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IS SIZE IMPORTANT FOR THE INVESTMENT-UNCERTAINTY RELATIONSHIP? AN EMPIRICAL ANALYSIS FOR DUTCH FIRMS

Robert Lensink (a), Paul van Steen (b) and Elmer Sterken (a)

SOM-theme E: Financial markets and institutions

Abstract
By using data from a survey amongst a panel of Dutch firms we investigate whether the investment-uncertainty relationship depends on the size of the firm. We find that uncertainty has a positive effect on investment of small firms, whereas it is negative for large firms. There are probably two reasons for this outcome. First, both small and large Dutch firms do not seem to be financially constrained. Second, sunk costs are much higher for large than for small Dutch firms.

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JEL Classification: C22, D81, D92
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1. Introduction

The theoretical results on the sign of the investment-uncertainty relationship are clear and fully developed by now. There is much less clear evidence as it comes to the empirical results of testing the sign of the relationship. The lack of empirical results can be explained by both the rather complicated nature of some of the theoretical option models as well as the problems in measuring uncertainty. Moreover, once empirical results are found it is not easy to interpret the results in terms of hypotheses concerning the structural elements of the investment decision.

The existing empirical studies in general provide support for a negative effect of uncertainty on investment (see for instance Aizenman and Marion (1993), Bell and Campa (1997), Caballero and Pindyck (1996), Forderer (1993a), Forderer (1993b), Leahy and Whited (1996), Pattillo (1998), Pindyck (1986), Pindyck and Solimano (1993), and Price (1996)). However, it is still hard to draw an overall conclusion concerning the way how uncertainty affects investment. The sign as well as the size of the effects does not only depend on the economic assumptions made, such as the source of uncertainty but also depends on econometric issues, such as the quantifying of uncertainty, the investment model chosen to test the effect of uncertainty, and the data used.

Most studies use ex post measurement of uncertainty. However, it is likely that an ex post measure of uncertainty does not reflect entrepreneurs’ subjective perception of risk, which is the relevant determinant that affects the investment decision. To come around this problem, Guiso and Parigi (1999) try to proxy the firms’ perception of risk by using results of an interview study in which Italian firms are interviewed about their subjective ideas on the variability of future demand for their products. Patillo (1998) uses a similar idea in her study on the investment-uncertainty relationship for Ghana.

In order to have a better insight into the impact of uncertainty on firm investment, more empirical studies are of utmost importance. In particular, there is a lack of empirical studies using an ex ante measurement of uncertainty. This study tries to partly fill this gap by applying the methodology developed by Guiso and Parigi (1999) to investigate the investment-uncertainty relationship for Dutch firms. More specifically, we interview Dutch firms about their investment plans and their expectations regarding future sales of
their products and investigate whether the uncertainty-investment relationship depends on the size of the firm. The relevance of the size of the firm is somewhat overlooked by the theoretical and empirical literature. Normally only large listed firms are used in the sample. However, it seems to be clear that the investment-uncertainty relationship differs between large and small firms. The reason is that large firms are characterised by other governance structures than smaller firms, have easier access to external financial markets and can show a more continuous investment pattern than smaller firms.

We find strong evidence for a positive investment-uncertainty relationship for small firms. Uncertainty only has a negative effect on investment for larger Dutch firms. The reason for this result probably is that sunk costs, and hence the irreversibility of investment, are lower for small firms than for large firms. Section 2 presents a survey of the literature on investment and uncertainty. Section 3 explains the interview study, including the measurement of uncertainty. Section 4 presents the estimation results. Section 5 concludes.

2. Literature Survey
The physical investment decision is mostly taken under genuine uncertainty. Some economists believe that the investor is tortured by fundamental uncertainty (Knight, 1921), which implies that the investor is not able to even give a subjective probability function of all possible outcomes. This might easily lead to the Keynesian animal spirits in investment. Here we assume that the investor is able to formulate a density function of all outcomes, which implies that the investor can analyse future prospects of the investment project.

In discussing investment models we restrict ourselves to dynamic investment models that can be derived from microeconomic optimisation exercises. It is about 40 years ago that the first microeconomic dynamic models of investment were presented (see Jorgenson (1963), Eisner and Strotz (1963) and Gould (1968)). We distinguish between two classes of dynamic investment models under uncertainty. The first class includes models that assume that investment is reversible, while the second class assumes investment to be at least partly irreversible. The latter class includes the more recent so-called real option models. The choice of presenting the literature in this way is rather subjective, since there are numerous alternative ways to do so as will become clear from
the following list of crucial characteristics that influence the sign of the investment uncertainty relationship:

1. The degree of product market competition. If an entrepreneur faces imperfect competition there is a greater likelihood that uncertainty will affect investment negatively.

1. The degree of returns to scale. With increasing returns to scale the entrepreneur will dislike uncertainty more, since there are decreasing marginal costs.

2. The degree of risk aversion. Risk loving entrepreneurs will react positively on more uncertainty.

3. Irreversibility of investment. An investor who faces high costs of reverting investment will probably not invest and wait until more information is revealed to the market.

4. The possibilities to obtain external credit. The probability of a negative investment-uncertainty relationship increases the more a firm is financially constrained.

We first discuss the models without costly reversibility of investment. Leland (1972) and Sandmo (1971) are the first studies that relate uncertainty and the level of output with the risk attitude of the entrepreneur for both demand and price uncertainty respectively. They show that there is a negative sign for risk-averse firms. The analysis of both Leland and Sandmo are static. Hartman (1972) includes adjustment costs and considers the case with perfect competition, constant returns to scale and risk neutrality. This setting is the common setting for a popular class of investment models, the Q-theory. The Q-theory is basically a model that discounts all future expected dividends into the current value of the firm and compares this financial value with the replacement cost of capital. Hartman’s analysis leads to a traditional but counterintuitive opinion on the effect of uncertainty on investment, namely a positive relationship (see also Abel (1983)). If the adjustment cost function is symmetric, under conditions of perfect competition and constant returns to scale, the marginal product of capital is a convex function of uncertainty variables. Therefore the higher the uncertainty, the higher the marginal productivity of capital will be. This encourages the firm to invest more. Caballero (1991) argues that the positive correlation between investment and uncertainty based on the Hartman-Abel prediction is traceable to the assumptions of perfect competition and constant returns to scale. So the positive relationship between investment and uncertainty seems to be an exception rather than a rule. Apparently the
risk attitude of the entrepreneur is an important element. Nickell (1978) analyses a model with a mean-variance setting of the value of the firm. He shows that this assumption changes the Hartman results into a negative sign between investment and uncertainty.

The second or more modern class that emphasises the role of uncertainty in investment decisions is the theory of costly reversibility of investment. The irreversibility property of investment is relevant to explaining investment behaviour only when investment decisions are made under uncertainty. Within the framework of irreversibility investment opportunities are modelled as the firm holding call options on real assets. The firm has the right but not the obligation to buy the sequence of cash flows that are generated by the investment project in the future by paying a certain amount of investment costs. The key assumptions of the real option approach to investment behaviour are irreversibility and the possibility of delay to invest. The irreversibility property of investment implies that the firm has no chance to regret the outcome of the state once the investment decision has been made. If investment decisions are irreversible, investment will be more sensitive to uncertainty facing the firm. Since the firm that has more irreversible capital has a higher opportunity cost of capital (including the option value of investing right now), the firm will require a higher marginal revenue product of capital to match the trigger of investment. Therefore waiting is highly demanded to obtain new information. Consequently uncertainty directly affects the threshold that triggers the occurrence of investment, through which it affects the timing decision of investment and hence the scale of investment at a specific point in time (Bernanke (1983), McDonald and Siegel (1986), Pindyck (1991), Dixit and Pindyck (1994)).

The above-presented short survey of the literature makes it clear that the investment-uncertainty relationship is far from clear. What can be said about the investment-uncertainty relationship in connection to the size of the firm, which is the focus point of this paper? The study of Ghosal and Loungani (1997) is the only study we are aware of in which it is tested whether the investment-uncertainty relationship differs for small and large firms. They present two alternate theories concerning the investment-uncertainty relationship on the one hand and the size of the firm on the other hand. First, sunk costs of small firms are probably much smaller than that of large firms. This implies that
investments of small firms are much more reversible than investments of large firms and hence the probability of a negative investment-uncertainty relationship is much higher for large firms than for small firms. The possible stronger negative effect of uncertainty on investment for large firms might become more substantial in the case where the degree of product market competition is higher for small than for large firms. Second, empirical evidence suggests that the probability of a negative investment-uncertainty relationship increases the more a firm is financially constrained (see, for instance, Peeters, 1997). Since it is often the case that small firms are more financially constrained than large firms, this would imply that an increase in uncertainty has a more negative effect on investments of small firms than that of large firms. Hence, the relative importance of the financing argument versus the sunk cost argument determines how the effect of uncertainty on investment differs for large and small firms. Ghosal and Loungani (1997) find a stronger negative effect of uncertainty on investment for small than for large firms, suggesting that for their sample of Italian firms especially the financing argument is important.

3. The Interview study
This paper uses data derived from one of the annual surveys amongst the panel of firms of the Faculty of Spatial Sciences at the University of Groningen. The 1999 survey on location strategies, investment behaviour and investment uncertainty was mailed to 1,967 panel members, of which 903 (45.9%) responded. To compensate for panel member exits due to firm death, unwillingness to continue panel participation and retirement or job change of the contact person, another 2,695 firms were mailed. The latter resulted in 197 questionnaire forms or a response rate 7.3%, which is more in line with response rates on written questionnaires amongst private firms. Not all of the 1,100 responding firms were useful for the analysis presented in this paper, since almost every question in the questionnaire suffered from a certain degree of missing response. Our key question on sales expectations was, however, correctly answered by 85% of the respondents.

The sectors strongly represented in the research group include industry (29%) and business services (22%), followed by wholesale (17%) and construction (15%). Smaller segments include retail and restaurants (10%) and transport and communication (6%). In line with the composition of the panel, agricultural business and government agencies
are not included. Moreover, the survey includes only a relative small number, 5%, of very small firms (less than 5 employees). Almost one out of every five firms has over 100 employees. Data were collected on the level of individual firm establishments as opposed to the company or organisational level.

In line with Guiso and Parigi (1999) and Patillo (1998) we have asked entrepreneurs about their expected sales in 2002 vis-à-vis sales in 1998. For each expected change in sales presented in Table 1 entrepreneurs are requested to provide the likelihood of the change on a scale of 0-100. Hence, firms give a density forecast of expected sales.

**Table 1: Expected growth of sales**

<table>
<thead>
<tr>
<th>Sales development 1998-2002</th>
<th>The probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of more than 20%</td>
<td></td>
</tr>
<tr>
<td>Increase of 15%-20%</td>
<td></td>
</tr>
<tr>
<td>Increase of 10%-15%</td>
<td></td>
</tr>
<tr>
<td>Increase of 5%-10%</td>
<td></td>
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<tr>
<td>Increase of 0%-5%</td>
<td></td>
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<tr>
<td>Decrease of 0%-5%</td>
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<tr>
<td>Decrease of 5%-10%</td>
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<tr>
<td>Decrease of 10%-15%</td>
<td></td>
</tr>
<tr>
<td>Decrease of 15%-20%</td>
<td></td>
</tr>
<tr>
<td>Decrease of more than 20%</td>
<td></td>
</tr>
<tr>
<td>Total amount of points</td>
<td>100</td>
</tr>
</tbody>
</table>

The answers to this question are used to proxy the conditional mean and variance of the growth rate of sales 3 years ahead. In order to do that, we have assumed that the central values of the open intervals more than 20% and less than 20% are 50 and 30 percent, respectively. Moreover, the distribution is assumed to be uniform within the intervals.

The conditional mean (\(CMEAN\)) and the conditional variance (\(CVAR\)) are measured as:

\[
CMEAN = (1+\delta)S_0 \\
CVAR = \text{var} \left( (S_0) \right)^2
\]
$S_0$ are sales in the base year (1998), and $d^e$ and $var^e$ are the expected mean and variance of the growth rate of sales computed from the information in Table 1.

The coefficient of variation of expected sales ($COEFV$) is our proxy for uncertainty. It is defined as the standard deviation divided by the mean of the distribution:

$$COEFV = \frac{(CVAR)^{0.5}}{CMEAN}$$

Table 2 gives a frequency distribution of $COEFV$ for all firms that have completed the questionnaire.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Number of firms</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>167</td>
<td>19.8</td>
</tr>
<tr>
<td>0&lt;FD&lt;0.1</td>
<td>179</td>
<td>21.3</td>
</tr>
<tr>
<td>0.1&lt;FD&lt;0.2</td>
<td>93</td>
<td>11.0</td>
</tr>
<tr>
<td>0.2&lt;FD&lt;0.5</td>
<td>64</td>
<td>7.6</td>
</tr>
<tr>
<td>0.5&lt;FD&lt;1</td>
<td>63</td>
<td>7.5</td>
</tr>
<tr>
<td>1&lt;FD&lt;1.5</td>
<td>94</td>
<td>11.2</td>
</tr>
<tr>
<td>1.5&lt;FD&lt;2</td>
<td>61</td>
<td>7.2</td>
</tr>
<tr>
<td>FD&gt;2</td>
<td>121</td>
<td>14.4</td>
</tr>
<tr>
<td>Total</td>
<td>842</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3 surveys descriptive statistics of the most relevant variables used in this study. This information is based on a balanced panel, so that the amount of observations differs from that in Table 2. $EMPL$ is firm employment on January 1, 1999. We use $EMPL$ to proxy for the size of the firm. $INV$ is the value of total investment in 1998.

<table>
<thead>
<tr>
<th></th>
<th>$COEFV$</th>
<th>$CMEAN$</th>
<th>$INV$</th>
<th>$EMPL$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.790395</td>
<td>52250151</td>
<td>1923769.</td>
<td>90.80709</td>
</tr>
<tr>
<td>Median</td>
<td>0.175115</td>
<td>12598000</td>
<td>333500.0</td>
<td>35.00000</td>
</tr>
</tbody>
</table>
As can be seen by comparing the mean and the median, the distribution of all variables is skewed. With respect to COEFV it is skewed to the left. This might be due to rather wide bands in Table 1, which leads to a low conditional variance. On the other hand, this result might indicate that Dutch firms are not facing real problems of uncertainty. With respect toEMPL the median is much lower than the mean, which implies that there are relatively much small firms in data set. Skewness is a normal phenomenon in cross-section and panel studies. It signals that in estimating the models one should be cautious about non-normality of the residuals.

Table 4 gives descriptive statistics of the logarithms of the variables presented in Table 3. This information is relevant since, as will be come clear in the next section, we also estimate the model in logarithmic form. The information again refers to a balanced sample.

### Table 4: Descriptive statistics logarithm of important variables

<table>
<thead>
<tr>
<th></th>
<th>LCOEFV</th>
<th>LCMEAN</th>
<th>LINV</th>
<th>LEMPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.949151</td>
<td>16.47296</td>
<td>12.85380</td>
<td>3.656462</td>
</tr>
<tr>
<td>Median</td>
<td>-0.607913</td>
<td>16.38200</td>
<td>12.76569</td>
<td>3.583519</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.033632</td>
<td>22.31030</td>
<td>18.24480</td>
<td>8.546364</td>
</tr>
<tr>
<td>Minimum</td>
<td>-4.629863</td>
<td>3.277145</td>
<td>7.60902</td>
<td>0.000000</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.592634</td>
<td>1.633569</td>
<td>1.764743</td>
<td>1.197504</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.253472</td>
<td>-0.655165</td>
<td>0.132479</td>
<td>0.363675</td>
</tr>
</tbody>
</table>
4. Model Specification and Estimation Results

We estimate a reduced-form accelerator type of investment model including an uncertainty term. The model is specified as follows:

\[ \text{INV} = a_1 \text{COEFV} + a_2 \text{EMPL} + a_3 \text{COEFV} \times \text{EMPL} + a_4 \text{CMEAN} + a_5 \]

\( a_1 \) to \( a_5 \) are parameters to be estimated. We expect \( a_4 \) to be positive: higher expected sales have a positive effect on investment. The effect of uncertainty on investment is given by the first derivative of the above equation with respect to \( \text{COEFV} \), hence:

\[ \frac{d\text{INV}}{d\text{COEFV}} = a_1 + a_3 \text{EMPL} \]

The uncertainty-investment relationship clearly depends on \( \text{EMPL} \), which is our measure for the size of the firm. By interacting \( \text{COEFV} \) with \( \text{EMPL} \) we are able to examine whether the impact of uncertainty on investment depends on the size of the firm. A significant positive (negative) value of \( a_3 \) would imply that the larger the firm the more positive (negative) the impact of uncertainty on investment would be. We have also added \( \text{EMPL} \) and \( \text{COEFV} \) individually since the possible significance of the interaction term may be the result of the omission of other relevant variables, notably \( \text{COEFV} \) and \( \text{EMPL} \). This specification enables to jointly test whether uncertainty and employment affect investment individually, or through the interaction term. The result of the estimation is as follows (White Heteroskedasticity-Consistent t-values in parenthesis):

\[ \text{INV} = 298932 (1.75) \text{COEFV} + 21949 (3.33) \text{EMPL} - 7977 (-2.95) \text{COEFV} \times \text{EMPL} + 0.0029 (1.50) \text{CMEAN} + 122661 (0.30) \]
Where the adjusted $R^2 = 0.36$, the $F$-statistic = 107 and the number of observations equals 762. Jarque-Bera (JB) = 90699. White test = 309.64.

The regression gives an interesting result: the linear term is significantly positive at the 10% level, whereas the interaction term is significantly negative. This suggests that the impact of sales uncertainty on investment is positive for small firms, whereas for firms of which the size passes some threshold value uncertainty starts to have a negative effect on investment.

The above estimate may suffer from heteroskedasticity: the error terms for the larger firms are possibly higher for larger firms than for small firms. For that reason, the $t$-values presented are based on White heteroskedastic-consistent standard errors. A usual possibility to come around this problem is to scale all variables with a suitable scaling factor, such as the value of the capital stock. Unfortunately, we do not have information on the capital stocks for the firms in our sample, and do not have information on another suitable scaling variable. Therefore, we try to find a specification of the model that gives constant error variances if heteroscedasticity turns out to be a problem.

We use the White test as a test on heteroscedasticity. The test is based on an augmented regression in which the residuals from the least squares regression are regressed on a constant, all independent variables, the independent variables squared as well as the products of all independent variables. The outcome of the White test uses the fact that when there is homoskedasticity $NR^2$ is $X^2$ distributed with degrees of freedom equal to the number of regressors in the test equation. In our case the test statistic equals 309.64 which is higher than the critical value (which equals 25 for 13 degrees of freedom at the 5 percent level). Hence, we have to reject the null hypothesis of homoskedasticity in favour of the presence of heteroskedasticity. Note that the White test is a general test for model misspecification, implying that the significant test statistic may also result from the errors not being independent from the regressors, or from incorrectly using a linear specification of the model. We also test for normality of the residuals by using the Jarque-Bera test statistic. Under the null hypothesis of normality, the Jarque-Bera (JB) statistic is $X^2$ distributed with 2 degrees of freedom. The critical value is 5.99, which is far below the JB of 90699 suggesting that the residuals are not normally distributed.
We proceed by re-estimating a logarithmic specification of the model. The outcome of this regression is given by equation 1 in Table 5.

Table 5: Regression Results

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCOEFV</td>
<td>0.213 (2.15)</td>
<td>0.374 (2.46)</td>
<td>0.244 (2.17)</td>
</tr>
<tr>
<td>COEFV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEMPL</td>
<td>0.684 (9.84)</td>
<td>0.818 (12.28)</td>
<td>0.559 (7.59)</td>
</tr>
<tr>
<td>LCOEFV*LEMPL</td>
<td>-0.050 (-1.83)</td>
<td>-0.058 (-1.99)</td>
<td>-0.094 (-2.29)</td>
</tr>
<tr>
<td>COEFV*LEMPL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCMEAN</td>
<td>0.232 (5.08)</td>
<td>0.250 (5.88)</td>
<td>0.239 (4.89)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>6.566 (10.54)</td>
<td>5.709 (9.84)</td>
<td>6.357 (9.46)</td>
</tr>
<tr>
<td>OBS.</td>
<td>607</td>
<td>749</td>
<td>574</td>
</tr>
<tr>
<td>ADJ. R²</td>
<td>0.44</td>
<td>0.45</td>
<td>0.37</td>
</tr>
<tr>
<td>F</td>
<td>121.95</td>
<td>153.83</td>
<td>84.67</td>
</tr>
<tr>
<td>WHITE:N*R²</td>
<td>20.51</td>
<td>11.95</td>
<td>16.26</td>
</tr>
<tr>
<td>JB</td>
<td>0.26</td>
<td>0.80</td>
<td>12.64</td>
</tr>
</tbody>
</table>

Dependent variable in equations 1 and 2 is the logarithm of total investment. In equation 3 the dependent variable is the logarithm of the value of the largest investment project of the firm.

Again it appears that \( COEFV \) is individually significantly positive, whereas the interaction term is significantly negative (at the 10% level), so that qualitatively the same conclusion holds: for small firms uncertainty has a positive effect on investment, whereas for larger firms this effect becomes negative. Moreover, the White test statistic now indicates that the model is correctly specified and that the null hypothesis of homoskedasticity can be accepted. In addition, the Jarque-Bera test statistic shows that the null hypothesis of normality of the residuals can not be rejected.

We have also estimated a slightly different specification of the model by not using \( LCOEFV \) but \( COEFV \). The reason is that for quite a few observations \( COEFV \) equals
zero, so that they drop out of the model when \textit{LCOEFV} is used. The result of this regression is given by equation 2 in Table 5. Again the same outcome results: for small firms uncertainty has a positive effect on investment, whereas the effect becomes negative for larger firms. Since the amount of observation in this regression is much higher, this provides a stability test on the robustness of the results.

In the last column we estimate the model by using the value of the largest investment project of the firm, instead of using the total value of the investment project. Also this estimate confirms the main hypothesis: the uncertainty-investment relationship becomes more negative for larger firms. Note that for this estimate the Jarque-Bera test statistic suggests non-normality of the residuals.

By using the estimation results, we are able to calculate the threshold value for the size of the firm above which uncertainty starts to have a negative effect on investment. If the equation with the most observations (equation 2) is used, the threshold value for \textit{LEMPL} is given by $0.374/0.094 = 3.98$. Hence, the threshold value of \textit{EMPL} is about 53.\textsuperscript{1} This implies that uncertainty has a positive effect on investment for very small firms with an employment below 53 uncertainty, whereas for firms with an employment above 53 this effect becomes negative. Note that most other available empirical studies do not include firms that have less than 50 employees. Moreover, 50 is much smaller than the usual criterion for small firms. For instance, the US Small Business Administration classifies a small business as one that employs 500 workers or less. Ghosal and Loungani (1997) classify a firm as a small firm when it has less than 100 workers. The mean and median of \textit{EMPL} are 90.8 and 35.0, respectively (see Table 3). Hence, for most firms in our sample uncertainty will have a positive effect on investment.

How can we explain that the uncertainty-investment relationship is positive for small firms and becomes negative for larger firms? In Section 2 alternative theories as to why the uncertainty-investment relationship probably differs between large and small firms were presented. The investment literature assumes that small firms are more credit constrained than large firms. This would imply that the investment-uncertainty relationship becomes more negative for small firms. Is this also the case for the Dutch firms in our sample? The questionnaire provides more insights since we have asked firms whether they have financed investments with external funds, and if so whether it
was difficult to obtain external financing. In total 930 firms have answered this question. From the 930 firms, only 279 have used external funds to finance investments. More importantly, only 6 firms, of which one is relatively big (400 employees) and 5 relatively small (less than 30 employees) answered that it was very difficult to obtain external finance. In addition, 16 firms answered that it was somewhat difficult to obtain external credit. However, the great majority of the firms using external finance found it very easy to borrow: 194 firms answered that it was easy or very easy to obtain funds. The rest of the firms using external funds answered that it was not easy, but also not difficult to obtain credit. This suggests that Dutch firms, both the small and the large firms, are not financially constrained. This does not come as a surprise given the fact that the Dutch economy probably is in the upper part of the business cycle. Hence, the degree of financial constraints cannot explain why the uncertainty-investment relationship differs for small and large firms. This leaves us with two possible explanations: small firms are more risk loving or sunk costs are lower for small firms. We do not have information about the risk behaviour of firms, but have some indirect insight into the sunk costs of firms.

Large sunk costs imply that investment will be irreversible and hence it will lead to an increase in the option value to wait when uncertainty increases. In the interview study we have asked firms to provide information about the composition of the investments. We use the share of investments in construction (mainly buildings) in total investments as an indicator for the irreversibility of investment. If a substantial part of investment contains investment in construction, the sunk costs, and hence the degree of irreversibility of investment would probably be large. For small firms with less than 50 employees, the share of investment in construction in total investment equals 19%, whereas it is 37% for firms with more than 50 employees. The share of investment in producer durables (e.g. machinery) in total investment equals 81% and 63% for small and large firms, respectively. This provides some indirect evidence for our hypothesis that sunk costs are much larger for large firms than for small firms.

5. Conclusions.
This paper investigates whether the investment-uncertainty relationship depends on the size of the firm. A special feature of the study is that it uses data from a survey amongst a panel of Dutch firms. In contracts to almost all other available
studies we find that uncertainty has a positive effect on investment of small firms. The relationship becomes negative for large firms. There are probably two main reasons for this outcome. First, both small and large Dutch firms do not seem to be financially constrained. Therefore, the usual argument that small firms are more negatively affected by an increase in uncertainty due to problems in getting access to the capital market does not hold in the Netherlands. Second, sunk costs seem to be much higher for large than for small Dutch firms. This indicates that the degree of irreversibility is increasing in the size of the firm, which makes it more likely that uncertainty has a negative effect on investment of large firms.
References


Knight, Frank H. (1921), *Risk, Uncertainty and Profit,* Chicago, University of Chicago Press.


Peeters, Marga (1997), *Dose Demand and Price Uncertainty Affect Belgian and Spanish Corporate Investment?* DNB-Staff Reports No. 13, Amsterdam.


Ghosal and Loungani (1997) compare effects of uncertainty in small and large firm dominated industries.

Alternatively, we could have distinguished between two or more groups of firms based on their size. However, since it is arbitrary as to what threshold is used and since it is not clear why the relationship within a group should be constant, we prefer to use interactive terms.

Equation 1 suggests that the threshold value is equal to about 71, whereas equation 3 suggests a threshold of 67.