includes more than 10 thousand Dutch firms. Our main argument to take the listed firms is twofold. First, the way of accounting financial results is comparable among listed firms, but typically different for non-listed firms. Secondly, we are interested in the impact of stock price volatility on firm investment.

From the balance sheet and profit and loss account we construct the following variables:

CF	cash flow (equals net profits plus depreciation);
D	depreciation;
EQ	equity;
FE	financial expense (interest rate payments);
I	capital expenditure (as denoted by the firm) in material fixed assets;
K	material fixed assets;
L	liquid assets;
LD	long-term debt;
MV	market value of equity at the end of the year (= stock price * number of shares outstanding);
S	sales;
SD	short-term debt;
TA	total assets.
WC	working capital: short-term assets minus short-term liabilities.

Moreover we include information on:

DIV	dividend per share;
EMP	the number of people employed;
HIGH	the highest stock price during the year;
LOW	the lowest stock price during the year.

Using these raw data series we transform the series into the usual variables I/K, CF/K, etc. Moreover we use the following definitions:

$DAR = 100*(SD+LD)/TA$	debt-to-assets ratio;
$Delta = 100*D/K$	depreciation rate
$FREECF = CF-I$	free cash flow;
$INTEREST = 100*FE/(SD+LD)$	implicit interest rate paid;
$GSAL$	annual growth rate of sales;
$MB = MV/EQ$	market-to-book ratio;
$ROA = 100*(CF-D)/TA$	return on assets;
$ROE = 100*(CF-D)E$	return on equity;
$UCC = INTEREST+Delta$	user cost of capital (raw approximation);

$EQVOL = 100*(HIGH-LOW)/LOW$ stock price volatility;

$SALVOL$ volatility of sales, measured by a 7-year window coefficient of variation of sales;

$EMPVOL$ volatility of employees (see measurement $SALVOL$)

<insert Table 1 about here>

Table 1 gives some descriptive statistics of the variables used. The figures represent averages (medians) of firm' averages (medians) over the years. So we first average over the years per firm and take averages of the average firm observations (and medians of medians to be precise). Table 1 shows that the data are not seriously skewed, since the mean and median values coincide to some extent. The first panel gives the major investment data. The average ratio of capital expenditure to the stock of material fixed assets is a little over 20 per cent. Cash flow as a percentage of the fixed capital stock is almost 40 per cent. This implies that the free cash flow (cash flow minus capital expenditure) is about 18 per cent on average. Most of the firms hold a relative large

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proportion of equity to fixed assets. On average the amount of working capital is also relatively large. During the 1990-1997 period most firms had a rather high market-to-book ratio. Leverage decreased in the Netherlands since 1985. Most listed firms tried to restore their solvability and succeeded in doing so. The average paid interest rate on short- and long-term debt is a little under 4 per cent. The raw measure of the user cost of capital (equal to the interest rate plus the rate of depreciation is about 20 per cent.

Stock price volatility is relatively large. Here we note that our measure of volatility (high minus low) is rather sensitive to shocks in equity prices. Introspection of the data however reveals that the high-lows are the result of a rather large volatility during the whole sample period. For the other measures of volatility, from which we will not use the dividend volatility, the coefficients of variation have rather modest means (median values) of about 20 per cent.

For our purpose it is good to describe the uncertainty measures more precisely. Table 2 gives the correlation matrix. This matrix shows that the stock price volatility is rather uncorrelated with the other measures. Sales and employee volatility correlate rather strongly.

<insert Table 2 about here>

A natural way to describe the data is the use of scatterplots of investment, cash flow and uncertainty and search for some non-linearity. Here we proceed as follows. First we estimate our base reference model. We regress *I/K* on Market-to-Book (*MB*), the change in working capital (*d(WC)/K(-1)*), lagged sales (*S(-1)/K(-1)*), the lagged investment ratio (*I(-1)/K(-2)*) and an intercept. We use the residuals from this equation as the "conditioned" investment data. Next we scatter these residuals with cash flow (*CF/K(-1)*) for low and high volatility separately. This gives us the first impression of the properties of the data.

<insert figure 1 about here>

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Figure 1 gives the results for the stock price volatility. The left panel shows the observations with stock price volatility below the median value, the right-hand panel the observations with stock price volatility above the median value. On the vertical axis we plot the residuals of the simple OLS equation and on the horizontal axis the variable *CF/K(-1).* The line represents a local linear Kernel fit. We did not trim the observations for outliers and note that the scale is different on both axes. Figures 2 and 3 give similar plots for low- and high sales and employment volatility. All the figures give the similar impression: the investment-cash flow sensitivity is higher for higher volatilities. Stock price plots are the least convincing in this respect due to the special shape of the low-volatility line.

<insert figures 2 and 3 about here>

The descriptive statistics point at differences with respect to investment-cash-flow sensitivities between regimes of low and high volatility. What could be an explanation? If we follow Kaplan and Zingales (1997, 1999) and assume that managerial risk aversion would be the main cause of a large cash-flow dependence of internal wealth one would indeed expect to see high-cash flow sensitivities in volatile situations. But the same holds for the Fazzari-Hubbard-Petersen (1988) hypothesis of external financing trouble. It is likely that in periods of high uncertainty it will be harder to attract external funds, therefore firms would be forced to use relatively more internal funds.

4. Threshold estimates

The descriptive data section shows that investment, cash flow and uncertainty are interrelated. In this section we explore this relation a bit further. The main argument made relates to the endogeneity of the cut-off rate of uncertainty. In the descriptive section we took the median values of the volatility variables. Here we integrate the cut-off level into the model. In order to analyze this problem we propose to estimate a threshold regression models for $i = 1, \ldots, n$ firms and $t = 1, \ldots, T$ observations of the following form:

$$\left(\frac{NI}{K}\right)_{it} = \alpha' z_{i,t-j} + \beta_1' CF_{it} I(V_{it} \leq \theta) + \beta_2' CF_{it} I(V_{it} > \theta) + \varepsilon_{it} \qquad\qquad j = 0,1 \qquad\qquad (3)$$

where NI represents net capital expenditure, K the beginning-of-period capital stock, z is the vector of regime-independent (or control) variables, such as cash flow; CF is the regime dependent variable (cash flow as a percentage of the beginning-of-period capital stock); α, β_1, and β_2 are (vectors of) parameters; and the error term ε_{it} is iid with mean zero and finite variance.[6] The threshold variable V is the uncertainty variable and θ is the threshold value to be estimated, which does not depend on the firm or the year indicator. I is the indicator function, which has the value one if the argument is true and zero otherwise. The threshold variable defines two regimes: a low uncertainty regime with $V_{it} \leq \theta$ and a high uncertainty regime with $V_{it} > \theta$. Based on the predictions of the standard cash flow model, we expect that when uncertainty is below the threshold, the cash-flow elasticity of capital expenditure is low and hence the firm is probably investing less than proportionally. But if uncertainty exceeds the threshold, the cash-flow sensitivity of investment increases. This suggests that the estimated coefficients for β_1 and β_2 are expected to differ. In other words, cash flow may have different effects on firm investment depending on the magnitude of the volatility effect.

The empirical model is estimated by conditional least squares. To that purpose the observations are sorted on the threshold variable and the sums of squared residuals are computed for all values of the threshold variable. The optimal value of the threshold variable is the value that minimizes the sum of squared residuals. The optimal parameter estimates are the estimated α's and β's that belong to this optimal threshold value. An important question is whether the threshold regression model of equation (3) is statistically significant to its linear counterpart, which has the null hypothesis H_0: $\beta_1 = \beta_2$. In this situation the threshold parameter is not defined under the null hypothesis. This makes the testing problem complex. However, Hansen (1996) shows that asymptotically valid p-values can be constructed by bootstrapping.

Valid confidence intervals for the threshold parameter can be based on the likelihood ratio (or F) statistic $LR(\theta) = \left(S(\theta) - S(\hat{\theta})\right)\big/\hat{\sigma}^2$, which tests the null hypothesis H_0: $\theta = \hat{\theta}$. Here $S(\theta)$ is the sum of squared errors of the estimated threshold regression when the threshold parameter equals θ, $S(\hat{\theta})$ is the sum of squared residuals belonging to the optimal threshold parameter $\hat{\theta}$ and $\hat{\sigma}^2$ is the residual variance belonging to the optimal threshold parameter $\hat{\theta}$. The likelihood ratio statistic is equal to zero at $\theta = \hat{\theta}$. Confidence intervals for the threshold parameter can be constructed by inverting the distribution function of the likelihood ratio statistic. A graphical method to find the confidence interval of the threshold parameter is to plot the likelihood ratio statistic $LR(\theta)$ against all values of θ and to check for which values of θ crosses the horizon line that shows the confidence level of the test. Confidence intervals of the other parameters in the threshold regression, the α's and β's can be approximated by the conventional normal approximation as if the threshold estimate $\hat{\theta}$ were the true value.

A few empirical choices have to be made. First, we need to decide on the choice of the control variables. Here we follow closely Houston and James (2001) by taking:

1. *MB*: the market-to-book value of equity. This variable is theoretically less appealing than Tobin's Q, but can be measured quite precisely on the contrary. There is whatsoever no information on the market value of debt, which troubles any specification of Q;

2. *S(-1)/K(-1)*: lagged sales over capital. This variable might signal any *mismeasurement as regarding future profitability (see Houston and James, 2001);*

3. *d(WC)/K(-1):* cash flow might have a simple other destiny: the change of working capital. This variable competes with capital expenditure;

4. *LIQ/K(-1):* the stock of liquid assets gives an indication of the availability of short-term funds.

The second empirical choice relates to the choice of the uncertainty measures. We use three: stock price volatility (*EQVOL*), sales volatility (*SALVOL*) and employment

volatility *(EMPVOL)*. The first two measures are widely used in empirical studies on the investment-uncertainty relation. The employment volatility measure is less used. This variable might represent the uncertainty the firm faces with respect to attracting or firing possibilities of workers.

We are not so much interested in the fit of the linear model, so we don't report the results of the linear model in detail. It is good to note that the Hansen estimation method is fixed effects method. We include moreover time dummies (but don't report the estimation results). Table 4 presents the results. Table 4 illustrates the effect we observed in the descriptive statistics: the cash-flow parameter for high volatility observations is about three times bigger than the corresponding parameter for low volatility. This conclusion holds for the three measures of volatility. The table also gives an indication of the likelihood of a second threshold. For all models the improvement of the fit with a double threshold is not convincing.

<insert Table 4 about here>

5. GMM Estimates

It is well-known that estimates of investment equations may suffer from endogeneity problems. Moreover, there may exist measurement errors of the explanatory variables that have to be taken into account. The use of an instrumental variable estimation technique may come around these problems. However, the ordinary least squares technique is used for the threshold estimates, and so may be subject to the abovementioned problems. Therefore, this section presents investment estimates using an instrumental variable approach (the system GMM estimator). In these estimates, we use information about the threshold values for the uncertainty measures as determined in the previous section. Ideally, the threshold should also be determined using the GMM routine. However, as yet there is no software available which can do that. So, we leave this to further research.

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We estimate different investment models with the system generalized methods of moments (GMM) estimator, using a new version of DPD98 for Gauss (Arellano and Bond, 1998). The system GMM estimator combines the differenced equation with a levels equation to form a system GMM. Lagged levels are used as instruments for the contemporaneous differences and lagged differences as instruments for the contemporaneous levels. We adopt the system GMM estimation procedure since first difference GMM may suffer from weak instruments problems (Blundell and Bond (1998)). The coefficients we present, as well as the p-values, refer to two step GMM estimates, based on robust, finite sample corrected standard errors (Windmeijer, 2000). Note that the not corrected two-step standard errors are severely biased for small samples. Therefore, most researchers present coefficients and standard errors based on one-step estimates. Windmeijer (2000) shows how the two step standard estimates can be corrected, and that is the approach we have followed.[2] In all estimations we control for time effects by adding time dummies for 1990-1997. These time dummies are used as additional instruments.

The reliability of the system GMM estimation procedure depends very much on the validity of the instruments. We consider the validity of the instruments by presenting a Sargan test. The Sargan test is a test on overidentifying restrictions. It is asymptotically distributed as χ^2 and tests the null hypothesis of validity of the (overidentifying) instruments. P-values report the probability of incorrectly rejecting the null hypothesis, so that a P value above 0.05 implies that the probability of incorrectly rejecting the null is above 0.05. In this case, a higher P-value makes it more likely that the instruments are valid. We also test the reliability of the instruments of the level equation by presenting the Difference Sargan test.[3] The Difference Sargan test is also asymptotically distributed as χ^2 and tests the null hypothesis of validity of the (overidentifying) instruments in the level equation. So, the levels equations instruments are not rejected if the calculated value of the Difference Sargan test is lower than the theoretical value of a χ^2 variable with n degrees of freedom.

The consistency of the estimates also depends on the absence of serial correlation in the error terms. This will be the case if the differenced residuals display significant negative first order serial correlation and no second order serial correlation. We present tests for first-order and second-order serial correlation related to the estimated residuals in first differences. The tests are asymptotically distributed as standard normal variables. The null hypothesis here relates to "insignificance" so that a low P-value for the test on first-order serial correlation and a high P-value for the test on second-order serial correlation suggests that the disturbances are not serially correlated.

The equations we estimate have the same structure as presented in the previous section. The main difference is that here we do not endogenously determine the threshold, but use the threshold value to determine an indicator function with value 1 for the low volatility regime and 0 for the high volatility regime.[4] This indicator function is used to determine two cash flow variables, one for the high volatility regime and one for the low volatility regime. The estimates are presented in Table 5.

<insert Table 5 about here>

Although coefficient values differ for the threshold estimates and the GMM estimates, the main message remains: the cash flow coefficient is much higher for the high volatility regime than for the low volatility regime. This holds for all volatility measures used in the estimates. Note that the estimates without a lagged independent variable suffer from second-order serial correlation in the differenced residuals. Therefore, we have also presented estimates in which the lagged dependent variable is added as an additional regressor. For these estimates, there is no evidence for serial correlation. Moreover, the Sargan and the Difference Sargan test suggest that the instruments are valid. Most importantly, also for the estimates with the lagged dependent variable, the cash flow coefficient is much higher for the high volatility regimes.

6. **Conclusions**

Our basic conclusion is that uncertainty and managers' responses to it can shed some light on the troubled investment-cash-flow relations. We show that it is likely that risk-averse managers confronted by a large degree of uncertainty will rely relatively more on cash flow to finance investment. We illustrate this in a slightly adjusted version of the Kaplan-Zingales (1997) model and an empirical illustration using Dutch panel data. The role to cash flow in investment equations we propose is not the ultimate proof of the identification of financial imperfections though. Our adjustment of the Kaplan-Zingales illustrates that for risk averse decision making there are plausible cases of relative return on investment and external cost uncertainty that turn the Fazzari-Hubbard-Petersen hypothesis relevant. These cases are no general conclusions though. Moreover, our model also supports the idea that the risk attitude of the decision maker (and not financial imperfections) make cash flow a determinant of current investment.

Our empirical illustrations show that for 96 Dutch listed firms investment depends more on cash flow for high uncertainty cases. We estimate two model versions: a threshold least squares model to determine the threshold values for the uncertainty variables and next a more elaborated model that allows for endogenity of the regressors. Both illustrations support the theoretical notion presented in the first part of our paper.

There are still some open ends to our analysis. First, our theoretical model is a simple one-period model that does not include any strategic response to e.g. demand or price uncertainty. Secondly, our empirical work would be stronger if we were able to combine our threshold estimation with the GMM-routine. Ideally we would like to determine the threshold values conditional on the endogenity of the regressors. Thirdly, we illustrate the model for a small open economy. It would be valuable to analyze other datasets (previously used for the analysis of the FHP-hypothesis) to determine whether our propositions hold in general terms.

Table 1 – Desciptive statistics

|	Mean	St.dev.	Median
I/K(-1)	24.40	16.97	19.10
CF/K(-1)	42.18	16.38	33.55
EQ/K(-1)	138.44	34.91	110.75
WC/K(-1)	75.21	30.54	45.06
d(WC)/K(-1)	3.51	27.29	2.04
L/K(-1)	42.39	19.72	12.13
FREECF/K(-1)	17.78	21.09	11.17
S(-1)/K(-1)	665.98	148.85	427.61
MB	2.45	1.46	1.53
DAR	53.13	5.83	53.65
INTEREST	3.84	1.24	4.14
Delta	17.36	3.40	15.84
UCC	21.20	3.93	19.69
ROA	9.94	3.89	9.42
ROE	13.12	28.81	14.11
GSAL	6.16	14.42	7.48
EQVOL	60.20	33.85	43.92
SALVOL	21.56	8.09	19.21
EMPVOL	18.80	8.33	15.60

Note: see main text for an explanation of the symbols used.
Source: REACH (Bureau van Dijk, 2001).

Table 2 – Correlation matrix of the volatility variables.

	VOL	SALVOL	EMPVOL
VOL	1	0.164	0.111
SALVOL	0.164	1	0.639
EMPVOL	0.111	0.639	1
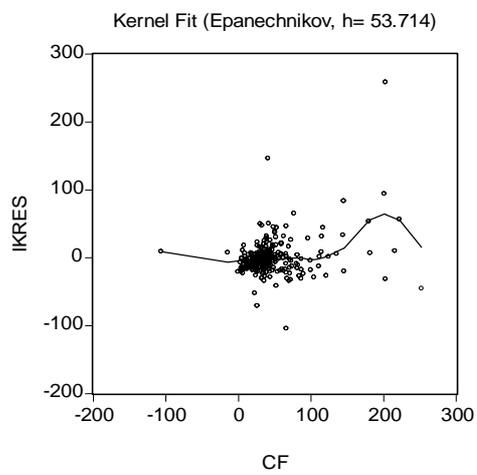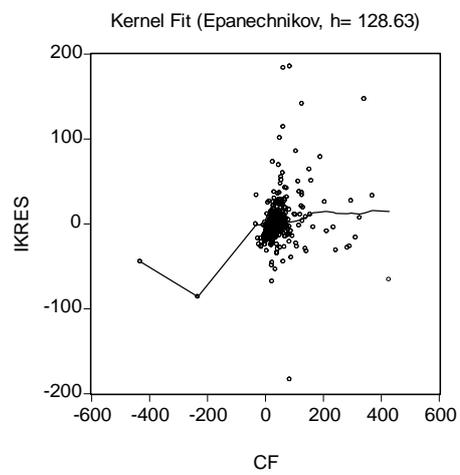
Figure 1 – Investment-Cash flow plots for low and high stock price volatility
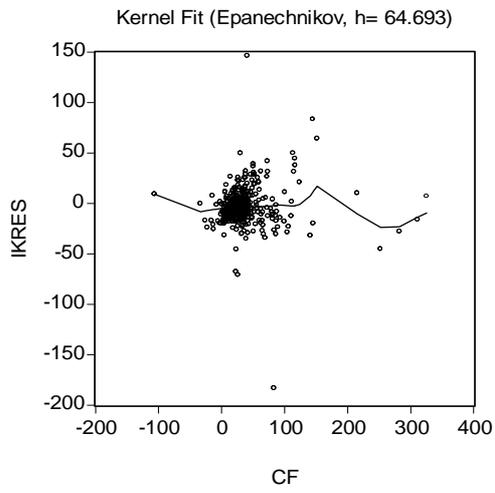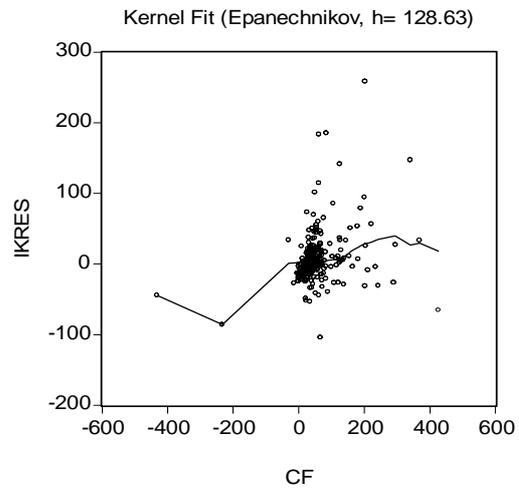
Figure 2 – Investment-Cash flow plots for low and high sales volatility

Kernel Fit (Epanechnikov, h= 64.693)

Kernel Fit (Epanechnikov, h= 128.63)
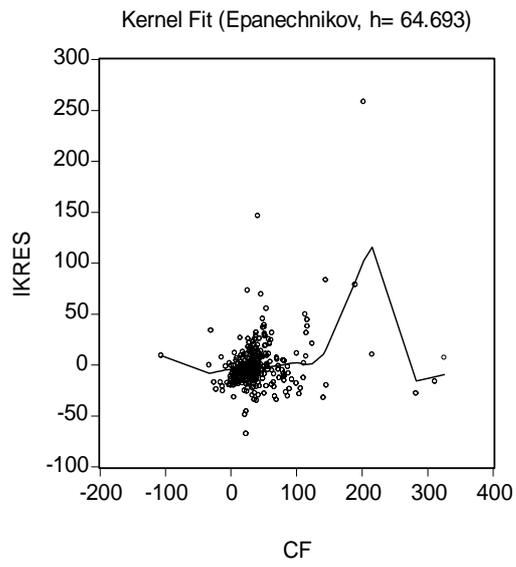
Low employment volatility
(EMPVOL<median)
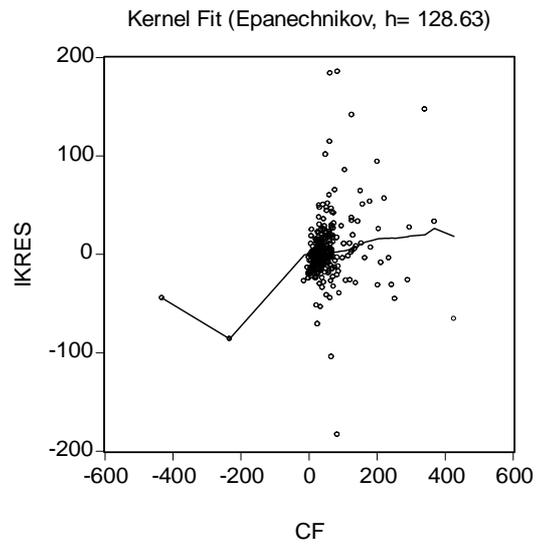
High employment volatility
(EMPVOL>median)

Figure 3 – Investment-Cash flow plots for low and high employment volatility

Table 4 - Threshold estimation results

Dependent variable I/K(-1)	EQVOL	SALVOL	EMPVOL
MB	0.144 (0.148)	-0.066 (0.122)	-0.062 (0.118)
D(WC)/K(-1)	-0.238 (0.063)	-0.230 (0.063)	-0.225 (0.064)
S(-1)/K(-1)	0.008 (0.004)	0.009 (0.005)	0.009 (0.004)
LIQ/K(-1)	0.071 (0.044)	0.092 (0.051)	0.078 (0.050)
Threshold	114.29 (105.20;124.53)	39.16 (38.03,40.22)	51.82 (25.60;61.74)
CF(1)	0.108 (0.042)	0.106 (0.041)	0.102 (0.044)
CF(2)	0.308 (0.050)	0.313 (0.057)	0.344 (0.054)
LR(1)	38.95	24.92	20.71
SSR(0) SSR(1) SSR(2)	251700.23 239551.24 231873.29	251700.23 240268.49 240268.49	251700.23 241091.65 239961.37
Second threshold	34.78 (31.09;36.39)	21.58 (13.63;27.77)	12.34 (9.67;46.59)
LR(2)	25.43	11.25	12.74

Standard-errors between parentheses. *CF(1)* gives the parameter estimate of the low-volatility regime, *CF(2)* gives the parameter estimate of the high-volatility regime, LR(1) denotes the likelihood-ratio test for the single threshold effect, LR(2) denotes the likelihood ratio of the double threshold effect, SSR(*i*) denotes the sum of squared residuals of the model with *i* thresholds. Time-dummies not reported. Confidence intervals based on 300 bootstrap-replications.

Table 5 - System GMM estimates

Dependent variable I/K(-1)	EQVOL	EQVOL	SALVOL	SALVOL	EMPVOL	EMPVOL
MB	0.311 (0.157) [0.047]	0.372 (0.156) [0.017]	0.041 (0.114) [0.719]	0.122 (0.146) [0.401]	-0.107 (0.154) [0.488]	0.024 (0.168) [0.885]
D(WC)/K(-1)	-0.111 (0.064) [0.085]	-0.118 (0.056) [0.034]	-0.146 (0.045) [0.001]	-0.141 (0.044) [0.001]	-0.202 (0.084) [0.016]	-0.177 (0.063) [0.005]
S(-1)/K(-1)	-0.002 (0.002) [0.236]	-0.002 (0.002) [0.291]	-0.001 (0.002) [0.410]	-0.001 (0.002) [0.587]	-0.001 (0.002) [0.684]	-0.001 (0.002) [0.574]
LIQ/K(-1)	-0.026 (0.027) [0.345]	-0.034 (0.028) [0.222]	0.004 (0.024) [0.855]	-0.009 (0.023) [0.702]	-0.003 (0.039) [0.944]	-0.016 (0.035) [0.640]
CF(1)	0.254 (0.077) [0.001]	0.278 (0.077) [0.000]	0.172 (0.055) [0.002]	0.218 (0.071) [0.002]	0.143 (0.092) [0.120]	0.208 (0.093) [0.025]
CF(2)	0.365 (0.078) [0.000]	0.401 (0.083) [0.000]	0.448 (0.047) [0.000]	0.468 (0.040) [0.000]	0.377 (0.050) [0.000]	0.382 (0.051) [0.000]
I(-1)/K(-2)		0.034 (0.070) [0.624]		-0.035 (0.076) [0.642]		0.047 (0.063) [0.458]
Sargan	72.345 [0.277]	79.533 [0.338]	73.309 [0.251]	79.187 [0.348]	77.084 [0.165]	77.631 [0.395]
Difference Sargan	29.09 df=33	22.11 df=38	35.88 df=33	29.20 df=38	33.35 df=33	25.50 df=38
CV DS	47.12	53.10	47.12	53.10	47.12	53.10
M_1	-2.311 [0.021]	-2.183 [0.029]	-2.583 [0.010]	-2.012 [0.044]	-2.515 [0.012]	-2.340 [0.019]
M_2	-3.161 [0.002]	-0.737 [0.461]	-2.047 [0.041]	-0.824 [0.410]	-2.638 [0.008]	-0.850 [0.395]

Standard-errors between parentheses; p-values between brackets. Sargan tests for the validity of the instruments in the differenced and levels equations; Difference Sargan tests for the validity of the instruments in the levels equation. df denotes degrees of freeedom. CV DS denotes the critical value for the Difference Sargan (instruments are reliable if Difference Saran is below CV DS). M_1 tests for the absence of first-order serial correlation in the first-differenced residuals; M_2 tests for the absence of second-order serial correlation in the first-differenced residuals. Time dummies are taken into account. They are not presented for reasons of space. *CF(1)* gives the parameter estimate of the

low-volatility regime, *CF(2)* gives the parameter estimate of the high-volatility regime. Instruments taken into account: for the contemporaneous differences, for *MB* the 4 period up to 6 period lagged values; for all other variables the 2 period lagged values, except for the lagged dependent variable. For this variable the 3 period lagged value is used. For the contemporaneous levels, the one period lagged value of the first difference of all independent variables, except for *MB*. For *MB* the 3 period lagged value is used.

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[1] The model draws heavily from the Kaplan-Zingales (1997) model. Sterken and Lensink (2001) discuss the original Kaplan-Zingales model, and examine in more detail a stochastic version of the Kaplan-Zingales model for a risk neutral and a risk-averse manager.

[2] We thank Frank Windmeijer for providing the package of DPD98 including the corrected two step standard errors.

[3] The Difference Sargan test is calculated by subtracting the value of the Sargan test of a first differenced GMM estimate form the value of the Sargan test of the system GMM estimate. The degrees of freedom of the Differenced Sargan test equals the degrees of freedom of the system GMM Sargan test minus the first differenced Sargan test.

[4] With respect to EMPVOL, we use the value of the lower confidence interval, in stead of the average value of the threshold, to compute the indicator function. In case the average value is used, the GMM estimates did not gave any results due to problems with inverting the matrix that is needed for the two-step estimates.

[6] As noted by Hansen (1999) this assumption excludes lagged dependent variables from the model.