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The Impact of Perceived Expectations and Uncertainty on Firm Investment

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ABSTRACT. This paper analyses the (differential) impact of *perceived* expectations and uncertainty on investment spending in small and large firms. We analyse two types of investment, viz. aggregate investment and investment in energy-saving technologies, using Dutch firm level data. The results show that expectations and uncertainty about input- and output prices and domestic demand have substantial but different effects on investment spending in firms of different sizes. Furthermore, we find evidence, at least for small firms, that there are important differences between the effects of uncertainty about input and output variables.

1. Introduction

The role of business planning in small firms and its impact on firm performance are important issues in the small business literature (see, e.g., Baker et al., 1993; Robinson and Pearce II, 1983; Unni, 1981). In this literature, attention for the effect of uncertainty on business planning has grown in recent years,[1] but the results of these studies are ambiguous. Some studies find a positive relation between uncertainty and business planning (see, for instance, Risseeuw and Masurel, 1994; Shrader et al., 1989), whereas other studies suggest that increased uncertainty reduces planning activities (see, for instance, van Gelderen et al., 2000; Matthews, 1991). Moreover, van Gelderen et al. (2000) show that different types of uncertainty have different consequences for business planning strategies, thereby providing a potential explanation for the apparent ambiguity.

In order to quantify the impact of uncertainty on firm decisions, our analysis focuses primarily on the effect of uncertainty and expectations on investment planning as an integral part of business planning. In doing so, we aim to contribute to the ongoing debate among economists on the size and sign of the investment-uncertainty relationship. This debate is complex because, similar to the relation between uncertainty and business planning, both theoretical and empirical insights regarding the sign of the relationship are ambiguous.

Our contribution to the empirical literature on the investment-uncertainty relationship has three specific features. First, as has been argued in the literature, firm size may be an important moderator of the relationship between private investment and uncertainty. We therefore explicitly explore the effects of uncertainty on investment in firms belonging to different size classes. Ultimately, we hope to provide additional evidence on whether uncertainty positively or negatively affects investment spending, and whether there are fundamental differences between small and large firms in this respect.

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Second, existing studies on the investment-uncertainty relationship mainly consider uncertainty measures that are constructed using *observed* variation in input or output prices. Uncertainty measured by observed variation in input or output prices may, however, differ to a large extent from the *perceptions* of managers. Since the latter are relevant for making investment decisions, using subjective measures of expectations and uncertainty on key economic variables is probably more suitable for explaining investment behaviour. We therefore explicitly incorporate perceived expectations and uncertainty in our empirical analysis.

Finally, next to investigating aggregate investment, we also try to explain investment in energy-saving technologies. This analysis contributes to the contemporaneous debate on transforming business practices into a more sustainable direction. It is, for example, relevant in the discussions on how to reach the goals set out in the Kyoto protocol. On the technology side of this debate, an important observation is that many available energy-saving technologies have been calculated to be economically attractive, whereas their adoption has been limited up till now; this phenomenon is generally referred to as the energy-efficiency paradox. Since uncertainty has been brought forward as one of the factors potentially explaining this apparent contradiction, we will empirically investigate its importance.

The remainder of this paper is structured as follows. In Section 2 we give an overview of the theoretical and empirical literature on the relationship between investment and uncertainty. Special attention is given to differences in firm size and to different types of investment goods as potentially important moderators of the relationship. In Section 3 we discuss the data, while Section 4 is dedicated to the model specification and the estimation approach. The results are presented and discussed in Section 5. Finally, Section 6 rounds off with conclusions.

2. Review of the literature

The relation between investment planning and uncertainty has been addressed from both a theoretical and an empirical perspective. The first theoretical models, developed by Hartman (1972) and Abel (1983), emphasise that when a firm's profit function is convex in the uncertain variable, there is an incentive to increase production and investment when uncertainty increases.[2] The weakness of these models is that the result is derived directly from the *assumption* that adjustment costs of capital are convex and symmetric. Stated differently, it is assumed that investments are reversible. Obviously, this assumption will be violated for many investments in capital. Moreover, the result rests on strong assumptions of perfect competition in the output market and of constant returns to scale in production technology.

Subsequent studies have therefore analysed the impact of alternating these assumptions. For instance, Caballero (1991) shows that under the alternative assumptions of imperfect competition and non-constant returns to scale production technology, the relationship between private investment and uncertainty can be negative. Nakamura (2002) obtains a similar result by assuming (i) decreasing returns to scale and (ii) a lifetime of capital that is shorter than the firm's planning horizon. A study by Pindyck (1982) on the other hand focuses on costs of adjusting the capital stock instead of focusing on the profit function, showing that the characteristics of the adjustment cost function determine the sign of the relationship.

A highly relevant framework for analysis in this field is the literature that explicitly emphasises irreversibility of capital investments (see Dixit and Pindyck, 1994; Drury, 2004). The main conclusion from this literature is that when uncertainty increases, postponing an investment to wait for new information on this variable to arrive in the (near) future can be profitable, despite the fact that the expected value of the investment itself remains unchanged; this is also referred to as the option value of waiting. Moreover, the relationship is predicted to be stronger the larger is the degree of irreversibility of the investment. The benefits of waiting are that the new information enables a firm to avoid investing in projects that look profitable ex-ante, but turn out to be unprofitable ex-post.[3]

When looking at the available empirical evidence the theoretical ambiguity is not resolved, although a negative effect of uncertainty on

investment appears to be dominant. Based on a meta-analysis, Koetse et al. (2005) find that approximately 60% of the available empirical estimates has a negative sign with a large part of these estimates being statistically significant. In contrast, the bulk of the positive estimates are statistically insignificant.

One reason for this apparent empirical ambiguity brought forward in the literature is that firms of different sizes may react differently to uncertainty (see, for instance, Bo, 2001; Campa, 1994; Ghosal and Loungani, 2000). The reasoning here is that large firms have more financial expertise and know-how, mainly because they are more specialised in certain (financial) areas and have more financial resources. Furthermore, it is likely that they have access to more and better information than small firms do, largely for the same reasons. Finally, large firms may have the opportunity to hedge against risk and uncertainty, while small firms do not, at least not to the same extent (see, for instance, Ghosal and Loungani, 2000; Peeters, 2001). These forces may give large firms an advantage in dealing with uncertainty or even reducing uncertainty as opposed to small firms, ultimately leading to a situation where uncertainty affects investment spending differently in large and small firms. The ambiguity in sign and statistical significance in this case results from the notion that firms of a certain size class may be over-represented in samples of empirical studies, thereby influencing the study outcomes in case this over-representation is not explicitly controlled for.

Another potential reason for the ambiguity found in the empirical literature is that the effect of uncertainty on investment depends on the specific type of investment. Studies that address this issue basically find that the negative effect is larger when the degree of irreversibility is higher (see Bo, 2001; Bell and Campa, 1997). Heterogeneity in the degree of irreversibility in aggregate investments across firms may therefore affect the outcome of the studies. Although other mediators of the investment-uncertainty relationship have been brought forward in the literature (see, among others, Bo, 2001), the focus in our empirical analyses will be on firm size and type of investment.

3. Data characteristics

The data that are used in our empirical analysis are gathered from a survey that resulted in a data set of 135 plant locations in the Netherlands. Firms were randomly selected and asked to fill out a 15-page survey in May 1998.[4] They were divided over the following nine sectors: the chemical industry, basic metals, metals, machinery, food, paper, horticulture, construction materials and textiles. In the survey, firms were asked to provide information on a large number of firm characteristics, their investment behaviour, their expectations on the development of, among others, costs of inputs and prices of output, uncertainty about these developments, etc. (see de Groot et al., 2001, for more details). Appendix A provides a description of the variables that we use in our estimations. After controlling for missing data, a sample of 71 observations results that we use to analyse aggregate investments. For energy-saving investments a sample of 62 useable observations remains. The former sample contains 43 (28) observations for small (large) firms, whereas the latter sample contains 36 (26) observations for small (large) firms.[5] All data pertain to 1997.[6]

The most important information for our purposes is aggregate investment spending, investment in energy-saving technologies, and firms' subjective evaluations of expectations on and uncertainty about a number of economic variables. These variables are wages and energy prices, being important variables on the input side of a production process, and output prices and domestic demand, which are key variables on the output side.

In most of the empirical literature historical data are used to construct proxies for uncertainty. Usually the standard deviation of a data series (such as wages or output prices) is used directly (see, among others, Bell and Campa, 1997; Butzen and Vermeulon, 2002; Carruth et al., 2000), although some studies use ARIMA models to filter out the predictable part of a series before constructing an uncertainty measure (see, e.g., Ghosal and Loungani, 2000; Peeters, 2001).[7] However, because it is not historical data but rather the perceptions of managers about future values of relevant economic variables that

matter for investment decisions, our analysis makes use of a firm's subjective evaluation to measure *perceived* expectations and uncertainty. Regarding the method to elicit such subjective measures there are several alternatives. A first possibility is to assess a manager's perceived probability of a certain increase or decrease in relevant prices or sales values (see Guiso and Parigi, 1999; Lensink et al., 2000; Patillo, 1998).[8] The problem with this method is that most people have great difficulties in assessing probabilities. Moreover, this measure of uncertainty says nothing about whether the measured amount of uncertainty is *perceived* as high or low. A second option – which can only be used in aggregate analyses where one is interested in non-individual measures of uncertainty – is to count the number of replies for different ranges of output price developments.

Being interested in *individual* behaviour, we adopted an alternative method. We asked firms whether they perceived uncertainty about the future development of a range of variables to be 'small', 'considerable' or 'high' (see Appendix A for details). Our method yields a subjective measure of *perceived* uncertainty and expectations per firm. We therefore do not have to rely on making untestable assumptions about the expectation formation process, as is the case in studies that construct uncertainty measures on the basis of historical information on, for example, price developments. Furthermore, the question is easy to understand, preventing large judgmental errors in the responses. Moreover, as emphasised before, although the reported perceptions may be well of the mark vis-à-vis actual uncertainty ex-post (if such a thing exists in the first place), it is perceived and not actual future developments that matter for investment decisions.

Finally, we are especially interested in structural differences between firms of different sizes. Since we have information on firm size in the form of 'number of employees' and 'sales in 1997', we can distinguish between small and large firms using some a priori defined criterion. We decided, in accordance with firm size definitions of the Dutch Central Bureau of Statistics, to distinguish between firms with less than 100 employees (small and medium sized firms) and firms with more than or exactly 100 employees (large firms).[9] We use this information to *split the sample* into small and large firms to see whether investment decisions differ between the two. Descriptive statistics of the variables used in our estimations are provided in Table I.

In the first sample (for aggregate investments) the investment to sales ratio is higher on average for small firms; it displays larger variation as well. With respect to the second sample (for energy-saving investments), the share of energy-saving investment in aggregate investment is higher in small firms than in large firms on average, while the average share of energy costs in sales (as a proxy for total production costs) is similar for the two size classes. The latter suggests that energy-intensive or energy-extensive firms are not over-represented in either of the two sub-samples. Also observe that aggregate investment in the second sample is much higher for large firms, as one would expect.

Furthermore, the share of firms in the chemical sector is much higher in the sample of large firms than in the sample of small firms, while the opposite is true for the share of firms in horticulture. Large firms appear to experience a higher degree of competition than small firms do, while the degree of knowledge on the existence of new energy-saving technologies is lower in small firms than in large firms. The latter holds even stronger for the perceived existence of *attractive* energy-saving technologies.

The mean and standard deviations of the expectation and uncertainty variables are fairly comparable across the two samples. The percentage of firms that expects wages, energy prices, output prices and domestic demand to increase within the next two years is higher for small firms than for large firms in both samples. The figures on uncertainty do not show such a clear pattern. Finally, note that the correlations between the explanatory variables are limited so problems of multi-collinearity are unlikely to plague the analysis.[10]

4. Model specification

Our analysis focuses on the impact of perceived expectations and uncertainty on (i) firm investment in general and (ii) investment in energy-saving technologies. The first model is estimated by

TABLE I
Descriptive statistics

Variable description	Sample on aggregate investment				Sample on investment in energy-saving technologies			
	Small firms N = 43		Large firms N = 28		Small firms N = 36		Large firms N = 26	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Continuous variables								
Investment ratio (aggregate investment divided by sales)	0.14	0.24	0.05	0.04	–	–	–	–
Share of energy-saving investment in aggregate investment[a]	–	–	–	–	0.13	0.21	0.05	0.07
Share of energy costs in sales		–	–	–	0.07	0.10	0.09	0.15
Aggregate investment (millions €)	–	–	–	–	0.20	0.48	8.27	18.8
Dummy variables[b]								
Horticulture industry	0.33	0.47	0.11	0.32	0.33	0.48	0.12	0.33
Chemical industry	0.09	0.29	0.39	0.50	0.08	0.28	0.38	0.50
Metal industry	0.33	0.47	0.25	0.44	0.33	0.48	0.23	0.43
Other industries	0.26	0.44	0.25	0.44	0.25	0.44	0.27	0.45
Competition	0.42	0.50	0.75	0.44	0.42	0.50	0.69	0.47
Knowledge on energy-saving technologies	–	–	–	–	0.11	0.32	0.23	0.43
Attractiveness of energy-saving technologies	–	–	–	–	0.03	0.17	0.15	0.37
Expectations on:								
Wages	0.91	0.29	0.75	0.44	0.92	0.28	0.73	0.45
Energy prices	0.77	0.43	0.43	0.50	0.81	0.40	0.38	0.50
Output prices	0.63	0.49	0.46	0.51	0.58	0.50	0.42	0.50
Domestic demand	0.47	0.50	0.21	0.42	0.47	0.51	0.27	0.45
Uncertainty on:								
Wages	0.21	0.41	0.21	0.42	0.19	0.40	0.23	0.43
Energy prices	0.37	0.49	0.43	0.50	0.36	0.49	0.50	0.51
Output prices	0.37	0.49	0.50	0.51	0.42	0.50	0.50	0.51
Domestic demand	0.21	0.41	0.18	0.39	0.22	0.42	0.19	0.40

[a] The mean and standard deviation of the share of energy-saving investments in aggregate investment is based on all observations, so including those for which the share is equal to zero. The number of observations for which this holds is 19 for small firms and 6 for large firms; [b] In order to get information on, for example, the number of small firms in horticulture, one can simply multiply the mean of the dummy for horticulture by the number of observations (N) and round to the nearest integer; this yields 0.33*43 = 14 small firms in horticulture.

OLS. Since sales have a positive effect on investment we take the log of the ratio of investment and sales in 1997 as the dependent variable; as such we explicitly control for firm size in explaining investment behaviour. Explanatory variables included in the model are a dummy variable on the degree of competition in a firms' sales market and three sector dummies for the metal, the chemical and the horticultural industry. The latter are included to account for remaining heterogeneity and because we expect investment behaviour to be different between sectors (the dummy on 'other industries' is the reference category; see Appendix A).[11] The explanatory vari-

ables of most interest are perceived expectations and uncertainty on wages, energy prices, output prices and domestic demand.

As discussed earlier, environmental sustainability is an increasingly important topic in contemporary thinking about business processes. One of the means to contribute to such sustainability is investing in energy-saving technologies. Interestingly, we can address how firms divide their aggregate investments over investments in energy-saving technologies and in non-energy related investment. The model that we estimate explains investment in energy-saving technologies as a fraction of aggregate investment.[12] Important for the estimation is that a fair number of firms did not invest in energy-saving technologies, which implies a censored dependent variable. Since censoring has the problem that OLS produces biased coefficient estimates, we use a Tobit model for our estimations.[13] Identical to the previous model we included three sector dummies, a dummy on the degree of competition and perceived expectations and uncertainty on wages, energy prices, output prices and domestic demand. In addition, we also included aggregate investment as an explanatory factor in order to test whether there are scale effects in the composition of investments.[14] Three other variables that are included in this model are the share of energy costs in sales (as a proxy for production costs) in 1997 (a relatively large share of energy costs in total production costs provides an incentive to invest in energy-saving technologies), a dummy variable containing information on the degree of knowledge on the existence of new energy-saving technologies (a *conditio sine qua non* for investment), and a dummy variable indicating whether a firm considers available energy-saving technologies to be attractive or not (measuring whether available energy-saving technologies are economically viable). The coefficients on all of these three variables are expected to be positive.

5. Estimation results

In this section we discuss the results from our model estimations.[15] The explanatory variables included in our model were set out in the previous sections. To test whether investment decisions and the effects of perceived expectations and uncertainty on investment spending differ between small and large firms, each coefficient is estimated separately for small and large firms in both models.

5.1. *Aggregate investment*

Model I in Table II shows the estimation results for aggregate investment.[16] To test whether we should prefer the unrestricted model with separate coefficients or the restricted model with identical coefficients for small and large firms, we perform a Likelihood-Ratio test. The statistic $2*(LL_{UR}-LL_R)$ – where LL_R is the log-likelihood of the restricted and LL_{UR} is the log-likelihood of the unrestricted model – follows a χ^2 distribution with the number of degrees of freedom equal to the number of restrictions. Based on this test, the restricted version of the model should be accepted in favour of the unrestricted version. Nonetheless, the results from the unrestricted model are presented since interesting differences between small and large firms can be observed on individual coefficients.[17]

The results suggest that there are little sectoral differences in investment spending and that stronger competition stimulates investment in large firms. Expectations do not appear to have a strong impact. Although expected increases in wages have a positive influence on investments in both small and large firms, possibly pointing to input factor substitution, the coefficients are statistically insignificant. Only expected increases in output prices appear to have a substantial positive and statistically significant effect on investment spending in large firms. In general, uncertainty appears to have a larger impact on firm investment than expectations, and interesting differences exist between small and large firms. For instance, increased uncertainty on wages has a positive effect on investment spending in small firms, again suggesting input factor substitution, while the effect is absent in large firms. However, most striking is that *output price uncertainty* depresses investment spending in large firms, while *domestic demand uncertainty* does the same in small firms. Our results therefore suggest that uncertainty has a differential impact on investment spending in small and large firms, and that these differences are also

TABLE II
Explaining aggregate investment (Model I) and investment in energy-saving technologies (Model II); t-statistics are reported in parentheses[18]

Variable	Model I (OLS)[a]			Model II (TOBIT)[b]		
	Small firms	Large firms	Difference	Small firms	Large firms	Difference
Intercept	−2.87**	−3.76**	−0.89	−9.58	−17.06*	−7.48
	(−3.48)	(−7.18)	(−0.83)	(−0.98)	(−1.73)	(−0.54)
Horticulture	0.62	1.05*	0.43	−7.87**	1.76	9.63**
	(1.07)	(2.00)	(0.46)	(−3.19)	(0.73)	(2.78)
Chemical	−0.63	0.14	0.77	−10.12**	−0.44	9.68**
	(−0.99)	(0.38)	(0.97)	(−3.22)	(−0.25)	(2.70)
Metal	−0.07	0.11	0.18	−0.97	−2.33	−1.36
	(−0.15)	(0.28)	(0.25)	(−0.55)	(−1.41)	(−0.57)
Competition	0.27	0.58*	0.31	−1.76	1.66	3.41
	(0.73)	(1.94)	(0.57)	(−1.24)	(1.06)	1.61)
Ln aggregate investment	–	–	–	1.20*	1.34**	0.14
				(1.81)	(2.12)	(0.15)
Ln share of energy costs in sales	–	–	–	1.39**	−0.05	−1.44*
				(2.06)	(−0.09)	(−1.67)
Knowledge	–	–	–	6.83**	−0.11	− 6.94**
				(2.67)	(−0.05)	(−2.10)
Attractiveness	–	–	–	−2.02	−0.91	1.11
				(−0.61)	(−0.48)	(0.29)
Expectations on:						
Wages	0.07	0.21	0.14	−7.05**	−1.40	5.65*
	(0.11)	(0.62)	(0.20)	(−2.74)	(−0.65)	(1.69)
Energy prices	−0.22	−0.50	−0.27	6.29**	0.95	−5.34**
	(−0.50)	(−1.70)	(−0.46)	(3.08)	(0.55)	(−2.00)
Output prices	−0.11	0.64*	0.76	−6.79**	2.52	9.31**
	(−0.27)	(2.00)	(1.24)	(−3.78)	(1.58)	(3.84)
Demand	0.21	−0.31	−0.52	2.81*	−1.78	−4.58**
	(0.65)	(−0.84)	(−0.84)	(1.78)	(−1.34)	(−2.22)
Uncertainty on:						
Wages	1.12**	−0.20	−1.32**	−6.00**	−2.73	3.27
	(2.33)	(−0.60)	(−2.02)	(−2.95)	(−1.27)	(1.11)
Energy prices	0.14	0.10	−0.05	−0.37	−0.83	−0.46
	(0.41)	(0.37)	(−0.09)	(−0.26)	(−0.65)	(−0.25)
Output prices	−0.32	−0.62**	−0.30	2.44**	0.26	−2.18
	(−0.98)	(−2.20)	(−0.58)	(2.28)	(0.22)	(−1.36)
Demand	−1.13**	0.55	1.68**	2.89	1.60	−1.28
	(−2.77)	(1.18)	(2.13)	(1.59)	(0.82)	(−0.48)
R^2 (adjusted)	0.32			0.63[d]		
NOBS(DOF)	71 (45)			62 (28)		
Log-L	−75.85			−94.70		
Log-L restricted[c]	−84.47			−113.61		

[a] Dependent variable is the natural logarithm of the ratio of aggregate firm investment to sales, both in 1997; [b] Dependent variable is the natural logarithm of the ratio of investment in energy-saving technologies to aggregate investment, both in 1997; [c] The restricted model in this case is the model without the separate coefficients for small and large firms; [d] ANOVA based fit measure. **, * = Statistically significant at 5% and 10%, respectively.

related to the source of uncertainty. Similar to this result is that, especially in small firms, there appears to be a differential impact of uncertainty on input and output variables; wage uncertainty increases while demand uncertainty depresses investment spending in small firms.

5.2. *Investment in energy-saving technologies*

For investment in energy-saving technologies as a fraction of aggregate investment a Tobit model is estimated because of censoring in the dependent variable. The estimation results are presented under Model II in Table II. The Likelihood-Ratio test suggests that the unrestricted version of the model should be accepted in favour of the restricted version. The results show that, although there are a number of significant differences in investment behaviour between sectors, the explanatory power of the sector dummies is relatively low. Interesting is that in both small and large firms the share of investment in energy-saving technologies in aggregate investment increases as aggregate investment increases. Furthermore, for small firms, investment in energy-saving technologies is substantially higher in those companies that are well-informed on available new technologies.

Expectations appear to have substantial influence on investment in small firms. Expected wage increases appear to depress investment. One way to explain this result is that because of increased wages a firm concentrates on reducing total wage costs, and spends less time on reducing energy costs. Especially in small firms, time and resource restrictions likely induce a firm to make such choices. Furthermore, expected increases in energy prices stimulate investment in energy-saving technologies, but surprisingly this effect is absent in large firms. Finally, there is an opposite influence of expected output price increases and domestic demand increases in small firms and large firms. This is something we cannot readily explain, but possibly we are picking up the influence of differences between small and large firms that we could not control for.

As for uncertainty, its impact is not statistically significant in large firms. Furthermore, in small firms uncertainty on energy prices and on domestic demand has no impact on investment in energy-saving technologies. Especially the former result is surprising, because if uncertainty would influence investment in these technologies, one would expect it to be uncertainty on energy prices. Furthermore, in contrast to the results on aggregate investment, we find a strong negative influence of wage uncertainty in small firms. This suggests that for aggregate investment, labour-capital substitution takes place as wage uncertainty increases, while under the same circumstances attention is shifted away from investment in energy-saving technologies. Striking is also that we again observe a differential impact of uncertainty around input and output variables (wages and output prices, respectively) on investment.

6. Conclusions

In this paper we analysed the effects of *perceived* expectations and uncertainty on firm investment using Dutch firm level data. The basic finding of our analyses is that perceived expectations and uncertainty have a substantial effect on investment spending, and that the specific effect depends on firm size and type of investment.

Especially for investment in energy-saving technologies, there is strong evidence for structural differences between small and large firms. Specifically, uncertainty appears to have a larger influence on decision making in small firms than in large firms. However, differences between the two size classes are related to the specific source of uncertainty as well.

In small firms, input uncertainty and output uncertainty have a differential impact on both aggregate and energy-saving investments. This in contrast to earlier theories on the sign of the investment-uncertainty relationship (see Section 2), but in line with Huizinga (1993). Moreover, the results suggest that increased uncertainty around wages – a crucial input variable especially in small firms – stimulates factor substitution from labour to capital and shifts attention away from investment in energy-saving technologies. Since expected increases in wages have a similar effect, the results suggest that whenever uncertainty on an important variable such as wages increases, small firms revert to what could be called ‘standard practice’;

investing in energy-saving technologies is not one of them. Therefore, the uptake of energy-saving technologies in small firms may be enhanced by a more stable environment, or by increased possibilities to hedge perceived risk associated with investing in these technologies.

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Appendix A: Description, reliability and validity of variables used in the empirical analyses

This Appendix provides a detailed description of the variables that we have used in our analysis (see Table A1). Since these variables are obtained using a questionnaire, we also devote attention to the reliability and validity of our variables.

TABLE A1
Description of variables

Variable	Description
Aggregate investment	The absolute amount of aggregate investment in 1997 (in €).
Energy-saving investment	The absolute amount of investment in energy-saving technologies in 1997 (in €).
Sales	Total firm sales in 1997 (in €).
Energy costs	The absolute amount of energy costs in 1997 (in €).
Employment	Total number of employees per firm.
Chemical industry	Dummy variable equal to 1 when a firm belongs to the chemical industry.
Metal industry	Dummy variable equal to 1 when a firm belongs to the metal industry.
Horticulture industry	Dummy variable equal to 1 when a firm belongs to the horticulture industry.
Food, paper and other industries	Dummy variable equal to 1 when a firm belongs either to the food, the paper or other industries. Industries belonging to the category 'other industries' had too few observations to allow a separate dummy to be created for them.
Knowledge on existence of energy-saving technologies	Firms were asked whether they had knowledge on new and not yet implemented energy-saving technologies. Six answers were possible, i.e., 'Don't know', 'Not informed', 'Barely informed', 'Reasonably informed', 'Well informed' and 'Very well informed'. We transformed this variable into a dummy, which takes on the value 1 when the answer to the question was either 'Well informed' or 'Very well informed'.
Attractiveness of energy-saving technologies	Firms were asked whether there exist technologies that are attractive for them but not for their competitors. Three answers were possible, i.e., 'Don't know', 'No' and 'Yes'. We transformed this variable into a dummy, which takes on the value 1 when the answer to the question was 'Yes'.
Degree of competition	Firms were asked to indicate whether the degree of competition in their sales market(s) was 'low', 'average/reasonable' or 'high'. We transformed this categorical variable into a dummy, which takes on the value 1 if the degree of competition in a sales market(s) was experienced as 'high'.
Expectations	Firms were asked for their 2-year-ahead expectations on several economic variables. Regarding the value of wages, energy prices, materials prices, prices of half products, capital prices, interest rates and the price of their end product, firms were asked whether they expected them to 'decrease with more than 15%', 'decrease between 5% and 15%', 'remain unchanged', 'increase between 5% and 15%' or 'increase with more than 15%'. We transformed the variables into dummies, which take on the value 1 if a firm indicated that it expected the value of the variable under consideration to either 'increase between 5% and 15%' or

TABLE A1
Continued

Variable	Description
	'increase with more than 15%', i.e., that a firm expected the value of the variable to have increased in 2 years vis-à-vis the time of the survey. For the value of domestic demand, foreign demand and the degree of competition firms were asked whether they expected them to 'decrease strongly', 'decrease', 'remain approximately unchanged', 'increase' and 'increase strongly'. Again, we transformed the variables into dummies, which take on the value 1 if a firm indicated that it expected the value of the variable under consideration to either 'increase' or 'increase heavily'.
Uncertainty	Firms were asked for their 2 year ahead uncertainty around the same economic variables set out in the previous point. Firms were asked whether they perceived uncertainty around values of the variables in 2 years to be 'small', 'considerable' or 'high'. For our analysis we transformed the variables into dummies, which take on the value 1 if a firm indicated that uncertainty around the value of the variable under consideration was either 'considerable' or 'high'.

Validity *and reliability*

In constructing our questionnaire, we have deliberately opted for an extensive 15-page questionnaire that has provided us with a unique and in-depth source of information on investment decision making by firms. For reasons of anonymity as well as for budgetary constraints, a repeated questionnaire was not feasible. We therefore have a data set that contains cross-sectional information only. An unavoidable consequence of our choice for an extensive in-depth questionnaire is that we possess no time-series data and that we have no responses of individuals at different points in time. This unfortunately prevents us from a statistical investigation of consistency of answers over time.

Having said that, and on a more qualitative account, we have full confidence in the validity and reliability of the responses. On variables that are more or less objectively attained, such as sales, investment, energy costs, number of employees and sector, there are no reasons to suspect that the responses are inaccurate or unreliable, or we would have to assume intentional deception by respondents (see also note 4 on the representativeness). On the questions about knowledge on existing energy-saving technologies there originally were six possible answers. It could be argued that different firms or managers interpret the response options differently. Therefore, transforming these variables into dummy variables has the advantage that it reduces the chance of finding a response that is well off the mark vis-à-vis other responses. A similar argument applies to the questions on the attractiveness of available energy-saving technologies and the degree of competition in the output market, although the possible answers to these questions in the original questionnaire were fewer and more concrete. Therefore, for these questions the probability of inaccuracy in the original sample was smaller in the first place.

As for expectations on the development of prices and quantities of key economic variables, the possible answers are well defined and easy to understand. It could of course be argued that expectations may be well off the mark and as such may not be realistic or accurate proxies for actual developments. This argument, although valid in its own right, is not relevant for our case, because it is expectations on economic variables that drive investment decisions, however misguided they may be. For the uncertainty variable a similar argument holds (see Section 3 in the main text).

Notes

[1] See, for instance, Escudero et al. (1999) for the impact of uncertainty on supply chain management and Hartmann (2000), Chenhall (2003) and Ditillo (2004) for its effects on management control systems.

[2] For completeness, note that the effect of uncertainty in these models operates through Tobin's marginal Q, defined as the marginal social value of capital divided by the market price of capital.

[3] An adverse effect is possible. On the one hand, if uncertainty around a certain economic variable increases, the value of this variable at which investment will take place (the trigger value) will increase, implying a negative effect. On the other hand, an increase in volatility of the variable under consideration increases the chance that the trigger value will be reached, implying a positive effect. The general conviction, however, is that the increase in the trigger value of investment dominates the increase in the probability of hitting the trigger value, implying a negative net effect.

[4] The questionnaire is available upon request (in Dutch only). The overall response rate of the survey was 4.2%. Response rates per sector differed considerably. They

ranged from 1.46% in the textile industry to 8.73% in horticulture. Although admittedly low, such a response rate is common and acceptable for this kind of extensive survey research (compare, for example, Vicini, 1998). A first rough analysis of the data suggests there is no serious selection bias in the sample. However, some caution is needed when generalising the results. Data on size in terms of employees and energy intensity were confronted with available evidence from the Dutch Statistical Bureau (CBS) in '*De Nederlandse Energiehuishouding, Deel 2*'. Although the data are not fully comparable (our measure of size is the number of people working in a firm, independent of whether they work part-time or not, and the CBS reports gross returns before taxation while we have data on net profitability), they suffice to express confidence in the representativeness of our data set. For details on the representativeness of the data set, we refer to de Groot et al. (2001).

[5] Regarding the aggregate investment sample, we excluded two observations for which exceptionally large values for investment were reported. For these observations, investments in 1997 were larger than the mean plus two times the standard deviation of the entire sample.

[6] The survey on which the analysis in this paper is based does not allow us to perform a panel-data analysis since we only have complete information for 1997. Although investment data are also available for 1995 and 1996, information on expectations and uncertainty are available for 1997 only. The reason for not asking firms to indicate their expectations on and uncertainty around key variables a year ago was that we felt that it would result in unreliable information, if any at all. The construction of a proper panel-data set would require presenting the same firms for several years with the same questionnaire. This was outside the scope of the project. Furthermore, given that our substantive goal in this paper is to determine whether perceived expectations and uncertainties play a role in business investment planning and whether differences exist between small and large businesses, we feel that the use of cross-section data is appropriate. Of course, the limitations of the data warrant some caution in generalising the findings to other time periods, but we feel that there are few reasons to believe that the investment uncertainty relationship is highly unstable over time.

[7] For a good overview of uncertainty measures see Bo (2001).

[8] As a variation on this method, Ferderer (1993) uses a so-called forecaster discord, which is based on monthly forecasts on several economic variables made by economists participating in a survey from 1976 to 1991 (see also Driver and Moreton, 1991).

[9] Note that the correlation between number of employees and sales in 1997 is high ($r = 0.91$), so in that sense it does not matter much what proxy we use for firm size.

[10] The correlation tables are available upon request.

[11] To our judgement we could not include dummies for all nine distinguished sectors because of the limited number of observations for some sectors.

[12] The dependent variable is the natural logarithm of the ratio of investment in energy-technologies to total investment, expressed as a permillage.

[13] Using a Tobit procedure to estimate the model on *aggregate* investment is not necessary since the sample is not censored.

[14] We also tested for scale effects in our analysis of aggregate investments. However, we found no evidence for this. The inclusion of the scale variable (sales) did not affect the estimates of the other coefficients. Details are available upon request.

[15] We started the estimation process with complete models, i.e., models that included all the expectations and uncertainty variables mentioned in Appendix A. Because of the limited number of observations, we re-estimated the models and excluded variables that had relatively large *p*-values, until stable models were acquired. The second reason for iterated estimation is that we want to prevent reporting spurious results, which may occur because of the small number of useable observations. The reported coefficients are robust across several model specifications.

[16] We tested for heteroskedasticity using the Breusch–Pagan statistic. Based on this test we could reject presence of heteroskedasticity at the 1% level.

[17] Although the test suggests that in general there are no differences in investment planning decisions between small and large firms, this does not invalidate the result that individual coefficients are different for the two size classes.

[18] In order to investigate whether our results are sensitive to the transformation on the explanatory variables (see Appendix A), we also estimated the models using the original expectation and uncertainty variables. From this exercise it is clear that the qualitative results do not change; the signs of the coefficients are identical, the relative magnitude of coefficients remains unchanged and the absolute values of coefficients are close to the values reported in the table. Admittedly, some statistically insignificant coefficients experienced a sign reversal, while the coefficients on domestic demand expectations in the second model became insignificant.

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