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DOES DEMAND AND PRICE UNCERTAINTY AFFECT BELGIAN AND SPANISH CORPORATE INVESTMENT?

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Abstract

Several recent studies have shown that uncertainty affects investment decisions. Specifically, demand and/or price uncertainty are found to depress corporate investment in e.g. the United States. This paper investigates whether similar results hold for Belgium and Spain, countries where financial markets are less developped and many firms evidently face financial constraints. Uncertainty of demand, output prices and investment prices are measured by the standard deviation of (pre-)filtered Belgian (1984-1992) and Spanish (1983-1993) panel data, and included as explanatory variables in the investment equations derived from a neo-classical model. The results indicate that investment behaviour towards uncertainty differs significantly between low- and high-leverage firms in both Belgium and Spain.

1 Introduction

Recent empirical research has shown that uncertainty plays a significant role in several economic models. Ramey and Ramey (1995) find a significant effect of economic growth uncertainty on average GDP-growth, where uncertainty is measured as the standard deviation of GDP-growth. In their cross-country sample the effect is negative which implies that a country with a high growth volatility[1] tends to grow slowly. In a different strand of literature, in casu consumption models, also a negative effect of volatility is found. Banks, Blundell and Brugiavini (1994) show that consumption growth is negatively affected by wealth volatility.

Also in investment models the effect of uncertainty has been discussed and in some ways investigated empirically. In these studies the emphasis is however not on investment growth, but on the level of investment, and the sign of the uncertainty-investment relation seems ambiguous. A major problem is that investment can be influenced by uncertainty from many different sources, e.g. output and investment prices, marginal returns, wages, product demand, financial factors, etc.

Recent empirical studies with US industrial sectors show strong evidence for a significant negative sign of demand uncertainty as well as output price uncertainty. Ghosal (1991) shows that demand uncertainty is important, though less important for large firms. It depresses the capital/labour ratio. Guiso and Parigi (1996) find a similar depressive effect on Italian corporate investment. In addition, Ghosal and Loungani (1996) show a depressive effect of output price uncertainty in competitive US industries[2].

These findings are interesting because the explanation of investment behaviour has been quite unsatisfactory until now. Empirical research has not often shown many significant explanatory factors but poor results instead, even for different models and for different countries.

The aim of this paper is to investigate demand and price uncertainty effects on corporate investment in Belgium and Spain. In these two countries a lot of small firms exist and not many firms are quoted at the stock exchange. Empirical studies have shown the importance of financial distress by significant effects of financial factors on corporate investment. To the best of my knowledge, no empirical evidence exists on the possible impact of demand and price uncertainty. So the first question to be answered here is whether demand and price uncertainty affect investment significantly, and if the answer to this question is confirmative, we try to understand the sign of the effect.

A firm's attitude towards uncertainty will probably not be independent of its characteristics. For instance, a small firm's attitude may differ from a large firm's one as it often has to rely on the sale of a less diversified product mix. Also, a firm with a high debt burden may be less

[1] The terms 'uncertainty' and 'volatility' are used interchangeably in this study.

[2] See also Ghosal (1995) and Ghosal (1996).

uncertainty averse than a firm financed by mainly own funds. As there is no evidence on hand on this relation between uncertainty and firm characteristics for those countries, and we have no theoretical indications, this issue is further investigated. In contrast to above mentioned investment studies, this is done with firm data, covering the period 1984-1992 for Belgium and 1983-1993 for Spain.

The adopted methodology is the following. Uncertainty factors are calculated, incorporated in the neo-classical model, first order conditions are derived and estimated with the uncertainty factors as explanatory variables. The uncertainty of each variable is measured as the standard deviation of the unpredictable part of the variable. By this procedure, sales (as an indicator of demand), the nominal output price and the nominal investment price can be considered because they are not within influential reach of (most) Belgian and Spanish firms. As financial distress can be considered to be an additional uncertainty factor in the two countries under investigation, it is taken into account explicitly. The uncertainty factors are tested for, conditional on the (other) relevant factors affecting corporate investment.

The outline of the paper is as follows. In section 2 theoretical and empirical findings on the uncertainty-investment relationship in the literature are reviewed. In section 3 the uncertainty measurement adopted in this study is introduced. In section 4 the data and in section 5 some stylized facts are presented. In section 6 an empirical model is derived from a neo-classical investment model with uncertainty factors. In section 7 GMM-results for these models are discussed. Section 8 concludes.

2 Discussion on the Investment-Uncertainty-Sign

It is important to discuss the different sources of uncertainty in investment decisions and to distinguish between the theoretical and empirical findings.

Theoretically it has been shown that the uncertainty-investment relationship is positive when considering output price uncertainty, see Oi (1961). In addition, Hartman (1972) shows that the relationship is also positive for wages, but invariant to future uncertainty in investment prices. An important assumption in these studies is perfect competition, by which the profit function is convex in prices. Caballero (1991) shows that dropping this assumption changes the sign in case of output price or demand uncertainty. The loss of being short of capital when demand is high is in this case not higher than the loss of having too much capital when demand is low. Abel and Eberly (1995) show furthermore that the sign depends on irreversibility and the "hangover effect".

Dixit and Pindyck (1994), who focus on an individual investment project, argue that return uncertainty affects investment negatively. This follows from the option theory, in which the value of the option of waiting-to-invest is always positive as information arrives over time. According to this theory return uncertainty leads thus to delaying investment.

Empirically Pindyck and Solimano (1993) and Caballero and Pindyck (1992), elaborate on the option-theory of Dixit and Pindyck (1994), and find a negative effect with firm data as well as with time series. They argue that the marginal costs of a project, say the investment price p, in addition to the standard deviation of returns, say σ, are the threshold value for inducing investment. If F_K indicates the marginal returns, investment will be triggered if

$$F_K > p + k\sigma \qquad \text{where} \qquad k > 0. \tag{1}$$

If there is no uncertainty, i.e. $\sigma = 0$, the standard neo-classical result holds where investment is triggered if marginal returns exceed marginal costs p. If there is uncertainty, i.e. $\sigma \neq 0$, investment is triggered if marginal returns exceed marginal costs p plus the uncertainty effect.

The main empirical findings by Pindyck and Solimano (1993) and Caballero and Pindyck (1992) are however not appropriate evidence for a negative uncertainty-investment relation. In both studies the uncertainty-investment relation is tested by regressing

$$Dec(F_K)_i = a_0 + a_1 Mean(F_K)_i + a_2 SD(F_K)_i$$

where the a's are parameters, Dec is an extreme value, $Mean$ is the average and SD the standard deviation, all of the marginal productivity. All statistics are calculated for firm i, and calculated over the time dimension. Their major result is that a_2 is significant and positive. This does however not indicate a negative effect of return uncertainty on investment since standard deviations and extreme values are always positively related.

Several other avenues of measuring uncertainty have been taken and, to the best of my knowledge, the signs that were found to be significant have always turned also out to be negative. Ferderer (1993) considers volatility in bond prices using time series of US-manufacturing, Guiso and Parigi (1996) consider future expectations of sales from questionaires in a reduced form model using a cross-section of Italian firms, and Leahy and Whited (1996) consider daily stock returns in a q-model using a US-panel of firms. Furthermore, Ghosal and Loungani (1996) find a negative effect from output price uncertainty on investment in competitive US industrial sectors.

In this study a dynamic neo-classical model is used as a benchmark. This model is more complete than the one of Pindyck and Solimano (1993), see (1), as dynamics and financial distress are taken into account. In the model we keep in mind that uncertainty factors appear that increase (decrease) marginal costs and hence can decrease (increase) investment (i.e. $k > 0$ ($k < 0$) in (1)). In order to test for uncertainty, uncertainty effects σ are calculated in a first step and included in the model. The parameter k is then estimated appropriately in the full model[3].

[3] See also Bourdieu and Coeur (1996).

3 An Empirical Measure of Uncertainty

In order to obtain an uncertainty measure of a certain variable that a firm is faced with, say variable $Z_{i,t}$, we need to consider the unpredictable part of the variable. Only this part cannot be anticipated by the firm and therefore reflects the uncertainty of the variable.

For firm i and for each variable $Z_{i,t}$ it will be assumed that

$$Z_{i,t} = \alpha_{0i} + \sum_{q=1}^{p} \alpha_{qi} Z_{i,t-q} + \epsilon_{i,t}^{Z} \qquad \text{where} \qquad \epsilon_{i,t}^{Z} = \epsilon_t + \epsilon_{i,t}^{I} \qquad \text{and} \qquad \epsilon_{i,t}^{I} \sim N(0, \sigma_i^2). \tag{2}$$

The unpredictable part of $Z_{i,t}$, i.e. $\epsilon_{i,t}^{Z}$, is decomposed in a time part (ϵ_t) and an idiosyncratic part ($\epsilon_{i,t}^{I}$). $\epsilon_{i,t}^{Z}$ is assumed to be i.i.d., but our main interest is the idiosyncratic part. Its standard deviation σ_i is a measure of uncertainty around Z to firm i. Notice that this measure is only firm specific. For each firm it will be weighted by the assets-to-equity ratio, denoted $\omega_{i,t}$. So the uncertainty measure considered is defined as

$$\hat{u}_{i,t} = \omega_{i,t} \hat{\sigma}_i, \tag{3}$$

where the $\hat{\sigma}_i$ indicates the sample standard deviation. The economic reasoning for this weighting is that firms with higher debt levels, so a higher assets-to-equity ratio $\omega_{i,t}$, are assumed to be faced with more uncertainty than firms with lower debt levels[4]. By this weighting of the firm-specific uncertainty measure $\hat{\sigma}_i$, the uncertainty effect $\hat{u}_{i,t}$ is both firm- and time-dependent.

Our main interest is to test for the uncertainty effect $u_{i,t}$ of different variables on investment, conditional on other relevant factors in investment decisions. Before discussing uncertainty in the neo-classical model, some of the main variables that have been investigated in other studies for different countries, are considered by running simple regressions.

4 Data Description

The data used in this study come from databases of the Belgian and Spanish Central Bank. They are annual and cover the period 1984-1992 for Belgian and 1983-1993 for Spain. Firms selected belong to the manufacturing industry. For Belgian nineteen main sectors are distinguished and for Spain thirteen. The firms selected are (i) public limited companies (corporate) (ii) with more than or with 20 employees (iii) with a net value added of 20.000 Belgian Francs or 1.000.000 Pesetas

[4] Leahy and Whited (1996) use also a weighting factor but take the equity-to-debt ratio. They argue that their uncertainty measure, being the return at the stock exchange, will increase with the leverage of the firm. Here, on the contrary, a high leverage is considered to amplify uncertainty, among others because the correlation between leverage and the uncertainty measure σ_i is in most cases not positive.

(iv) with a positive capital stock (v) with positive total assets (vi) with positive wages (vii) with positive dividends (viii) with positive equity and (ix) that do no change sector. As there is a hugh amount of variation in both databases firms have been eliminated that have (i) a real capital stock growth of more than 300% or less than -0.90% (ii) a real assets growth of more than 500% or less than -0.90% (iii) a q of more than 25 or less than 0 (iv) a sales-to-capital ratio of more than 25 and (v) a value-added-to-capital ratio of more than 25. Furthermore, firms are only included when existing more than five consecutive years. So the two panels are unbalanced.

Table 1 Means (Standard deviations in brackets)

	Belgium	Spain
Investment-to-Capital ratio, $\frac{I}{K}$	0.28	0.16
	(0.31)	(0.21)
Cash-Flow-to-Capital ratio, $\frac{CF}{K}$	0.76	0.65
	(0.67)	(0.54)
Value-Added-to-Capital ratio, $\frac{Y}{K}$	2.65	1.79
	(1.66)	(1.31)
Sales-to-Capital ratio, $\frac{S}{K}$	7.15	5.89
	(4.58)	(4.09)
Debt-to-Capital ratio, $\frac{B}{K}$	0.76	1.04
	(0.98)	(1.10)
Real Investment Price, P^I	1.05	1.01
	(0.10)	(0.07)
Modified User Cost of Capital, J	0.32	0.27
	(0.12)	(0.03)
Tobin's q, q	4.55	2.22
	(2.68)	(1.48)
Number of Employees, N	441.8	264.1
	(1132.1)	(924.2)
Uncertainty Sales-to-Capital, $\hat{u}(\frac{S}{K_0})$	1.09	1.43
	(1.42)	(2.22)
Uncertainty Nominal Output Price, $\hat{u}(P)$	0.015	0.02
	(0.007)	(0.02)
Uncertainty Nominal Investment Price, $\hat{u}(P^{In})$		0.007
		(0.007)

The lower part of the table presents the means of the measured sales and price uncertainty effects ($\hat{u}_{i,t}$ in (3)). Output prices and investment prices are only sector-time specific. For Belgium uncertainty measures for investment prices are missing since these prices are not available per sector. K_0 is the capital stock at the beginning of the sample. K_0 instead of K is used in the econometric analyses to ensure that the uncertainty measure is exogenous.

Detailed information on the data construction is given in Appendix A. Information on the number of firms and number of observations over the years and sectors are given in Tables A.1 and A.2. In Table 1 some summary statistics of the main variables are presented. As a result of the selections mentioned above, the standard deviation of many variables is about equal to the mean. A comparison between the Belgian and Spanish statistics shows that for almost all Belgian variables the mean and standard deviation exceed those of the Spanish variables. This seems to result from the fact that in the Belgian database more small than large firms are represented than in the Spanish, and turn out to have higher ratios. Moreover, the variation in this dataset is overall higher.

5 Some First Measures

The uncertainty factors are estimated as follows. For each variable under investigation an AR(1)-, an AR(2)-, an AR(3)- and an ARI(1,1)-equation are estimated, see (2). The equation with the lowest mean square error is assumed to fit the data best, and the average of its residuals is then calculated for each year. These estimates, denoted by $\hat{\epsilon}_t$, are the estimates for ϵ_t. The estimates for $\epsilon^I_{i,t}$ are obtained from $\hat{\epsilon}^I_{i,t} \equiv \hat{\epsilon}^Z_{i,t} - \hat{\epsilon}_t$ and the standard deviation for each firm i is calculated.

In Table 2 the results are given of simple regressions of the investment-to-capital ratio of firm i on the measured uncertainty factors $u_{i,t}$, see (3). The variables under investigation are those variables that are (approximately) used in other studies: the investment-to-capital as in Ramey and Ramey (1995), the cash flow-to-capital ratio and the value-added-to-capital as in Caballero and Pindyck (1992), the q-value as in Leahy and Whited (1996), the sales-to-capital ratio as in Guiso and Parigi (1996) and Ghosal (1991), the nominal output price as in Ghosal (1996) among others, and the nominal investment price.

The results presented show that correlations are (highly) significant, except for Tobin's q-uncertainty for Belgium and the cash-flow- and value-added-uncertainty for Spain. These results thus suggest that most uncertainty measures affect investment in Belgium and Spain indeed. Most important at this stage are the findings of strongly significant uncertainty measures, suggesting that uncertainty around these variables might matter for Belgian and Spanish manufacturing investment decisions in more complete analyses.

The expected sign of the correlations according to previous studies for other countries, mostly based on more than simple partial correlations, is negative for the first four variables. For sales uncertainty also a negative sign was found in the US study of Ghosal (1991) and the Italian study of Guiso and Parigi (1996), being also more complete studies. For output price uncertainty the same holds in the US-studies of Ghosal.

Table 2 Partial correlations investment-uncertainty	Belgium	Spain
Investment-to-Capital, $\frac{I}{K}$	-0.02^{**}	-0.008^{**}
	(0.005)	(0.002)
Cash-Flow-to-Capital, $\frac{CF}{K}$	0.027^{**}	0.0004
	(0.008)	(0.002)
Value-Added-to-Capital, $\frac{Y}{K}$	0.015^{*}	-0.001
	(0.007)	(0.002)
Tobin's q, q	0.001	-0.01^{**}
	(0.006)	(0.002)
Sales-to-Capital, $\frac{S}{K_0}$	0.025^{**}	0.013^{**}
	(0.005)	(0.001)
Nominal Output Price, P	-0.039^{**}	0.006^{*}
	(0.012)	(0.003)
Nominal Investment Price, P^{In}		0.011^{**}
		(0.002)

The presented figure are the OLS-estimators for c_1 in the regression $\left(\frac{I}{K}\right)_{i,t} = c_0 + c_1\hat{u}_{i,t} + e_{i,t}$. Standard deviations are given in brackets. The three variables below the solid line are included in the econometric analyses. K_0 is the capital stock at the beginning of the sample and is used in the econometric analyses to ensure that the uncertainty measure is exogenous. Output prices and investment prices are only sector-time specific. For Belgium uncertainty measures for investment prices are missing since these prices are not available per sector.

* significant at 5%-level

** significant at 1%-level

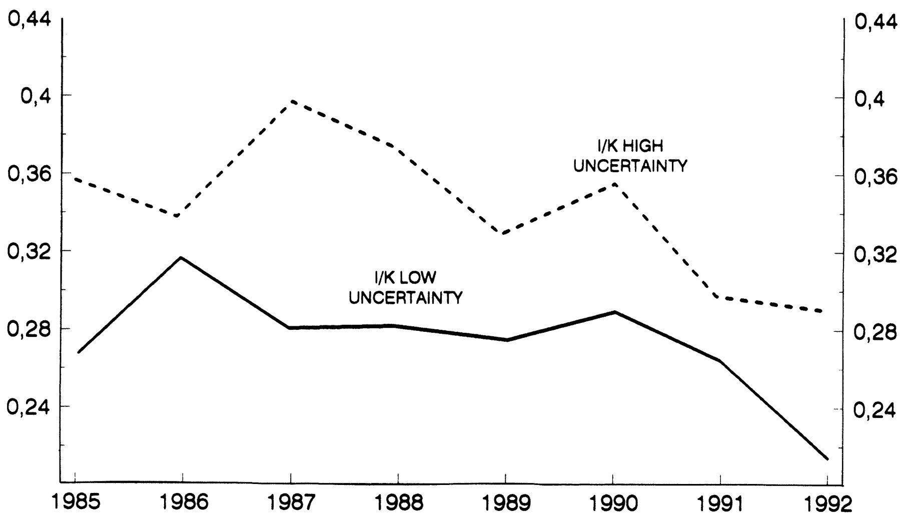
As a confirmation that these partial analyses show significant differences, some graphs are shown for the sales- and price-uncertainties. In these graphs, see Graph 1, the whole sample of firms is splitted at the mean according to the uncertainty measures in "low" and "high" uncertainty and then the average investment-to-capital ratio is calculated. For instance, Graph 1a shows for sales in Belgium that the firms with "low"-sales uncertainty have on average a low investment-to-capital ratio in comparison with the firms with "high"-sales uncertainty. As during the whole period the two lines do not cross each other, the difference between the two types of firms is strong. The same holds for sales uncertainty in Spain and output price uncertainty in Belgium, though a bit less for output and investment price uncertainty in Spain.

Also if the same analyses as in Table 2 are carried out with the uncertainty measure σ_i instead of the weighted one, i.e. $u_{i,t}$ in (3), highly significant results are obtained[5]. So the significance of the presented results is independent of the weighting. These correlations are even more significant than

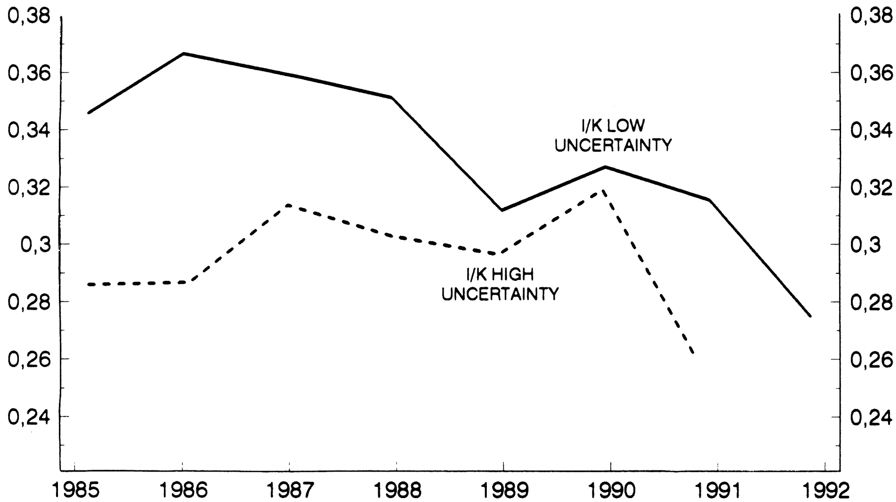
[5]In this case for each firm the same uncertainty measure holds in all years.

the ones presented here. Also, in case where the cash-flow-to-capital ratio instead of investment-to-capital is taken, significant correlations are found. So these results confirm once more that uncertainty seems to matter for investment decisions.

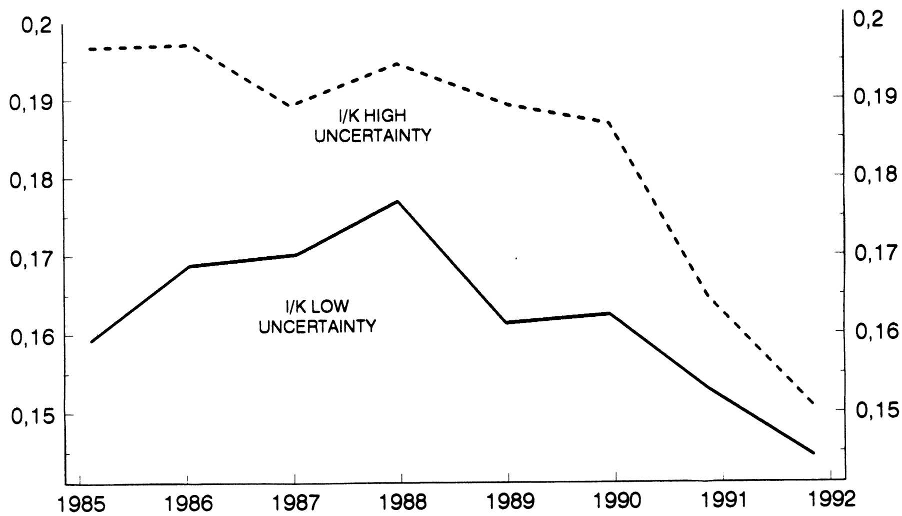
The sales and price uncertainty measures are used in our further analyses. They are assumed to be exogenous to the firm in neo-classical models and for this reason possible to calculate as in (2). The significance and signs for demand and price uncertainty are investigated, conditional on other relevant factors that are by and large used to explain investment demand.



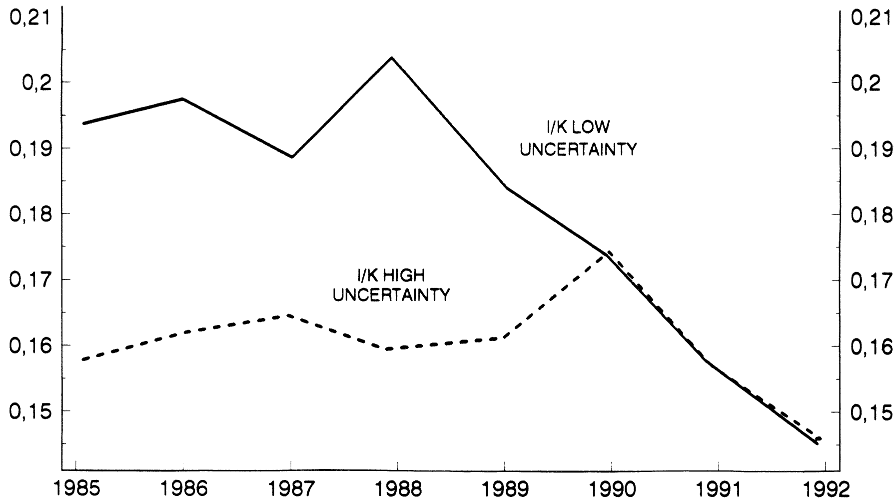
Graph 1a Average I/K for low and high sales uncertainty Belgian firms
The sample is split into "low" and "high" at the mean.



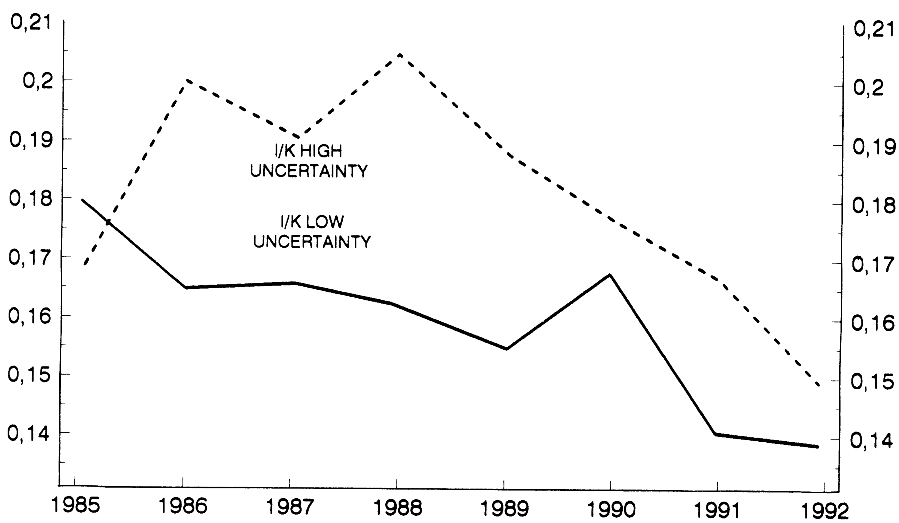
Graph 1b Average I/K for low and high output price uncertainty Belgian firms
The sample is split into "low" and "high" at the mean.



Graph 1c Average I/K for low and high sales uncertainty Spanish firms
The sample is split into "low" and "high" at the mean.



Graph 1d Average I/K for low and high output price uncertainty Spanish firms
The sample is split into "low" and "high" at the mean.



Graph 1e Average I/K for low and high investment price uncertainty Spanish firms
The sample is split into "low" and "high" at the mean.

6 An Empirical Investment Model

In this section we derive from the standard neo-classical model the dynamic investment model, that is similar to Bond and Meghir (1994). The main focus is on the inclusion of the demand and price uncertainties. These factors are represented as marginal costs, denoted $\nu_{1i,t}$ and/or $\nu_{2i,t}$.

6.1 The Neo-Classical Model

Risk-neutral managers are assumed to maximize the present value of future profits of the firm. The profit stream of firm i at time t is specified as

$$E\{\sum_{t=0}^{\infty}\prod_{k=0}^{t-1}\left(\frac{1}{1+\tau_k}\right)[F(K_{i,t},N_{i,t})-G(I_{i,t},K_{i,t},P^I_{s,t},\nu_{1i,t},\nu_{2i,t})-W_{i,t}N_{i,t}]|\Omega_{i,t}\} \tag{4}$$

E is the rational expectations operator and the information set $\Omega_{i,t}$ contains the information until period t, τ_k is the real discount rate at the end of period k, $F(.)$ a production function and $G(.)$ an investment cost function. It further holds that

$K_{i,t}$ = the end-of-period real capital stock of firm i at t;

$I_{i,t}$ = real gross investment of firm i at time t;

$N_{i,t}$ = number of employees of firm i at t;

$W_{i,t}$ = real wage paid by firm i at t;

$P^I_{s,t}$ = the real investment price of sector s at time t;

$\nu_{1i,t}$ = exogenous shock to variable investment costs to firm i at time t;

$\nu_{2i,t}$ = exogenous shock to investment adjustment costs to firm i at time t.

Capital stock accumulates according the standard capital accumulation rule, i.e.

$$K_{i,t}=I_{i,t}+(1-\delta_{i,t})K_{i,t-1} \qquad \Leftrightarrow \qquad I_{i,t}=K_{i,t}-(1-\delta_{i,t})K_{i,t-1}, \tag{5}$$

where $\delta_{i,t}$ represents the economic depreciation rate of firm i at t. The investment cost function is specified quadratically as

$$G(I_{i,t},K_{i,t},\nu_{1i,t},\nu_{2i,t})=(\nu_{1i,t}+P^I_{s,t})I_{i,t}+\frac{b}{2}\left(\left[\frac{I}{K}\right]_{i,t}-\nu_{2i,t}\right)^2K_{i,t}. \tag{6}$$

The term $(\nu_{1i,t}+P^I_{s,t})I_{i,t}$ are the variable investment costs and the quadratic term are adjustment costs[6]. $\nu_{1i,t}$ and $\nu_{2i,t}$ are stochastic shocks that affect the investment costs. $\nu_{1i,t}$ may be thought of as a shock that is associated with each new acquirement of an investment good, increasing or decreasing the price of the good. $\nu_{2i,t}$ is a shock that affects the optimal level of investment

[6] Strictly speaking, the term $\nu_{1i,t}I_{i,t}$ can be interpreted as either variable or adjustment costs (see Whited (1994)) but we will refer to it as variable costs here.

adjustment, see Whited (1994). The derivatives with respect to the first and second argument are given by

$$G_{Ii,t} = \nu_{1i,t} + P^I_{s,t} + b\left(\left[\frac{I}{K}\right]_{i,t} - \nu_{2i,t}\right) \quad \text{and} \quad G_{Ki,t} = -\frac{b}{2}\left(\left[\frac{I}{K}\right]^2_{i,t} - \nu^2_{2i,t}\right). \tag{7}$$

6.2 The Dynamic Investment Model

The dynamic investment model can be derived by substituting gross investment, given in equation (5), in (4) and taking derivatives with respect to $N_{i,t}$ and $K_{i,t}$. The Euler-equations are given by

$$F_{Ni,t} = W_{i,t} \tag{8}$$

$$F_{Ki,t} = G_{Ii,t} + G_{Ki,t} - \left(\frac{1-\delta_{i,t}}{1+\tau_t}\right) E\{G_{Ii,t+1}|\Omega_{i,t}\}, \tag{9}$$

where $F_{Ni,t}$ and $F_{Ki,t}$ is the marginal productivity of labour and capital at time t, respectively. From the first order conditions the reduced form solution can be derived which is, as described in Appendix B,

$$\left[\frac{CF}{K}\right]_{i,t} - J_{i,t} = \gamma_1\left(\left[\frac{I}{K}\right]_{i,t} - \frac{1}{2}\left[\frac{I}{K}\right]^2_{i,t} - \psi_{i,t}\left[\frac{I}{K}\right]_{i,t+1}\right) + \gamma_2\left[\frac{Y}{K}\right]_{i,t} - \gamma_3\left[\frac{B}{K}\right]^2_{i,t}$$

$$+ \nu_{1i,t} - \psi_{i,t}\nu_{1i,t+1} - \gamma_4(\nu_{2i,t} - \frac{1}{2}\nu^2_{2i,t} - \psi_{i,t}\nu_{2i,t+1}) + \epsilon_{i,t} \tag{10}$$

where $\psi_{i,t} \equiv \frac{1-\delta_{i,t}}{1+\tau_t}$.

CF/K is the cash-flow-to-capital stock ratio, Y/K is the value-added-to-capital-stock ratio that controls for non-constant-returns-to-scale, B/K is the debt-to-capital stock ratio and J is a modified user cost of capital. In case of constant returns to scale, $\gamma_2 = 0$. In case where the firm is debt-constrained, γ_3 is significant. The sign of γ_3 is negative as a firm will invest more when it has more debt, as explained in Bond and Meghir (1994). ϵ is a disturbance term that represents the forecast errors arising from substituting the realized values for the unobserved variables. All parameters are expected to be positive.

6.3 The Inclusion of the Uncertainty Factors

The dynamic model (10) is equivalent to the one by Bond and Meghir (1994) iff $\nu_{1i,t-i} = 0$ for i=0,1, and $\nu_{2i,t}$ equals a constant. Bond and Meghir (1994) estimate it without the price variable J. Time-, sector- and individual effects are included and said to cover the price effect. To eliminate the fixed effects the model is taken in first differences.

The model estimated by Bond and Meghir (1994) is re-arranged in such a way that the term $(I/K)_{i,t+1}$ is on the left side of the equality sign, instead of $CF/K - J$. We have two important reasons for not following this approach. Firstly, by explaining I/K instead of $CF/K - J$ the adjustment cost specification (6) is very strongly relied upon[7]. By explaining $CF/K - J$, on the other hand, it can be tested whether adjustment costs are significant. This is the case if γ_1 is significant since γ_1 equals b divided by the elasticity of demand, see Appendix B. Secondly, the form of (1) is kept, in that the gap between marginal returns and user costs are explained by the adjustment costs, liquidity constraints, and uncertainty effects that are to be included in the ν's. So the effect of uncertainty on the gap between the marginal product of capital and the user costs is analyzed, and its effect on investment is thus only derived indirectly.

In our further analyses and in contrary to most other studies, price variable J is included. This is according to the model, and moreover, including it is different from replacing it by time-, sector-dummies and fixed effects because only *one* parameter is estimated for a variable that is sector-time dependent instead of S + T (=the number of sector + the number of years). Moreover, the interest rate and depreciation rate are observed. Another reason for including it is that the uncertainty effect of these variables is measured, that might interfere with the level effect.

To include the uncertainty effect in ν_1 it will be assumed that only variable costs are affected by uncertainty. This is along the lines of Dixit and Pindyck (1994). Each time a capital good is bought, price P^I is paid and *in addition* a "price" for the uncertainty effects associated with it. There are more possibilities to include uncertainty effects, but in case of demand and price uncertainty, the inclusion as variable costs seems most logical. This is further explained in Appendix C.

To include the uncertainty effect(s) and fixed effects, time-dummies and sector-dummies, denoted d_i, d_t and d_s, respectively,

$$\nu_{1i,t} = \kappa \hat{u}_{i,t} + d_i + d_t + d_s + \epsilon^{\nu_1}_{i,t} \qquad \text{and} \qquad \nu_{2i,t} = c + \epsilon^{\nu_2}_{i,t} \tag{11}$$

is assumed, by which the equation

$$\begin{aligned}\left[\frac{CF}{K}\right]_{i,t} - J_{i,t} &= \gamma_1 \left(\left[\frac{I}{K}\right]_{i,t} - \frac{1}{2}\left[\frac{I}{K}\right]^2_{i,t} - \psi_{i,t}\left[\frac{I}{K}\right]_{i,t+1} \right) + \gamma_2 \left[\frac{Y}{K}\right]_{i,t} - \gamma_3 \left[\frac{B}{K}\right]^2_{i,t} \\ &+ \gamma_4^*(\hat{u}_{i,t} - \psi_{i,t}\hat{u}_{i,t+1}) + d_i^* + d_t^* + d_s^* + \epsilon^*_{i,t} \end{aligned} \tag{12}$$

results. The starred variables and parameters are the re-defined old ones.

[7] In this case the terms $(I/K)_{i,t}$ and $(I/K)^2_{i,t}$ on the right hand side should have a coefficient that is larger than one and a coefficient smaller than zero, respectively. As in this case all coefficients are divided by the adjustment cost parameter b to obtain this form, it is not possible to test for the non-significance of it. Many empirical studies show very different parameter estimates, probably due to the adjustment cost specification.

In this dynamic model uncertainty affects -ceteris paribus- the gap $CF/K - J$ positively if $\gamma_4^* > 0$ and future uncertainty does not exceed current uncertainty (then $\hat{u}_{i,t} - \psi_{i,t}\hat{u}_{i,t+1} > 0$ since $\psi < 1$). In this case uncertainty *depresses* investment as more returns are required on the new investment. On the contrary, if future uncertainty is (much) higher than current uncertainty, i.e. $\hat{u}_{i,t} - \psi_{i,t}\hat{u}_{i,t+1} < 0$, the gap $CF/K - J$ decreases. Investment should thus be triggered as it is profitable.

7 Estimation Results

The GMM-results are obtained with the DPD-program of Arellano and Bond (1988). Instruments used are two until four years lagged values of the explanatory variables for each year (in the "gmm"-command in the program), time-dummies and sector-dummies. Experiments have been carried out by using different variables and different lags, but show no significant changes. For further comments on the estimation results, see the notes of Tables 3-8.

The whole sample

Tables 3 and 4 present the results of model (12) for the full sample of 308 Belgian firms and 1298 Spanish firms, respectively. Column (1) gives the benchmark model, i.e. the model without uncertainty factors. In subsequent columns the uncertainty effects are included, first separately, and finally jointly.

For Belgium all models are accepted according to the Sargan-statistic, see "p-value Sargan" in Table 3. The "adjustment cost" parameter, which is actually the adjustment cost parameter b divided by the demand elasticity, is significant and equals about 0.09. So investment adjustment costs are important. Furthermore, the parameters associated with value-added-to-capital are significant. This indicates that constant returns to scale are rejected. The parameter of the financial variable debt-to-capital is about -0.03. It has the right sign because investment is stimulated by higher debt-to-capital levels. The estimate is significant, so firms face debt-constraints. Most important for our analyses are the results concerning the uncertainty factors. Columns (2)-(4) show that sales and price uncertainty, neither individually, nor jointly, are significant.

The results for Spain in Table 4 are slightly different. All models are accepted according to the Sargan-statistic, though, only at about the 5%-level. The "adjustment costs" parameter is *not* significant, a result which corroborates some previous Spanish findings[8]. Like for Belgium, constant

[8]This does not imply that investment dynamics are negligible. Possibly a different adjustment cost specification is needed to fit the data. As this specification is not on hand yet, cash-flow instead of investment is explained here, see also section 6.3.

returns to scale are rejected and the financial variable is (here highly) significant. The estimate for returns to scale is about 0.45 for Spain whereas it is 0.50 for Belgium, indicating that -on average- returns to scale are higher in Spain. Demand and investment price uncertainty are not significant, but output price uncertainty is significant at the 10%-level. The sign of the latter is positive which indicates that this type of uncertainty depresses investment. This is according to findings of Ghosal (1996) for US industrial sectors.

So these results suggest that sales uncertainty does not affect corporate investment, only output price uncertainty matters for Spanish corporate investment, and adjustment costs (in Belgium), value-added-to-capital and debt-to-capital are important. The results of the highly significant partial correlation between sales uncertainty and investment presented in Table 2 and Graph 1 are thus not replicated in this more complete analyses. They are overruled by investment dynamics, scale effects and financial constraints.

Notes Tables 3-8:

- Estimation results are given for model (12) in first differences.
- All results presented are the DPD one-step GMM estimators, with standard errors robust to heteroskedasticity. Time-dummies and sector-dummies are included in each model and highly significant. In Table 4 interrelated time- and sector-dummies are used since the model is not accepted according to the Sargan-statistic elsewise.
- Instruments used in Tables 3-8: $(I/K)_{i,t-2}...(I/K)_{i,t-4}$, $(I/K)^2_{i,t-2}...(I/K)^2_{i,t-4}$, $(Y/K)^2_{i,t-2}...(Y/K)^2_{i,t-4}$, time-dummies and sector-dummies (19 for Belgium and 13 for Spain).
- Figures in brackets are standard errors.
- "*adj.costs*" represents $\left(\left[\frac{I}{K}\right]_{i,t} - \frac{1}{2}\left[\frac{I}{K}\right]^2_{i,t} - \psi_{i,t}\left[\frac{I}{K}\right]_{i,t+1}\right)$, i.e. the variable associated with adjustment costs.
- $\hat{u}(\frac{S}{K_0})$, $\hat{u}(P)$ and $\hat{u}(P^{In})$ represent the sales uncertainty, the output price uncertainty and the investment price uncertainty. In Tables 3-8 they are measured as $\hat{u}(\frac{S}{K_0})_{i,t}$, $\hat{u}(P)_{s,t} - \psi_{i,t}\hat{u}(P)_{s,t+1}$ and $\hat{u}(P^{In})_{i,t} - \psi_{i,t}\hat{u}(P^{In})_{s,t+1}$. See appendix C.
- "*p*-value Sargan", m_1 and m_2" are the *p*-values of the statistics for overidentifying restrictions, and the first and second order autocorrelation, respectively. "*p*-value Wald" is the *p*-value of the joint test statistic on the uncertainty effects. The figure in square brackets is the number of degrees of freedoms.
- * Significant at 10%-level, ** Significant at 5%-level

Table 3 Results dynamic model for Belgian firms

	(1)	(2)	(3)	(4)
$\hat{u}(\frac{S}{K_0})$		0.308		0.508*
		(0.220)		(0.301)
$\hat{u}(P)$			-9.09	-33.36
			(15.64)	(21.74)
"*adj.costs*"	0.085**	0.086**	0.088**	0.098**
	(0.036)	(0.036)	(0.037)	(0.040)
$[\frac{Y}{K}]$	0.502**	0.507**	0.503**	0.513**
	(0.085)	(0.086)	(0.084)	(0.086)
$[\frac{B}{K}]^2$	−0.032*	−0.037*	−0.030*	−0.032*
	(0.020)	(0.021)	(0.020)	(0.020)
p-value Sargan	0.38	0.42	0.36	0.46
p-value m_1	0.10	0.12	0.09	0.09
p-value m_2	0.77	0.80	0.81	0.89
"p-value Wald" [2]				0.13

firms: 308, # obs.: 1773, Period: 1986-1992

Table 4 Results dynamic model for Spanish firms

	(1)	(2)	(3)	(4)	(5)
$\hat{u}(\frac{S}{K_0})$		0.049			0.041
		(0.065)			(0.069)
$\hat{u}(P)$			0.169*		0.060
			(0.093)		(0.127)
$\hat{u}(P^{In})$				0.006	-0.083
				(0.067)	(0.143)
"*adj.costs*"	0.006	-0.001	-0.001	0.006	-0.001
	(0.043)	(0.046)	(0.045)	(0.043)	(0.047)
$[\frac{Y}{K}]$	0.462**	0.454**	0.453**	0.462**	0.455**
	(0.036)	(0.041)	(0.037)	(0.036)	(0.041)
$[\frac{B}{K}]^2$	−0.024**	−0.025**	−0.025**	−0.024**	−0.025**
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)
p-value Sargan	0.05	0.05	0.07	0.04	0.04
p-value m_1	0	0	0	0	0
p-value m_2	0.11	0.39	0.11	0.11	0.45
"p-value Wald" [3]					0.64

firms: 1298, # obs.: 7207, Period: 1985-1993

Table 5 Results dynamic model for small and large Belgian firms

	Small firms			Large firms		
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{u}(\frac{S}{K_0})$	0.568		0.639	0.119		0.040
	(0.388)		(0.407)	(0.211)		(0.251)
$\hat{u}(P)_{s,t}$		0.681	-14.74		23.95**	22.70*
		(18.28)	(19.46)		(11.40)	(13.57)
"*adj.costs*"	0.171**	0.173**	0.176**	0.006	0.003	0.004
	(0.052)	(0.048)	(0.050)	(0.019)	(0.016)	(0.018)
$[\frac{Y}{K}]$	0.600**	0.583**	0.599**	0.391**	0.383**	0.385**
	(0.113)	(0.110)	(0.112)	(0.080)	(0.077)	(0.080)
$[\frac{B}{K}]^2$	-0.020	-0.011	-0.018	-0.013	−0.019*	−0.021*
	(0.016)	(0.013)	(0.016)	(0.010)	(0.010)	(0.010)
p-value Sargan	0.78	0.72	0.76	0.36	0.50	0.47
p-value m_1	0.04	0.01	0.06	0.85	0.67	0.68
p-value m_2	0.74	0.80	0.87	0.01	0.03	0.02
"p-value Wald" [2]			0.34			0.002

small firms: 179, # obs.: 1013; # large firms: 129, # obs.: 760

Table 6 Results dynamic model for small and large Spanish firms

	Small firms				Large firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\hat{u}(\frac{S}{K_0})$	0.073			0.067	0.088			0.098
	(0.051)			(0.053)	(0.085)			(0.083)
$\hat{u}(P)$		2.88		4.249		-1.562		-2.829
		(5.43)		(11.00)		(3.197)		(7.859)
$\hat{u}(P^{In})$			-0.165	-5.44			-2.489	0.924
			(8.03)	(16.24)			(4.185)	(9.463)
"*adj.costs*"	0.062	0.068	0.070	0.062	−0.130*	−0.114*	−0.114*	-0.135
	(0.054)	(0.055)	(0.054)	(0.055)	(0.069)	(0.068)	(0.068)	(0.071)
$[\frac{Y}{K}]$	0.508**	0.517**	0.516**	0.508**	0.329**	0.344**	0.344**	0.326**
	(0.053)	(0.049)	(0.049)	(0.054)	(0.046)	(0.050)	(0.050)	(0.047)
$[\frac{B}{K}]^2$	−0.018*	-0.017	-0.016	-0.018	−0.025*	−0.022*	−0.022*	−0.025*
	(0.011)	(0.011)	(0.010)	(0.011)	(0.014)	(0.012)	(0.012)	(0.014)
p-value Sargan	0.02	0.01	0.01	0.02	0.55	0.50	0.49	0.48
p-value m_1	0	0	0	0	0.001	0	0	0.001
p-value m_2	0.19	0.19	0.12	0.16	0.88	0.51	0.62	0.76
p-value Wald" [3]				0.14				0.11

small firms: 771, # obs.: 4034; # large firms: 527, # obs.: 3173

Table 7 Results dynamic model for low- and high-leverage Belgian firms

	Low-leverage firms			High-leverage firms		
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{u}(\frac{S}{K_0})$	6.14*		6.06*	0.456*		0.523*
	(3.17)		(3.17)	(0.234)		(0.292)
$\hat{u}(P)$		58.10	56.84		14.48*	-12.56
		(49.94)	(49.87)		(11.56)	(17.27)
"adj.costs"	0.371**	0.311*	0.331**	0.101**	0.093**	0.105**
	(0.148)	(0.160)	(0.154)	(0.041)	(0.041)	(0.044)
$[\frac{Y}{K}]$	0.461**	0.457**	0.461**	0.535**	0.514**	0.538**
	(0.094)	(0.095)	(0.094)	(0.098)	(0.097)	(0.098)
$[\frac{B}{K}]^2$	−2.93**	−2.44**	−3.36**	−0.030*	−0.024*	−0.029*
	(0.861)	(0.773)	(0.972)	(0.018)	(0.016)	(0.017)
p-value Sargan	0.43	0.37	0.30	0.62	0.48	0.53
p-value m_1	0.12	0.19	0.21	0.13	0.09	0.14
p-value m_2	0.12	0.17	0.10	0.85	0.34	0.83
"p-value Wald" [2]			0			0.17

low-lev. firms: 86, # obs.: 498; # high-lev. firms: 222, # obs.: 1275

Table 8 Results dynamic model for low- and high-leverage Spanish firms

	Low-leverage firms				High-leverage firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\hat{u}(\frac{S}{K_0})$	0.365			0.160	0.056			0.034
	(0.328)			(0.300)	(0.064)			(0.068)
$\hat{u}(P)$		40.27*		2.305		2.296		13.89
		(19.13)		(29.16)		(4.275)		(8.90)
$\hat{u}(P^{In})$			124.91**	109.09			-1.88	-19.43
			(42.61)	(72.55)			(5.78)	(12.47)
"adj.costs"	-0.041	-0.036	-0.041	-0.047	-0.003	0.007	0.005	0.001
	(0.046)	(0.045)	(0.045)	(0.045)	(0.050)	(0.048)	(0.048)	(0.050)
$[\frac{Y}{K}]$	0.445**	0.457**	0.465**	0.460**	0.441**	0.452**	0.450**	0.447**
	(0.057)	(0.049)	(0.049)	(0.056)	(0.048)	(0.043)	(0.043)	(0.049)
$[\frac{B}{K}]^2$	-0.013	-0.029	-0.032	-0.029	−0.022**	−0.022**	−0.021**	−0.023**
	(0.022)	(0.025)	(0.029)	(0.028)	(0.010)	(0.009)	(0.009)	(0.009)
p-value Sargan	0.20	0.44	0.64	0.62	0.12	0.07	0.09	0.10
p-value m_1	0.02	0	0.01	0	0	0	0	0.0
p-value m_2	0.38	0.43	0.07	0.08	0.14	0.11	0.10	0.28
p-value Wald" [3]				0				0.02

low-lev. firms: 302, # obs.: 1665; # high-lev. firms: 996, # obs.: 5542

Splitting the sample

It is appropriate to test whether demand and price uncertainties are irrelevant for all types of firms. In case where only certain groups of firms react to uncertainty, and others do not, it is incorrect to assume the same uncertainty coefficients for all firms. To investigate this, the sample of all firms is splitted according to the uncertainty measures (at the mean values). Two groups are then obtained, one with "low"- and one with "high"-uncertainty for sales. The same is done for prices[9]. For these groups the averages of the variables mentioned in Table 1 are then compared.

This excercise shows, very interestingly, that the low-uncertainty (high-uncertainty) firms in Belgium are mainly small (large) firms. This holds for sales uncertainty as well as for price uncertainty[10]. Large Belgian firms thus face, for instance, a more volatile demand than small Belgian firms, possibly due to the fact that they have a larger product mix. In Spain, on the other hand, the sample of low and high uncertainty are more associated with low and high debt-to-equity (leverage). No direct relation between firm size and leverage exists, because e.g. small firms can have a low or a high leverage. For this reason, a split-sample according to size and leverage is carried out here consecutively.

In Table 5 the results for Belgium are therefore presented, similar to Table 3, albeit for small and large firms separately. Three main differences catch the eye. First, adjustment costs are only significant for small firms. Second, more interpretable economicly, returns-to-scale are higher for large than for small firms. The parameter estimates differ considerably as for small firms they are 0.59 (on average) and for large firms 0.39 (on average). Third, large firms are debt-constrained, whereas small firms seem not. This might be explained by the fact that small firms would hardly increase investment in case where they had more access to debt. Most important, again, are the findings concerning the uncertainty effects. Except for output price uncertainty for large firms, these effects turn out to be insignificant, implying that neither the low uncertainty around sales and prices affect small firms' investment, nor does the high sales uncertainty affect large firms' investment. Like for Spain in the whole sample, output price uncertainty has a positive sign, indicating a depressing effect on investment.

In Table 6 the results for Spain are presented. Returns-to-scale clearly differ between the two samples, being 0.51 for the small firms and 0.33 for the large firms, and debt constraints have a higher impact on large than small firms. Here, however, results should be interpreted with care since the Sargan statistic indicates that the model is rejected at the 1%-level for the small firms. It is difficult to trace the cause of the bad fit of the model for this group of firms. Clearly the whole

[9]This is done for the unweighted uncertainty effects to avoid any artificial influence from the weighting factor.

[10]This cannot be due to scale-effects since the sales-to-capital ratio is about equal for both groups.

group of Spanish firms is heterogeneous because the model was only accepted according to the Sargan statistic at the 5%-level in Table 4. Splitting the sample in small and large firms explains the large firms cash-flows well (acceptance of the Sargan-statistic at the 50%-level) whereas the small firms' behaviour either should be explained by other variables or splitted up further to avoid having constant parameter estimates for all these 771 firms. To come back to the main issue, none of the uncertainty effects for Spain are significant.

In Tables 7 and 8 the results for the low- and high-leverage firms are then given. In comparison with the previous results, they are very different for the uncertainty factors.

For Belgium a scale effect exists between the two groups as the low-leverage group has higher returns-to-scale. From this and the results in Table 5 can be concluded that many large firms have a low leverage. Furthermore, debt-to-capital influence investment by low-leverage firms more negatively and more significantly. This can be a result of the fact that these firms have low levels of debt indeed, by which a small increase in debt would increase investment much. Remarkably, most uncertainty effects are significant. They have a positive sign, indicating that their impact on investment is negative. Moreover, the magnitude of the parameter estimates show that sales and price uncertainty have a much higher impact on investment for the low-leverage firms. The Wald-test on the joint exclusion of the two uncertainty effects is rejected for the low-leverage firms (column(3)), indicating the importance of the uncertainty effects. It is however accepted for the high-leverage firms (column (6)) despite the fact that each uncertainty effect is significant individually (columns (4)-(5)). Sales and price uncertainty are possibly strongly correlated. After all, sales uncertainty can both be a cause or a consequence of price uncertainty, and both factors can move at the same speed.

The results for Spain in Table 8 show no differences in size effects as the value-added-to-capital ratio is about 0.45 -like in Table 4- for each group. So low- and high-leverage firms are not directly associated with small and large firms. Remarkably also, only high-leverage firms are debt-constrained. The uncertainty effects are significant for both output and investment prices of low-leverage firms. So also for Spain, there is a significant difference between both groups of firms here. Like for Belgium, the Wald-test on the exclusion of the uncertainty factors for low-leverage firms, see column (4), is rejected here.

As said before, the point estimates presented in Tables 3-8 are the one-step GMM estimates. These estimates are usually presented, instead of the two-step GMM-estimates, because the latter are known to have a standard deviation that is downward biased in small samples (Arellano and Bond (1991)). So all the parameter estimates presented here that are significant, are even more significant in the second GMM-step. The two-step estimates (not presented here) show in three of all cases a significant result (even) at the 5%-level, while a non-significant one-step estimate is found and presented here. These cases are the output price uncertainty parameter for the low-leverage Belgian firms and the output and investment price uncertainty parameters for the the high-leverage Spanish firms. The parameter estimates are 57.73 (56.84 for the one-step, see column (3) in Table 7) and 11.65 and -18.17 (13.89 and -19.43 in column (8) in Table 8), respectively. According to these estimates price effects seem important indeed, in Belgium as well as in Spain for both the low- and high-leverage firms. It is to be kept in mind however that some of these results should be taken with more care because we do not know whether the two-step estimator is fully appropriate here. The significant negative effect of investment price uncertainty would suggest a stimulation of investment.

The Sargan and Wald-statistics presented in Tables 3-8 are the statistics associated with the two-step results[11]. For this reason it is possible that the Wald-statistic in column (8) in Table 8 rejects the non-significance of the three uncertainty effects, whereas the (individually and jointly) presented one-step GMM-parameter estimates of these effects are not significant.

8 Summary and Conclusions

Firm specific uncertainty measures have been calculated for sales and prices for both Belgium and Spain. First, their relation with investment is analyzed in a direct way. The results show that both demand and price uncertainty correlate significantly with corporate investment, giving us an indication that these types of uncertainty might influence investment. Next, these uncertainty effects are included in dynamic investment equations, taking into account price levels, average capital productivities and debt-to-capital ratios.

GMM-results show that output price uncertainty depresses investment in Spain, a result exactly in line with US results for competitive firms described by Ghosal (1996). But for the whole sample of firms in both Belgium and Spain, sales uncertainty has no effect. A closer look at the data shows that low and high uncertainty turn out to be directly linked with small and large firms, strongly for Belgium and a bit weaker for Spain. Possibly large firms face larger demand fluctuations than small ones. But, neither for the small nor the large firms, the impact on investment is significant.

On the contrary, splitting the sample in low- and high-leverage firms shows the impact from uncertainty on investment. Those firms that (have to) rely on own funds, instead of debt, are significantly affected by both sales and output price uncertainty in Belgium and output and investment price uncertainty in Spain. Uncertainty depresses investment, and is more depressive for low- than high-leverage firms. A possible explanation for these results is that firms with much debt do not react as much to uncertainty as firms funded with relatively more equity. A high probability

[11]These statistics are not provided in the GMM-program for the one-step estimations.

of bad outcomes, so low sales and/or low output prices, and hence low revenues, seems to refrain owners and/or managers of firms in Belgium and Spain from investing or gives them an incentive to delay investment.

To conclude, these analyses corroborate the findings in other studies that uncertainty factors are not negligible and tend to depress investment for certain groups of firms. Even after strongly filtering the data over a considerable period of 9 to 11 years, taking into account price levels, scale effects and financial restrictions that are faced by Belgian and Spanish investors, significant effects are found from demand and price volatility. Firm-specific aspects have been shown to be decisive to analyze firms' reactions towards uncertainty.

A Appendix : Data Constructions

Most variables are from the balance sheet and the income statement of the Central Belgian and Spanish Bank (see also Barrán Cabrera (1996) and, for instance, Estrada and Vallés (1995) where the Belgian and Spanish dataset, respectively, were used previously):

- For Belgium the real physical capital stock ($K_{i,t}$) is the balance sheet value of capital stock deflated by the sectoral investment goods price. For Spain the physical capital stock is constructed with the capital accumulation rule, with an initial capital stock value and depreciation rate. For Spain the capital stock variable does not include land and natural resources. For Belgium land is included because it appears on the balance together with buildings.
- For Belgium gross investment ($I_{i,t}$) is calculated with the capital accumulation rule, i.e. $I_{i,t} \equiv \frac{I^n_{i,t}}{P^{In}_{s,t}}$ where $I^n_{i,t} \equiv K^n_{i,t} - K^n_{i,t-1} \frac{P^{In}_{s,t}}{P^{In}_{s,t-1}}$ + capital depreciation, $K^n_{i,t-1}$ is the nominal capital stock and $P^{In}_{s,t}$ the nominal sectoral investment price. For Spain gross investment is calculated from questionaires.
- Cash flow ($CF_{i,t}$) is value added minus wage costs;
- Value added ($Y_{i,t}$) equals the value of production minus intermediate inputs;
- Sales ($S_{i,t}$) is turnover;
- Tobin's q ($q_{i,t}$) is calculated as the sum of real equity and real debt minus real inventories, divided by the real capital stock (following, among others, Leahy and Whited (1996)). The first variables are obtained by deflating by the sectoral output prices, the capital stock is deflated by the investment price for Belgium, and by a capital stock deflator for Spain;
- Debt is the sum of the financial debts payable within one year and the financial debts payable after one year;
- Equity is total liabilities minus debt;
- Real investment price ($P^I_{s,t}$) are obtained by dividing the nominal sectoral investment price by the sectoral output price $P_{s,t}$;
- The adjusted user cost of capital is $J_{i,t} \equiv P^I_{s,t} - (\frac{1-\delta_{i,t}}{1+r_t}) P^I_{s,t+1}$, where $\delta_{i,t}$ is the depreciation rate of the capital stock and r_t a nominal interest rate. De depreciation rate is calculated for each firm from the aggregate depreciation (available from the income sheet) and the nominal capital stock. Like in Alonso-Borrego (1994), the nominal interest rate is a weighted average of the market long-term interest rate and short-term interest rate, being here the government bond yield and the three-months interest rate of the International Financial Statistics (IMF). As weights the proportion of long- and short-term debt are used.

The data for the Belgian output prices were kindly provided by Eurostat. In Tables A.1 and A.2 some descriptive statistics are presented.

Table A.1 Number of firms per number of years

	Belgium 1984-1992	Spain 1983-1993
Number of years	Number of firms	Number of firms
5	2	131
6	8	159
7	11	144
8	16	144
9	271	164
10		140
11		396
Number of firms	308	1278
Total observations	2697	11101

Table A.2 Number of observations per industry

Belgium		Spain	
Industry	# obs	Industry	# obs
1 Heavy metal	107	1 Minerals and heavy metal products	197
2 Mineral extraction	52	2 Non-metal minerals and products	1083
3 Minerals, non-metal	204	3 Chemicals	1472
4 Chemical	299	4 Metal products	1136
5 Synthetics	18	5 Industrial equipment	693
6 Metal	282	6 Office equipment	39
7 Machinery	298	7 Electrical equipment	636
8 Electrical equipment	191	8 Transport equipment	629
9 Cars	80	9 Food	1824
10 Transport equipment	45	10 Textiles, clothing and footwear	1466
11 Optical equipment	7	11 Paper and publishing	776
12 Food	81	12 Rubber and plastics	541
13 Textile	131	13 Wood, cork and other manufacturing	609
14 Leather	340		
15 Shoes and clothing	9		
16 Wood and wooden furniture	72		
17 Paper and publishing	136		
18 Rubber and plastics	249		
19 Other manufacturing industry	96		
Total obs.	2697		11101

B Appendix : Derivation Dynamic Model

Under the assumption of linear homogeneity of the production function it holds that

$$F(K_{i,t}, N_{i,t}) = F_{Ki,t}K_{i,t} + F_{Ni,t}N_{i,t} \qquad \Leftrightarrow \qquad F_{Ki,t} = \left[\frac{CF}{K}\right]_{i,t} \tag{13}$$

where $CF_{i,t} \equiv F(K_{i,t}, N_{i,t}) - W_{i,t}N_{i,t}$ is the cash flow and (8) has been substituted.

Substituting (13) and (7) in (9) it follows that

$$\begin{aligned}
\left[\frac{CF}{K}\right]_{i,t} &= b\left(\left[\frac{I}{K}\right]_{i,t} - \nu_{2i,t}\right) - \frac{b}{2}\left(\left[\frac{I}{K}\right]_{i,t}^2 - \nu_{2i,t}^2\right) - b\left(\frac{1-\delta_{i,t}}{1+r_t}\right)E\{\left[\frac{I}{K}\right]_{i,t+1} - \nu_{2i,t+1}|\Omega_{i,t}\} \\
&+ \nu_{1i,t} + P_{s,t}^I - \left(\frac{1-\delta_{i,t}}{1+r_t}\right)E\{\nu_{1i,t+1} + P_{s,t+1}^I|\Omega_{i,t}\} \qquad \Leftrightarrow \\
\left[\frac{CF}{K}\right]_{i,t} - J_{i,t} &= b\left(\left[\frac{I}{K}\right]_{i,t} - \frac{1}{2}\left[\frac{I}{K}\right]_{i,t}^2 - \psi_{i,t}\left[\frac{I}{K}\right]_{i,t+1}\right) \\
&+ \nu_{1i,t} - \psi_{i,t}\nu_{1i,t+1} - b(\nu_{2i,t} - \frac{1}{2}\nu_{2i,t}^2 - \psi_{i,t}\nu_{2i,t+1}) + \epsilon_{i,t}
\end{aligned} \tag{14}$$

where

$$\begin{aligned}
J_{i,t} &\equiv P_{s,t}^I - \psi_{i,t}P_{s,t+1}^I \\
\psi_{i,t} &\equiv \frac{1-\delta_{i,t}}{1+r_t}.
\end{aligned}$$

The unobserved terms have been substituted by their realisations. Therefore an error term, $\epsilon_{i,t}$, with mean zero and uncorrelated with the information set available to the firm at time t, is added to the equation. In case of non-constant-returns-to-scale the term Y/K appears. It is further possible to include credit constraints, in the sense that the interest rate depends on the debt-to-capital ratio (see Bond and Meghir (1994) or for a full derivation Barrán Cabrera and Peeters (1996)), by which a debt-to-capital ratio (squared) appears in the equation. The final reduced form solution is then given by (10).

C Appendix : Justification Inclusion Uncertainty Effects

The first order conditions of the profit maximizing model (4) are given as

$$\tilde{F}_{Ki,t} = \frac{\tilde{p}_{i,t}^{In}}{\tilde{p}_{i,t}} - \psi_{i,t}\frac{\tilde{p}_{i,t+1}^{In}}{\tilde{p}_{i,t+1}}, \tag{15}$$

where $\tilde{F}_{Ki,t}$ represents the marginal capital productivity, $\tilde{p}_{i,t}$ the nominal output price, $\tilde{p}_{i,t}^{In}$ the nominal input price and $\psi_{i,t}$ is as defined in (14). For the sake of simplicity, perfect foresight is assumed and adjustment costs are assumed to be zero here, i.e. $b = 0$ in (6). So (9) has boiled down to (15).

We consider demand uncertainty, that affects the marginal productivity, and price uncertainties, that affect output and investment prices. So it can be assumed that

$$\tilde{F}_{Ki,t} \equiv F_{Ki,t} + \kappa_1\sigma_{i,t}^s, \qquad \tilde{p}_{i,t}^{In} \equiv p_t^{In} + \kappa_2\sigma_{i,t}^I, \qquad \tilde{p}_{i,t} \equiv p_{i,t} + \kappa_3\sigma_{i,t}^p, \tag{16}$$

where $\sigma^s_{i,t}, \sigma^I_{i,t}, \sigma^p_{i,t}$ are the standard deviations of sales, output prices and investment prices (possibly dependent on time t), and all κ's are in between (about) -2 and 2. In case of certainty, that is the standard case, all σ's are zero. In the case of uncertainty, the marginal productivity and prices can vary between the average value and $\pm 2\sigma_{i,t}$.

From substituting (16) in (15) it follows that

$$\begin{aligned} F_{Ki,t} &= \frac{p^{In}_{i,t}}{p_{i,t}} - \psi_{i,t}\frac{p^{In}_{i,t+1}}{p_{i,t+1}} + \nu_{i,t} - \psi_{i,t}\nu_{i,t+1} \qquad \text{where} \qquad (17) \\ \nu_{i,t} - \psi_{i,t}\nu_{i,t+1} &\equiv -\kappa_1\sigma^s_{i,t} + \frac{\kappa_2\sigma^I_{i,t}}{p_{i,t} + \kappa_3\sigma^p_{i,t}} - \frac{\kappa_3\sigma^I_{i,t}p^I_{i,t}}{p^2_{i,t} + \kappa_3\sigma^p_{i,t}p_{i,t}} - \psi_{i,t}[\frac{\kappa_2\sigma^I_{i,t+1}}{p_{i,t+1} + \kappa_3\sigma^p_{i,t+1}} + \frac{\kappa_3\sigma^I_{i,t+1}p^I_{i,t+1}}{p^2_{i,t+1} + \kappa_3\sigma^p_{i,t+1}p_{i,t+1}}] \\ &\approx -\kappa_1\sigma^s_{i,t} + \kappa_2[\frac{\sigma^I_{i,t}}{p_{i,t}} - \psi_{i,t}\frac{\sigma^I_{i,t+1}}{p_{i,t+1}}] - \kappa_3[\sigma^p_{i,t}\frac{p^I_{i,t}}{p^2_{i,t}} - \psi_{i,t}\sigma^p_{i,t+1}\frac{p^I_{i,t+1}}{p^2_{i,t+1}}]. \end{aligned}$$

In this last step, all small terms have been omitted.

This expression equals (10) where $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$ and labour is neglected. If we call the right hand side of (17) the "marginal costs", it follows that *current* sales uncertainty, and *current* as well as *future* nominal output price and nominal investment price uncertainty affect these costs. The current uncertainty effects are estimated to be as in (3), whereas the future uncertainty effects are predicted. The effect they actually have, depends on the κ's that reflect the "risk" attitude of the investors. In case where $\kappa_1 > 0$, sales uncertainty depresses the marginal costs, which is logical as an increase in the expected sales improves the revenues. The higher uncertainty is, the sooner investment is triggered. The same holds for the output price uncertainty (in general, since $\psi_{i,t} < 1$). On the other hand, if $\kappa_3 > 0$ more investment price uncertainty increases the marginal costs in which case there is a tendency to delay investment.

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