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FIRMS INVESTMENT DECISIONS IN RESPONSE TO DEMAND AND PRICE UNCERTAINTY

FIRMS' INVESTMENT DECISIONS IN RESPONSE TO DEMAND AND PRICE UNCERTAINTY

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Abstract

We investigate the effect of demand and price uncertainty on firms' planned and realized investment from a panel of manufacturing firms. Uncertainty measures are derived from firms' own expectations about demand and prices and firm's sales. We find that demand uncertainty at the time of planning depresses planned and subsequent realized investment. Firms do not revise their plans due to demand uncertainty at the time of spending, suggesting that reducing demand uncertainty will only have lagged effects on investment. We do not find any effect of price uncertainty. Our results are consistent with the behavior of monopolistic firms with irreversible capital.

I.   Introduction

In this paper we empirically assess the effect of demand and price uncertainty on firm's investment decisions. Our unique dataset not only contains actual realized investment but also investment plans a year in advance so that we are able to assess the impact of uncertainty on the level of investment, and also analyze its effect on the timing of investment decisions. A large body of literature has investigated the effect of uncertainty on investment. The theoretical implications of uncertainty on investment are twofold. First, uncertainty may affect the level of investment. Second, uncertainty may affect the timing of investment. Although it is uncontroversial that uncertainty may theoretically affect investment, there is no conclusive agreement on the sign of the investment-uncertainty relationship

We construct measures of demand and price uncertainty that are relatively close to their theoretical counterparts and capture the investment decision process at the firm level. To measure uncertainty, we rely on a survey in which firms report their own subjective expectations of future demand and output price changes. This allows us to avoid measurement problems often encountered in the literature, and which are related to the assumption on the expectation formation model, and the identification of demand shocks. For robustness we compare our results with those obtained using more widely used measures of uncertainty. More precisely we consider the volatility of sales growth and the volatility of sales growth forecast errors. As to investment decisions, we use an investment survey that contains quantitative information on planned and realized investment of manufacturing firms. Combining the two surveys, we examine the effect of demand and price uncertainty on the level of investment. We consider both the ex ante investment decisions (investment plans) and the ex post investment realizations. Next, by comparing the difference between planned and realized investment, we analyze the effect of uncertainty on the timing of investment. By looking at both the level and timing effects and by considering both demand and price uncertainty this paper provides empirical tests of three theories: the theory of firm investment under price uncertainty, the theory of firm investment under demand uncertainty and the real-options theory of investment. To our knowledge, only Butzen et al (2002) and Guiso and Parigi (1999) analyze firm-specific investment plans.

The implications of demand and price uncertainty for the level of firm investment have been derived by Hartman (1972), Abel (1983) and Caballero (1991), among others. Hartman (1972) and Abel (1983) show that output price uncertainty increases investment of a risk-neutral firm operating in perfect competition with a constant returns to scale production function and no irreversibility. Within such a setting, the marginal profitability of capital is convex in the output price, so that Jensen's inequality applies.[1] Caballero (1991) shows that this result solely depends on

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[1]   An increase in price uncertainty increases the probability of both positive and negative price shocks. However, by convexity of the marginal profitability of capital, increases in profitability due to positive price shocks are larger than reductions in profitability due to negative price shocks.

the assumption of perfect competition and constant returns to scale. He finds that the investment-uncertainty relationship remains positive for perfectly competitive firms even if the capital stock is irreversible. Imperfect competition (or decreasing returns to scale) dampens the positive effect of demand uncertainty on investment.[2] If, in addition, the capital stock is irreversible, i.e. if capital cannot be resold or only at a lower price than the purchase price, the sign of the investment-uncertainty relationship may turn negative. Indeed, when the capital stock cannot be resold free of charges, the firm prefers to have insufficient capacity rather than excess capital stock. Since increased uncertainty raises the probability of excess capital stock, the firm will invest less today to reduce the probability of excess capacity tomorrow.[3]

In conclusion, the direction of the investment-demand uncertainty relationship depends on the combination of the slope of the demand curve (i.e. the degree of competition), the asymmetry of adjustment costs (i.e. the degree of irreversibility) and the degree of returns to scale.[4] More market power, more decreasing returns to scale and more irreversibility all make it more likely that the investment-demand uncertainty relationship is negative. So, under imperfect competition (or decreasing returns to scale), more demand uncertainty may reduce investment. On the contrary, under perfect competition, increased price uncertainty should enhance investment. Since we have no prior information on whether firms in our sample operate in rather imperfect or in close to perfectly competitive markets, we test both demand and price uncertainty on the same firms. In doing so, we examine the predictions made in Hartman (1972) and Abel (1983) for perfectly competitive firms, and in Caballero (1991) for imperfectly competitive firms. We predict that, if firms of our sample are perfectly competitive, our measure of price uncertainty will affect investment positively, whereas, if they are imperfectly competitive, the measure is likely to be insignificant, and demand uncertainty is likely to reduce investment.

The effect of uncertainty on the timing of investment is investigated in the real-options theory. Using the theory of options, McDonald and Siegel (1986), Dixit and Pindyck (1994) and Abel and Eberly (1994), among others, show that, when investment is irreversible and there is some flexibility in the timing of investment, there is a positive-value option to wait. In fact, by waiting, the firm incurs a loss of current profits but acquires more information about the uncertain future; hence, waiting (partly) dissolves uncertainty. Uncertainty increases the value of the waiting option thereby making it more optimal to postpone investment. Abel et al. (1996) consider the more general case with additional costs of waiting and the capital stock not necessarily being fully irreversible. In their model, on the one hand, the firm has an option to wait (expandability option),

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[2]   This can be attributed to the following fact. With a flat demand curve, the perfectly competitive firm can benefit from both price and output increases, in response to a positive demand shock. With an elastic demand curve, the imperfectly competitive firm can increase output only at the cost of lower prices. Therefore, the profit derived from a positive demand shock is lower.

[3]   For perfectly competitive firms the marginal profitability of capital does not depend on previous investment so that irreversibility does not affect the sign of the investment-uncertainty relationship.

[4]   We do not consider risk aversion in the discussion and rather assume that firms are risk-neutral.

but this may be costly when future investment prices are higher than current investment prices. On the other hand, when the capital stock may be resold, even though the resale price may be lower than the purchase price, the firm has a reversibility option. Increased uncertainty (about future returns) increases the value of both the expandability and the reversibility options, so that the ultimate effect on investment is ambiguous. But the effect turns negative, as investment is more irreversible. In sum, increased uncertainty tends to delay investment when the capital stock is more irreversible. In this paper, we investigate the effect of new information on investment revisions, defined as the difference between realized and planned investment. In this way, we analyze the predictions of the real-option theory, according to which firms have a positive-value option to wait in order to gather more information about the uncertain future, thereby reducing uncertainty. We test whether firms modify their investment plans in view of new information on their fundamentals or because firms are faced with different uncertainty at the time of investment realization than at the time of investment planning.

Our results show that demand uncertainty has a negative effect on investment plans and realized investment. These results confirm the prediction of the literature on uncertainty for imperfectly competitive firms (as in Caballero, 1991). We find no effect of price uncertainty. We argue that our measure of price uncertainty is ill-suited for imperfectly competitive firms, because future price changes may be known rather than uncertain for price-setting firms. In addition, we find that, on average, firms carry out little revisions of their investment plans, although there are substantial variations across firms. Our estimates indicate that firms do not adjust their investment decisions given a reevaluation of uncertainty at the time of the investment realization. This results holds for all measures of uncertainty considered. On the contrary, our results suggest that firms adjust their investment decisions to new information about sales growth.

The rest of the paper is structured as follows. In section II we describe the related literature in more detail. Section III discusses our measures of uncertainty. In section IV we present the data. In Section V we develop the empirical framework. Section VI contains our empirical results. We first evaluate the effect of uncertainty on investment plans and investment realizations. Next, we investigate the differences in the plans and realizations behavior. Then, we test whether, as predicted by the real-option theory, firms revise their investment decisions in response to new information about fundamentals or because they consider uncertainty at the time of realization in addition to uncertainty at the time of planning. Section VII concludes.

II.   Related literature

The literature on the relationship between uncertainty and investment is relatively extensive. A recent detailed survey is provided by Carruth et al. (2000). In this paper we focus on the effect of firm-specific uncertainty on firm 's investment. Three types of firm-level uncertainty are recurrent in this literature. First, the relationship between investment and output price uncertainty for the

perfectly competitive firm is developed in Hartman (1972), Abel (1983) and Abel and Eberly (1997). They focus on uncertainty about future output price changes, which is formally defined as its variance. Second, the effect of demand uncertainty on investment for the imperfectly competitive firm is analyzed in Caballero (1991). He defines uncertainty as the variance of a shock to the demand curve. Third, the consequences of profit uncertainty for investment are investigated in Abel and Eberly (1994). Uncertainty in this model is defined as the variance of a shock to the profit function. The advantage of this modeling approach is that the shock to the profit function incorporates all possible shocks stemming from both demand and supply side factors: i.e. changes in tastes, technology, output prices and input prices.

There is a large literature on the macroeconomic effects of uncertainty on investment. For example, in a panel of OECD countries, Caselli et al (2003) find that increased uncertainty, measured by the standard deviation of monthly and sector industrial production indexes, reduced the sensitivity of investment to sales growth and contributed to the slowdown of capital accumulation in the early nineties in Europe. Price (1995) finds that uncertainty about GDP, measured through using a GARCH-M model for GDP, reduces macroeconomic investment, by 5% on average in the United Kingdom. He also finds evidence of delayed effects of uncertainty, his estimates suggest that the full effect of uncertainty on investment comes after three years.

At a more disaggregated level, most of the empirical literature use industry-level data. For example, Ghosal and Loungani (2000) measure profit uncertainty by the standard deviation of the residuals of a profit-forecasting equation at the industry level and hence are close to the theoretical uncertainty measure. They find that profit uncertainty reduces industry investment. Ghosal and Loungani (1996) and Henley et al. (2003) test the effect of output price uncertainty on investment at the industry level. They find a negative impact of price uncertainty on investment. The magnitude of the effect may depend on the degree of competition. For Ghosal and Loungani (1996) it is significant only in competitive industries. For Henley et al. (2003), the effect is more significant in concentrated industries. Fedderke (2004) finds that the effect of sector uncertainty, measured by the standard deviation of value added, has a negative effect on manufacturing investment.

In contrast to these papers, we focus on individual investment by firms, which is the level of investment considered in theory. We only know of a few other papers that investigate the relationship between firm's investment and firm-specific uncertainty. Most of these papers however use measures of uncertainty that are difficult to interpret in light of the theory. In a seminal paper, Leahy and Whited (1996) use a forecast of the variance of the daily stock return as their measure of uncertainty. They find that it negatively affects investment. Although they argue that stock return volatility captures all forms of uncertainty that are relevant for the firm 's investor, it remains that their measure has no direct theoretical counterpart. In addition, stock returns are quite noisy. In the same spirit, Bulan (2005) measures total firm uncertainty as the realized volatility of the firm's

equity returns. She finds that industry uncertainty as well as firms-specific uncertainty reduces investment. Bloom et al. (2003) also use the variance of stock returns to measure uncertainty and again find that uncertainty depresses investment. Bond and Cummins (2004) introduce a dispersion measure of analysts profits forecasts as the measure of uncertainty and find that it negatively affects investment.

A few papers use the volatility of unpredictable sales shocks to construct measures of output uncertainty. Von Kalckreuth (2003) uses the variance of the errors of a sales forecasting equation. Bo (2002) relies on forecast errors of sales derived from a state space model. They both find that output uncertainty negatively affects investment. However, sales uncertainty measures are difficult to interpret. Since sales changes are the result of both demand and supply shocks, sales volatility is caused both by demand uncertainty and the volatility of supply shocks.[5] As such, sales volatility is not directly related to any theoretical counterpart. In contrast to these papers, we use a measure of demand uncertainty. However, for the sake of comparison and as a robustness analysis, we also consider two measures of output volatility, namely the volatility of sales growth and the volatility of the forecast errors of sales growth.

In all the papers mentioned above, except that of Bond and Cummins (2004)[6], the uncertainty measures are based on observable variables. At best, forward-looking measures are obtained from forecasting equations. By doing so, the econometrician implicitly assumes that all firms produce their forecasts according to this particular forecasting model. Only a small number of papers have used survey data to measure directly firms' perceived uncertainty. Guiso and Parigi (1999) and Patillo (1998) use surveys in which the respondents provide their subjective probability distribution of their own demand changes. Thus, they are able to construct firm-specific measures of future demand growth variance. This measure is clearly the closest to the variance of the shock to the demand curve as in Caballero (1991). Guiso and Parigi (1999) find that increased demand uncertainty reduces investment, and more so for firms with more market power and a more irreversible capital stock. For Ghanaian firms, Patillo (1998) finds that uncertainty raises the trigger value at which firms invest. Temple et al. (2001) use a survey in which firms must report whether demand uncertainty limits their capital expenditure, but they do not construct a measure of uncertainty. As in our paper, Driver et al. (2004) rely on a survey in which firms convey their qualitative expectations about future developments to construct a measure of uncertainty. In an

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[5] To illustrate this, consider the following simplified demand and supply functions for a single firm (1) $P_d = C_d.e^{\varepsilon d}.Q^{\psi}$ with $\psi \leq 0$ ($\psi = 0$ for a perfectly competitive firm), and (2) $P_s = C_s.e^{\varepsilon s}.Q^{\varphi}$ with $\varphi > 0$, where εd and εs are, respectively, demand and supply shocks independent of each other and with respective variances σ_d and σ_s. From the equilibrium condition on the goods market it may easily be shown that the variances for (the log of) output, q, and prices, p, depend on the variance of both demand and supply shocks:

$$\text{var}[q] = \sigma_q = \left(\frac{1}{\varphi - \psi}\right)^2 (\sigma_d + \sigma_s) \quad \text{and} \quad \text{var}[p] = \sigma_p = \left(\frac{1}{\varphi - \psi}\right)^2 (\varphi^2.\sigma_d + \psi^2.\sigma_s)$$

[6] Bond and Cummins (2004) use analysts' quantitative expectations of the firm's future profits. Since expectations are not formed by the firm itself, their uncertainty measure is essentially the market's perceived risk about the firm rather than the firm 's perceived uncertainty.

industry-level analysis, they find that uncertainty about future business conditions depress investment authorizations.

III. Measuring uncertainty

We use the monthly Belgian Business Cycle survey to construct our measures of uncertainty. This survey provides firms' expectations about their own future demand and price changes, on the basis of which we construct demand and price uncertainty measures. It reports qualitative information on firms' own subjective expectations about future demand and prices changes. Our measure of demand uncertainty is based on the answers to the following question:[7]

Do you expect demand for your product, in the next three months (A) to rise, (B) to remain unchanged, (C) to decrease, with respect to its average level at that time of the year?

The question directly asks for *demand*, not output. We assume that the person answering that question therefore presumably thinks first about external factors that can affect the firm's demand, i.e. shocks that shift the demand curve. It seems less plausible that the person thinks of the firm's supply function, hence of input prices, labor costs, technology shocks, taxation, etc.

The answers to the question above capture the firm's own subjective expectation of the value of a future demand shock. These answers are qualitative and are used to construct a measure of demand uncertainty. This approximates the variance of demand shocks on the following assumptions. Assume each firm i from industry j at time t+1 will receive a demand shock $d_{ijt+1}=M_{ijt+1}+I_{ijt+1}$, whereby the demand shock can be written as the sum of a random variable M_{ijt+1} that distributes good and bad outcomes across firms within industry j, and I_{ijt+1} is a firm idiosyncratic shock, orthogonal to M_{ijt+1} with mean zero. M_{jt+1}, can take three values: $+m_{jt+1}$, 0, $-m_{jt+1}$ with respective probabilities $p_{jt+1}(+)$, $p_{jt+1}(0)$ and $p_{jt+1}(-)$. In other words, a fraction $p_{jt+1}(+)$ of the firms will receive a good outcome, a fraction $p_{jt+1}(-)$ of the firms will receive a bad outcome. The variance of the demand shocks firms face each period is equal to $var(d_{ijt+1})=m_{jt+1}^2 \cdot ([p_{jt+1}(+)+p_{jt+1}(-)]-[p_{jt+1}(+)-p_{jt+1}(-)])^2)+var(I_{ijt+1})$.

Assume now that at time t (the time at which the firms answer the questionnaire) each firm observes a signal S_{ijt} that can take on three values, say 1,0,-1, and that is perfectly correlated with the shock M_{ijt+1}. Firms use this signal to form rational expectations about the mean value of their future demand shock and to answer the question of the Business Survey above. Firms receiving the signal 1 can rationally expect a positive shock and expect demand to rise and therefore answer (A), firms receiving the signal −1 rationally expect a negative shock and therefore answer (C). The

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[7] The Business Survey reports information by firms' product and plant rather than by firm. Since the information is qualitative we cannot simply add the information for each product. We select the product that accounts for most of the firm's turnover to approximate the firm's total demand.

variance of the signal is equal to $\mathrm{var}(S_{ijt}) = [p_{jt}(+) + p_{jt}(-) - (p_{jt}(+) - p_{jt}(-))^2]$. Because the signal S_{ijt} is perfectly correlated with M_{ijt+1}, there will be a fraction $p_{jt}(+) = p_{ijt+1}(+)$ of the firms expecting a positive demand shock and a fraction $p_{jt}(-) = p_{ijt+1}(-)$ of the firms expecting a negative demand shock. Therefore the variance of the signal is also equal to $([p_{jt+1}(+) + p_{jt+1}(-)] - [(p_{jt1}(+) - p_{jt+1}(-)]^2)$

The answers to the questions above allow us to approximate this variance. We estimate $p_{jt}(+)$ and $p_{jt}(-)$ by the fraction of the answers (A) ($\%_{up\_jt}$) and (C) ($\%_{down\_jt}$), over all months of year t and over all firms of industry j. We use the variance of the signal as our proxy of the variance of the demand shock. The measure of demand uncertainty is then $\hat{\sigma}^d_{jt} = [(\%_{up\_jt} + \%_{down\_jt}) - (\%_{up\_jt} - \%_{down\_jt})^2]$. Using this measure, we do not take into account idiosyncratic differences in uncertainty across firms of the same industry, i.e. we neglect the term $\mathrm{var}(I_{ijt+1})$. This will understate true uncertainty. However, insofar as the variance of the idiosyncratic part of the demand shock $\mathrm{var}(I_{ijt+1})$ varies little over time, it can be subsumed by entering fixed effects in the regressions. Also, our uncertainty measure does not capture changes (over time and across industries) in the "magnitude" of the demand shocks i.e. changes of m^2_{jt+1}. Entering time dummies in the regression will capture common changes in the magnitude of the demand shocks across firms. The construction of the measure also assumes that positive and negative shocks are of equal magnitude m_{jt+1}. We do take into account shifts, over time and across industry, in the probabilities of getting positive, zero, or negative shocks.

Our uncertainty measure is identical to Theil 's disconformity index (1952) for qualitative surveys, i.e.: $a^2 \cdot [(\%_{up\_jt} + \%_{down\_jt}) - (\%_{up\_jt} - \%_{down\_jt})^2]$, with a set to unity. Other measures of the variance of expectations have been proposed (see Nardo, 2003, for a survey). Carlson and Parkin 's probability method (1975) and the time-varying parameter extension of it, are based on the assumption that agents' expectations are drawn from a common probability distribution. One of the drawbacks of these methods is that the variance of expectations cannot be computed as soon as the percentage of respondents that expect an increase, or the percentage of respondents that expect a decrease, is zero. Another method, Pesaran 's regression method (1984, 1987), is based on a regression of agents' expectations as to realized values. In the case of demand expectations, using such approach would impose assumptions on the regression used and identifying assumptions to evaluate realized firm 's demand. For all these reasons, we prefer to use Theil 's disconformity measure of uncertainty.

Uncertainty of a firm in a given industry is higher as more firms in that industry disagree about future economic conditions, or if firms change their mind very often during the same year. Our disconformity measure is a qualitative counterpart to disagreement measures. These have been shown to reflect variance changes directly. Bond and Cummins (2004) construct firm-specific disagreement measures of the firm 's future profits, based on the firm 's earnings forecasts by security analysts. Using an inflation survey in which respondents report their forecasts together with some probability distribution, Bomberger (1996) and Giordani and Söderlind (2003) show that

disagreement, i.e. the cross-sectional variance of forecasts, is proportional to individual uncertainty, i.e. the average of each individual's standard deviation of forecast errors.

Our measure of uncertainty is at the same time forward-looking and time-varying and is therefore well suited to the analysis of the microeconomic behavior of investment in a changing and uncertain environment. An additional advantage is that it is derived from directly observable firms' subjective expectations rather than being based on an assumption about the firms' expectations-formation model. To measure uncertainty the econometrician will in general face two measurement problems. First he has to postulate some forecasting model in order to estimate expectations. Second, he has to identify the appropriate variable of interest. In particular, to measure demand uncertainty, identifying restrictions are necessary to evaluate demand shocks. Price uncertainty is generally measured at the industry level because information on firm-specific output prices is seldom available. Our measure avoids both problems, as it relies on observed expectations for firm-specific demand and price changes. A possible limitation of our uncertainty measure is the short-time horizon (three months) of the question from which it is derived. However, as long as uncertainty over longer horizons is positively correlated with uncertainty over a shorter horizon, our measure will capture relevant features of firms' uncertainty.

We also compare our results with those obtained by two other measures of uncertainty. The first, $\sigma^{\Delta y}_{jt}$, is the sector cross-section standard deviation of sales growth in the sector and over the year in which the firm operates. The second, $\sigma^{\Delta ye}_{jt}$, is the sector cross-section standard deviation of the forecast errors of sales, (as in von Kalckreuth (2003) for example) where forecasts are based on an AR(1) process with sector specific slope, sector specific time trends and firms specific intercept. These measures will ease comparison with other results in the literature. Second they will be used as robustness checks of our measures of demand and price uncertainty. Their main advantage is that they capture longer-term horizon uncertainty than our demand uncertainty measure. On the other hand, they may suffer from the measurement problems as described above.

Finally, our measure of price uncertainty follows that of demand uncertainty; it is based on the answers to the following question of the Business Survey:

> *Do you expect the price of your product, in the next three months, (A) to rise, (B) to remain unchanged, (C) to decrease?*

We construct our measure of price uncertainty in the same way as above, i.e. $\hat{\sigma}^P_{jt} = [(\%_{up\_jt} + \%_{down\_jt}) - (\%_{up\_jt} - \%_{down\_jt})^2]$. It should be clear from the outset that the answer to the question above contains entirely different information for perfectly competitive (price-taking) firms and for imperfectly competitive (price-setting) firms. For perfectly competitive firms the "*price of your product*" is set by market forces independently of the firm's actions. In other words, for perfectly competitive firms, the question can be interpreted as "*Do you expect your (flat) demand*

curve to rise, to remain unchanged or to decrease?". In this case, our price uncertainty measure is a proxy for uncertainty as defined in Hartman (1972) and Abel (1983). On the contrary, for an imperfectly competitive firm, the answer to this question may be related to demand shocks as well as to supply shocks. In addition, and maybe more importantly, the answer to the question above also reflects the firm's (known) price-setting strategy rather than price uncertainty. Therefore, if our measure of price uncertainty mainly reflects intended (and known) price changes rather than market price uncertainty, it may have no effect on the level of investment. We are convinced that our measure of price uncertainty is only a correct measure if firms are price-takers. Since we have no prior knowledge on whether the firms in our sample are price-takers or not, we consider both demand and price uncertainty.

IV.   The data set

We combine three data sources to construct our data set: the Investment Survey data base, the Annual Accounts data base, and the Business Cycle Survey data base. All those three data bases are held at the National Bank of Belgium (NBB).

We focus on large manufacturing firms. We construct two samples, one for investment plans and the other for investment realizations. After matching the various data bases and trimming for outliers, our samples contain respectively 1613 observations for 279 firms for the investment plans sample and 1888 observations for 319 firms observations for the realizations sample. The period covered is 1987-2000 for the investment plans sample and 1987-1999 for the realizations sample. Focusing on large firms offers two advantages. First we avoid the aggregation bias that may result when pooling small and large firms.[8] Second, because large firms in Belgium are required to provide more detailed annual accounts information, we are able to measure the capital stock and output variables more precisely. In particular, for the capital stock, we make a distinction between five types of capital goods, use depreciation rates specific to each type and evaluate the age of the capital stock separately for each component. Appendix A outlines our sample, the construction of the variables, and our trimming procedure in more detail.

The Investment Survey data base contains *quantitative* information on planned and realized investment. Every year, in Autumn, firms announce the amount of their planned investment for the coming year, I^P_{it+1}, the estimated investment of the current year, I_{it}, and the realized investment in the preceding year.[9] The Annual Accounts information is used to construct the capital stock, K_{it}, sales, Y_{it}, cash flow, CF_{it}, and the capital-output ratio.

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[8]   See Butzen et al. (2002) for different cash flow sensitivities between small and large Belgian firms and Ghosal and Loungani (2000) for different investment-uncertainty sensitivity of US firms.

[9]   We very much rely on this survey because in 85% of the cases reported realized investment in the survey coincides with investment as reported in the annual accounts.

Table 1 below summarizes the variables in our sample. The planned investment rate has a mean of 0.09 and a standard deviation of 0.08. The realized investment rate is close to the planned investment with a mean of 0.09 and a standard deviation of 0.09. It is interesting to note that price uncertainty is lower than demand uncertainty and this holds over all years and across all sectors.

Table 1: Descriptive statistics

	Investment plans I^P_{t+1}/K_t					Realized investment I_{t+1}/K_t				
	mean	std	min	median	max	mean	std	min	median	max
I^P_{t+1}/K_t or I_{t+1}/K_t	0.09	0.08	0.00	0.07	0.52	0.09	0.09	0.00	0.06	0.71
I_t/K_{t-1}	0.09	0.09	0.00	0.07	0.77	0.10	0.10	0.00	0.07	1.01
Δy_t	0.02	0.17	-1.02	0.01	1.08	0.01	0.18	-1.05	0.01	1.08
CF_t/K_{t-1}	0.16	0.18	-0.48	0.14	2.07	0.16	0.16	-0.48	0.13	2.06
$(y_{t-1}-k_{t-1})$	0.73	0.74	-1.84	0.68	3.62	0.72	0.74	-1.52	0.69	3.62
σ^d_{st}	0.35	0.05	0.18	0.34	0.54	0.35	0.06	0.18	0.34	0.54
σ^P_{st}	0.25	0.05	0.04	0.24	0.46	0.25	0.05	0.04	0.24	0.46
$\sigma^{\Delta y}_{st}$	0.22	0.02	0.17	0.22	0.27	0.22	0.02	0.17	0.22	0.27
$\sigma^{\Delta ye}_{st}$	0.20	0.02	0.14	0.20	0.25	0.20	0.02	0.14	0.20	0.25

Plans sample: 1613 observations and 279 firms over the period 1987-2000.

Realizations sample: 1888 observations and 319 firms over the period 1987-1999.

I_t represents real fixed investment, I^P_{it+1} plans for real fixed investment in t+1, K_{it} is the capital stock at the end of period t, and k_{it} is the log of K_{it}, y_{it} represents the log of sales in year t, CF_{it} stands for cash flow, σ^d_{st} for demand uncertainty and σ^P_{st} for price uncertainty. $\sigma^{\Delta y}_{st}$ is the sector-specific variance of sales growth, $\sigma^{\Delta ye}_{st}$ is the sector-specific variance of the forecast error of sales growth.

V.   The empirical framework

The theoretical framework of the investment under uncertainty generally does not offer estimable closed-form solutions for investment. The investment equations are therefore not directly suited for empirical testing. Bloom et al. (2003), Bond and Cummins (2004), Fedderke (2004), Ghosal and Loungani (1996, 2000), Guiso and Parigi (1999) and Leahy and Whited (1996) all use some type of reduced-form investment model. We follow this empirical literature. To capture general investment dynamics owing to adjustment costs, installation lags, realization lags etc., we specify investment as an error-correction model. In period t, firms set up their investment plans for year t+1 given the information on the current and past values of their fundamentals, but also given their expectations about the future value of their fundamentals as well to uncertainty about future demand and prices. In period t+1 investment plans are realized. So we regress investment realizations on the same variables as for plans. Defining the planned investment rate in period t for period t+1 as I^P_{it+1}/K_{it} and the realized investment rate as I_{it+1}/K_{it}, our basic specifications for planned and realized investment are

(1) $I^P_{it+1}/K_{it} = \phi_{Pi} + \delta_{Pt} + \alpha_P.I_{it}/K_{it-1} + \gamma_P.E_t(\Delta y_{it+1}) + \beta_P.\Delta y_{it} + \theta_P.\sigma_{jt} + \lambda_P.(y_{it-1}-k_{it-1}) + \varepsilon_{Pit+1}$

(2) $I_{it+1}/K_{it} = \phi_i + \delta_t + \alpha.I_{it}/K_{it-1} + \gamma.\Delta y_{it+1} + \beta.\Delta y_{it} + \theta.\sigma_{jt} + \lambda.(y_{it-1}-k_{it-1}) + \varepsilon_{it+1}$

with σ_{jt} representing uncertainty at time t on future demand or output price (the subscript j denoting that we compute uncertainty of price and demand shocks industry by industry, as explained in section III). Small cases represent logs. Our specification essentially follows Bond et al. (2003) by modeling investment in a dynamic adjustment model. Current output is controlled by entering sales growth (Δy_{it}) in the regression. We also include an error-correction term and assume, as in Bloom et al. (2003), that, in the long run, the capital-output ratio is constant, so that deviations from the long-run equilibrium can be reduced to (k_{it-1}- y_{it-1}). This assumption holds under constant returns to scale. In a forward-looking setup, when making plans in year t for investments in year t+1, firms must forecast sales growth. Since no quantitative measure of firms' own expectations about future sales growth is available, we replace the expected sales growth in period t+1 by realized sales growth Δy_{it+1} and instrument this by lagged values of all RHS variables. This is equivalent to assuming that firms form rational expectations with respect to next-year sales growth[10]. When investment is realized, in t+1, firms now observe sales growth of the period t+1, so Δy_{it+1} must no longer be forecasted. However, Δy_{it+1} still needs to be instrumented because it is endogenous. Indeed, investment realizations in t+1 determine the capital stock in t+1, and therefore the firm's supply and sales. Finally, we include time dummies and fixed effects in the equation. The time dummies (δ_{Pt}, δ_t) capture macroeconomic fluctuations; and together with fixed effects they are also used as a proxy for the user cost of capital. In addition, fixed effects may account for other firm-specific factors such as productivity growth. As argued above, time dummies and fixed effects will also capture time-invariant differences across firms in the level of uncertainty and aggregate fluctuations in uncertainty. Note that, in order to take into account the possibility of financial constraints, we also experiment with including the cash flow-capital ratio CF_{it}/K_{it-1}, in the spirit of Fazzari et al. (1988).

We estimate equations (1) and (2), using the system-GMM estimator, as in Arellano and Bover (1995) and Blundell and Bond (1998). This simultaneously estimates the equation in levels and in first differences. In a sample smaller than ours (140 firms with 7 to 9 annual observations), Blundell and Bond (1998) show that the standard first-differenced GMM estimator shows small sample biases and imprecision in the estimates which can be substantially reduced by exploiting the additional moment conditions of the system-GMM estimator. Differences of the RHS variables serve as instruments for the equation in levels, and lagged levels are used as instruments for the equation in first differences. We assume the uncertainty variables to be exogenous and therefore

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[10] Replacing expected future sales growth by its realization introduces a forecast error in the residual of the investment equation. Therefore the equation must be estimated by instrumental variables. We use the past values of all RHS variables as instruments. So it is equivalent to rational expectations where the information set consists in the past values of all RHS variables.

instrument them by themselves. We assume that all variables in period t are predetermined, i.e. the firm knows the realizations of the current period when it draws up its plans for the next year. Therefore, RHS variables in t-1 and earlier are valid instruments for the difference equation and differences of the variables in t are additional instruments for the level equation. For the difference equation, we use the instruments I_{t-1}/K_{t-2} and I_{t-2}/K_{t-3}, Δy_{t-1} and Δy_{t-2}, σ_{jt} to σ_{jt-2}, as well as $(y_{t-1}-k_{t-2})$. For the level equation, we use $\Delta I_t/K_{t-1}$, $\Delta\Delta y_t$, $\Delta(y_{t-1}-k_{t-1})$, and σ_{jt} as instruments. By not taking all possible further lags we reduce the number of instruments and thereby avoid potential overfitting problems. We report the second step estimation results with t-statistics corrected for small sample bias, using Windmeijer's correction (2004).

VI. Empirical results

We first estimate equations (1) and (2), using the system-GMM estimator, including our measure of either demand or price uncertainty. The results are shown in Table 2a and Table 2b for planned and realized investment. The model is correctly specified, as indicated by the standard Sargan test, m1 and m2 statistics.

Our results indicate that planned investment is significant and positively related to the current investment rate, consistent with a dynamic adjustment of the capital stock. Current sales growth is significant and positively related to planned investment. Next year's sales growth is in general not significant for planned investment.[11] The error-correction term has the right sign and is significant at traditional levels. Demand uncertainty is statistically significant and negative. This is consistent with Caballero's theoretical results (1991) on investment under uncertainty for imperfectly competitive firms. The point estimate is -0.09. A one standard deviation increase in demand uncertainty (0.05) decreases the planned investment-capital ratio by 0.005. With respect to the average level of the investment-capital ratio (0.09), this signifies a drop in investment of around 6.2%. This represents almost one half to one third of the cumulative effect of a one standard deviation decrease in sales growth. Price uncertainty is insignificant. This is also consistent with the theoretical predictions for imperfectly competitive firms. Indeed, for price setting firms, future price changes may be part of the firm's strategy rather than uncertain for price setting firms. Further, under imperfect competition, price uncertainty is a mix of demand and supply uncertainty, and there is no clear theoretical prediction on the effect of the latter. The results are robust to entering the cash flow-capital ratio (not shown in the table)..

The conclusions and order of magnitude of the coefficients are similar for realized investment. As to investment plans, demand uncertainty is negative and significant. The effect of a one standard

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[11]   However it is significant for realized investment. This result is not surprising since firms have to forecast next year's sales growth at the year of planning and know next year's sales growth at the year of realization. This finding is consistent with the firm's forecast of next years sales growth being largely captured by current sales growth and firms reacting to sales growth surprises in the year of realization (a more formal test is performed below.)

deviation increase in demand uncertainty on realized investment is of the same order of magnitude as for investment plans (6.2%).

In Table 2b, we also consider two measures of sales uncertainty, the standard deviation of sales growth and the standard deviation of forecast errors of sales. The impact of each variable on investment is of the same order of magnitude. The volatility of sales growth has a significant negative impact on planned and realized investment of that year. The same holds for the volatility of forecast errors of sales, although it is not significant in the realization sample. A one standard deviation increase in sales uncertainty reduces investment plans by 5%. The impact on investment realization lies between 4% and 5.7%.

Our results indicate that demand uncertainty reduces both investment plans and investment realizations. We estimate the effect of a one standard deviation increase in uncertainty as around 6% of -the average investment ratio. This is close to but somewhat higher than what can be computed from the results of Butzen et al. (2003), 2.9%, and Guiso and Parigi (1999), 4.7%, for demand uncertainty. For sales uncertainty, von Kalckreuth (2003) estimates this effect at 3.7%. And for price uncertainty the results in Ghosal and Loungani (1996) for competitive industries amount to 4.2% to 6.9% and in Henley et al. (2003) to 3.6%. The results of Bond and Cummins (2004) suggest an effect on the investment ratio of around 6%.

Table 2.a: Effect of demand and price uncertainty on planned and realized investment

Dependent variable	Investment plans I^P_{t+1}/K_t				Realized investment I_{t+1}/K_t			
	coef,	t-stat	coef,	t-stat	coef,	t-stat	coef,	t-stat
constant	0.08	4.51 ***	0.05	3.36 ***	0.10	5.93 ***	0.07	4.15 ***
I_t/K_{t-1}	0.13	3.70 ***	0.11	3.21 ***	0.18	4.27 ***	0.18	4.04 ***
Δy_{t+1}	0.01	0.46	0.01	0.80	0.08	3.12 ***	0.04	1.69 *
Δy_t	0.05	4.05 ***	0.04	4.35 ***	0.03	2.80 ***	0.03	3.07 ***
$(y_{t-1}-k_{t-1})$	0.03	3.68 ***	0.03	3.94 ***	0.02	3.75 ***	0.01	2.41 **
σ^d_{st}	-0.09	-2.76 ***			-0.10	-2.64 ***		
σ^p_{st}			0.04	1.07			-0.01	-0.14
	coef,	p-value	coef,	p-value	coef,	p-value	coef,	p-value
Sargan	130.44	0.35	139.79	0.42	129.39	0.31	129.41	0.31
m1	-5.47	0.00	-5.22	0.00	-6.62	0.00	-6.57	0.00
m2	1.37	0.17	1.08	0.28	0.88	0.38	0.83	0.41
#obs # firms	1613	279	1613	279	1888	319	1888	319

Second step system GMM estimates with Windmeijer (2000) 's corrected t-stat 2nd step Sargan. All estimations include time dummies. As to the difference equation, we use Arellano-Bond instrument matrix for I_{t-1}/K_{t-2} to I_{t-2}/K_{t-3}, Δy_{t-1} to Δy_{t-2}, σ_{jt} to σ_{jt-2}, and the level of $(y_{t-1}-k_{t-1})$ As to the level equation, we use Arellano-Bond instrument matrix for $\Delta I_t/K_{t-1}$, $\Delta\Delta y_t$, $\Delta(y_{t-1}-k_{t-1})$, and σ_t σ^d_{st} represents demand uncertainty, it

is the Theil index of firms' qualitative expectations of their own future demand growth. σ^p_{st} represents price

uncertainty, it is the Theil index of firms' qualitative expectations of their own future prices

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 2.b: Effect of sales uncertainty on planned and realized investment

Dependent variable	Investment plans I^P_{t+1}/K_t				Realized investment I_{t+1}/K_t				
	coef,	t-stat	coef,	t-stat	coef,	t-stat		coef,	t-stat
constant	0.09	3.24 ***	0.08	3.46 ***	0.11	7.48 ***		0.09	3.53 ***
I_t/K_{t-1}	0.12	3.22 ***	0.13	3.58 ***	0.19	13.23 ***		0.18	4.21 ***
Δy_{t+1}	0.03	1.33	0.04	2.11 **	0.05	3.44 ***		0.05	2.03 **
Δy_t	0.05	4.24 ***	0.05	4.62 ***	0.04	6.80 ***		0.04	3.45 ***
$(y_{t-1}-k_{t-1})$	0.04	3.64 ***	0.04	3.64 ***	0.02	4.48 ***		0.02	2.36 **
$\sigma^{\Delta y}_{st}$	-0.17	-1.72 *			-0.22	-3.45 ***			
$\sigma^{\Delta ye}_{st}$			-0.17	-1.80 *				-0.13	-1.10
	coef,	p-value	coef,	p-value	coef,	p-value		coef,	p-value
Sargan	153.17	0.16	148.74	0.23	138.25	0.15		126.87	0.36
m1	-5.32	0.00	-5.35	0.00	-6.55	0.00		-6.65	0.00
m2	1.02	0.31	1.02	0.31	0.83	0.41		0.78	0.44
#obs # firms	1613	279	1613	279	1888	319		1888	319

Second step system GMM estimates with Windmeijer (2000) 's corrected t-stat 2nd step Sargan. All estimations include time dummies. As to the difference equation, we use Arellano-Bond instrument matrix for I_{t-1}/K_{t-2} to I_{t-2}/K_{t-3}, Δy_{t-1} to Δy_{t-2}, σ_{jt} to σ_{jt-2}, and the level of $(y_{t-1}-k_{t-1})$ As to the level equation, we use Arellano-Bond instrument matrix for $\Delta I_t/K_{t-1}$, $\Delta\Delta y_t$, $\Delta(y_{t-1}-k_{t-1})$, and σ_t σ^d_{st} represents demand uncertainty. $\sigma^{\Delta y}_{st}$ is the sector-specific variance of sales growth, $\sigma^{\Delta ye}_t$ is the sector-specific variance of the forecast error of sales growth.

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

The magnitude of the coefficients is of the same order for planned and realized investment. Table 3a below reports a test for the hypothesis of equal coefficients in the planned and realized investment equations. We regress investment revisions, defined as the realized investment ratio minus planned investment ratio, on all RHS variables. If the hypothesis holds, all coefficients should be not significantly different from zero. Table 3 below reports the system GMM estimates.[12] None of the coefficient is significant, except that of sales growth. We can therefore not reject the hypothesis that the other coefficients on planned and realized investment are equal. In particular,

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[12] The system GMM estimator is necessary because Δy_{t+1} is endogenous since investment revisions in year t+1 will affect the capital stock in year t+1, hence sales over that period. In addition the system GMM estimator allows for fixed effects to differ in the plans and realizations equations. Although this might suggest a systematic bias in the investment plans, this may be the case because firms report investment plans for year t+1 only when these have been approved by the board. So investment decided on in January t+1 and carried out in the same year would not be reported in the plans in year t.

our results indicate that uncertainty has the same impact on investment plans and on investment realizations.

Table 3: Test of equal coefficients in the planned and realized investment equations

Dependent variable is investment revisions: $I_{t+1}/K_t - I^P_{t+1}/K_t$

	coef,	t-stat		coef,	t-stat		coef,	t-stat	
constant	0.017	0.79		-0.009	-0.35		-0.015	-0.60	
I_t/K_{t-1}	0.073	1.27		0.098	1.76	*	0.082	1.42	
Δy_{t+1}	0.034	2.54	**	0.031	2.12	**	0.034	2.30	**
Δy_t	0.007	0.43		0.004	0.26		0.006	0.39	
$(y_{t-1}-k_{t-1})$	-0.001	-0.16		0.002	0.23		0.004	0.36	
σ^d_{st}	-0.019	-0.53							
$\sigma^{\Delta y}_{st}$				0.039	0.36				
$\sigma^{\Delta ye}_{st}$							0.107	0.98	
		p-value			p-value			p-value	
Sargan	81.43	0.50		89.32	0.27		85.92	0.36	
m1	-4.26	0.00		-4.45	0.00		-4.37	0.00	
m2	0.79	0.43		0.94	0.35		0.88	0.38	
# obs	1267			1267			1267		
# firms	261			261			261		

The system GMM reports second step estimates, (ii) Windmeijer (2004) 's corrected t-stat, (iii) 2nd step Sargan. All estimations include time dummies. The estimation period is 1989-1998. The sample contains 622 observations for 94 firms. In system GMM, the difference equation is instrumented with I_{it-1}/K_{it-2} and I_{it-2}/K_{it-3}, Δy_{it} and Δy_{it-1}. The level equation is instrumented with $\Delta(I_{it}/K_{it-1})$, $\Delta\Delta y_{it}$, $\Delta(y_{it-1}-k_{it-1})$, and σ_{st}. σ^d_{st} represents demand uncertainty. $\sigma^{\Delta y}_{st}$ is the sector-specific variance of sales growth, $\sigma^{\Delta ye}_{st}$ is the sector-specific variance of the forecast error of sales growth.

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

If firms' investment decisions at the time of planning fully determine investment realizations, i.e. if plans made at time t are simply carried out in t+1, the coefficients should be equal in the planned and the realized investment regressions. Further, investment revisions should be equal to zero. In our sample investment revisions are very small on average. The sample mean of investment revision amounts to 0.0047, which represents 6% of the mean planned investment rate. However, there is heterogeneity in investment revisions across firms, as the standard deviation of investment revisions is equal to 0.06. Thus, although revisions are on average small, they may be substantial for some firms and years. We therefore investigate the determinants of investment revisions.

By doing so, we not only assess the impact of uncertainty on investment, but we also analyze the investment decision process by comparing investment plans and investment realizations. Due to the unique feature of our data set which contains both investment plans and realizations, we can

construct investment revisions. Thus we are able to study another prediction made in the theoretical literature, which focuses on the effect of uncertainty on the timing of the investment rather than on the level invested. The real-option theory (Dixit and Pindyck, 1994) stresses that, before undertaking investment, firms may have an incentive to wait until new information about the uncertain future is available. We now test whether firms revise their investment decision when new information about the firm's fundamentals is available or because firms are faced with different uncertainty at the time of investment realization than at the time of investment planning.

Investment plans for year t+1 were decided on, given the information and uncertainty that existed when the decision was made, in t. In year t+1, the firm may revise its investment plans because the level of uncertainty has changed from σ_{st} to σ_{st+1} (one year has passed since the investment decision). In addition, at the time the firm realizes its investment decisions it observes rather than forecasts sales growth Δy_{t+1}. We regress the ratio of investment revisions to capital on sales growth and on uncertainty at the time of realization. [13]

(3) $(I_{it+1} - I^{P}_{it+1})/K_{it} = \alpha_1.\Delta y_{it+1} + \alpha_2.\sigma_{st+1} + \varepsilon_{it+1}$

Equation (3) is estimated by system GMM[14]. Results, reported in Table 4, show that none of the uncertainty coefficients is significant. We conclude that, as to investment, firms might find it difficult to deviate substantially from their plans, even if uncertainty changes. This suggests that the investment planning decision determines investment realizations to a large extent. An important factor for investment is the level of uncertainty at the time plans are on the drawing board rather than when the plans are carried out. For policymakers this implies that reducing uncertainty will only have lagged effects on investment.[15] On the contrary, investment may be revised according to realized sales growth.

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[13] We cannot construct revisions of future sales growth since we have no data on expected sales growth. In the investment equations expected sales growth was estimated indirectly by GMM. In equation (3) Δy_{t+1} should at least be correlated with revisions in future sales growth. Therefore a significant coefficient α_1 may be considered as supportive of the assumption that firms revise their investment decision due to new information regarding their fundamentals.

[14] See footnote 13.

[15] Strictly speaking, this only applies for uncertainty at the horizon of our measures. Realizations may differ from the plans due to shifts in longer-horizon uncertainty that are not captured by our measure. The same goes for longer-term sales expectations.

Table 4: Determinants of investment revisions

Dependent variable is investment revisions: $I_{t+1}/K_t - I^P_{t+1}/K_t$

	coef,	t-stat		coef	t-stat		coef	t-stat	
constant	0.01	0.36		0.02	0.63		0.02	0.90	
Δy_{t+1}	0.03	2.21	**	0.02	1.94	**	0.03	2.05	**
σ^d_{st}	0.06	1.48							
$\sigma^{\Delta y}_{st}$				0.00	0.02				
$\sigma^{\Delta ye}_{st}$							-0.02	-0.20	
		p-value			p-value			p-value	
Sargan	61.82	0.52		58.95	0.62		59.34	0.61	
m1	-4.14	0.00		-4.17	0.00		-4.16	0.00	
m2	0.47	0.64		0.45	0.65		0.45	0.66	
#obs # firms	1267	261		1267	261		1267	261	

All estimations include time dummies, The system GMM reports second step estimates with Windmeijer

(2000) 's corrected t-stat 2nd step Sargan In system GMM, the difference equation is instrumented with Δy_t

to Δy_{t-1}, and σ_{jt} to σ_{jt-1},.The level equation is instrumented with Δy_{t+1} σ_{t+1}

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

To summarize, our results indicate that investment responds negatively to changes in the level of demand uncertainty. The effect is of a similar order of magnitude for investment plans and investment realizations. Investment revisions are small on average and do not depend on uncertainty. In short, reducing demand uncertainty will stimulate firms' investment but only with delay. At the time firms revise their investment plans they will pay much more attention to a realized sales growth than to updated information about demand uncertainty. These results are robust to our alternative measures of uncertainty, the volatility of sales growth and the volatility of forecast errors of sales.

VII. Conclusions

Empirical investigations of the relationship between investment and uncertainty seldom use appropriate empirical proxies that are close to the concept of uncertainty for which the theory is developed. Using survey information in which firms reveal their forecasts regarding their own future demand and price changes has proved useful in filling this gap. We have analyzed the effect of demand and price uncertainty on firms' planned and realized investment from a panel of manufacturing firms. Our results show that demand uncertainty reduces both planned and subsequent realized investment, in line with the predictions made by Caballero (1991) for imperfectly competitive firms. We find no evidence of an effect of price uncertainty on investment, which is also consistent with the assumption of price-setting firms. In this case, price volatility results from both demand uncertainty and supply shocks, and there is no theoretical prediction for

the latter. Further, for monopolistic firms future price changes are decided on by the firm rather than being uncertain.

Our results show that demand uncertainty depresses investment. This is consistent with Guiso and Parigi (1999) and Patillo (1998) who also report a negative effect of demand uncertainty on firms' investment. Driver et al. (2004) also find that uncertainty about future business conditions reduces investment authorizations. Our estimates indicate that the quantitative effect of demand uncertainty on both planned and realized investment are non-negligible. A one standard deviation increase in demand uncertainty leads to reductions of investment of around 6%. These results are robust to alternative measures of uncertainty. Our estimates using a proxy for sales uncertainty are qualitatively the same.

Our results suggest that, on average, firms adjust their investment plans very little, although revisions may be substantial for some firms and years. Firms revise their plans due to the observations of sales growth, but not in response of uncertainty observed at the time of spending. This suggests that a reduction in the level of uncertainty would indeed enhance investment, but will do so with a lagged effect, since uncertainty affects investment plans for the coming year but not revisions of current investment.

All in all our results point to substantial effects of demand uncertainty on firms' investment decisions. They suggest that economic policies aimed at stabilizing the economic environment may be able to stimulate private investment.

Appendix

Sample description

We construct two samples, one for investment plans, I^P_{t+1}, the other for realized investment, I_{t+1}. The former is used to analyze firms' investment decisions, the latter to compare our results with firms' investment realizations. We focus on large and medium-sized enterprises. This offers two advantages. First, as is often reported in the literature, small and large enterprises have a different investment behavior so that pooling the two types of firms may lead to an aggregation bias. Second, in Belgium, all firms are held to provide their annual accounts, but large firms report more detailed information. In particular, they convey information on sales and information on the capital stock by type of capital good.

Table 1 below summarizes the trimming procedure. Constructing the investment-capital ratio, the initial sample of investment plans contains 4551 observations and that of realized investment 5857 observations. We then clean our sample for outliers. Since the distribution is censored at left (investment rates are positive), trimming for outliers was carried out by taking investment rates

below the 98th percentile. We trim year by year in order to avoid trimming bias due to business cycle fluctuations. By doing so, we lose about 5% of the sample. Annual accounts data of sales growth and the cash flow-capital ratio were trimmed symmetrically, by taking the P2-P98 interpercentile range year by year. Both samples were then matched together and matched with the Business Survey (to obtain uncertainty and expectation indicators)[16]. These samples contain all variables of the investment equation. It represents around 65% of the initial sample. Then, we select firms with three consecutive observations in order to guarantee appropriate instrumentation in our SGMM estimations.. Our final samples contains 1613 observations on 279 firms in the plans sample over the period 1987-2000 and 1888 observations on 319 firms over the period 1987-1999 in the realizations sample.

Table A.1. Trimming the sample

	Plans sample		Realizations sample	
	# obs	# firms	# obs	# firms
1. investment-capital ratios	4551	773	5857	851
2. I/K trimmed by P98	4367	758	5544	838
3. matching with trimmed CF/K, Δy, (y-k) trimmed by P2-P98, and with the Business Survey (σ^d, σ^p)	2972	636	3916	740
4. at least 3 consecutive observations	1613	279	1888	319

We focus on six manufacturing sectors: (1) food, drinks and tobacco (NACE codes 15 and 16), (2) textile, clothing, leather and shoes (NACE codes 17, 18 and 19) (3) wood, wood products and furniture (NACE codes 20), (4) paper, cardboard, publishing and printing (NACE code 21 and 22) (5) other non-metal mineral products (NACE code 26), and (6) metallurgy and metal transformation (NACE code 27 and 28). Firms are more or less evenly distributed among sectors, except for the wood sector.

Table A.2 Number of firms and observations by sector

	Plans sample		Realizations sample	
	# firms	# obs	# firms	# obs
food, drinks and tobacco	62	368	80	463
textile, clothing, leader and shoes	59	334	71	417
wood, wood products and furniture	10	55	13	78
paper, cardboard, publishing and printing	38	236	46	287
other non metal mineral products	22	162	27	196
metallurgy and metal transformation	88	458	82	447
total	279	1613	319	1888

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16   Since the Business Survey is conducted product by product and the Investment Survey by firm, we consider the product that accounts for the largest part of the firm 's turnover as a proxy for the firm's output.

<u>Definition of the variables</u>

Investment plans and investment realizations are provided in the Investment Survey. In this survey, each Autumn, firms have to provide quantitative evaluations of their investment plans for the coming year and their evaluation of investment over the current period; they are asked to report the acquisition value of total tangible fixed assets as reported in the annual accounts. To construct investment capital ratios, we construct series of the capital stock from the Annual Account data base. Sales and cash flow are also constructed from this data base. Sales are defined by turnover. Cash flow is defined as net profits plus depreciation. We use sector-specific prices to obtain real series.

For the construction of the capital stock, we distinguish between five different types of capital goods: (1) land and buildings, (2) plant and machinery, (3) furniture and motor vehicles, (4) leasing, and (5) other. For each of these capital goods and each sector we construct the capital stock in the following way.

We use the perpetual inventory method to construct the real capital stock, i.e.:

$$\overline{K_t} = \overline{K_{t-1}} \cdot (1-\delta) + p_t.I_t/p_t$$

We use the industry-specific price index of investment goods provided by the National Accounts, in which the price index at 1995 is equal to one. Nominal investment is the sum of several factors, each of which is deflated by the investment price index of the time at which the investment was made. In particular, the acquisition of tangible assets in the current year is deflated by current prices, but sales and the disposal of old capital are deflated by the prices related to the age of this capital.[17] The initial nominal capital stock at historical prices in t is equal to the sum of all acquisitions of new capital minus (accumulated) depreciation over the entire history of the firm up to t-1. The real initial capital stock is obtained by deflating the initial nominal capital stock with investment prices related to the age of the capital stock.[18] We construct depreciation rates by sector and type of capital good, based on the lifetimes of the capital goods reported in the National Accounts.

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[17] The average age of sold and used capital is estimated from the annual accounts information on depreciation. Details will be provided by the authors on request.

[18] This is again inferred from annual accounts information on depreciation.

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