UNCERTAINTY AND GROWTH OF THE FIRM

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Abstract

Using data from a survey of 1097 Dutch firms we investigate the relation between growth of the firm and uncertainty. We focus on the impact of uncertainty on various types of investment, employment demand, and expected maturity of the firm. The special feature of the survey is that it includes data on non-listed (small) firms. We include uncertainty with respect to expected sales and Return on Investment (ROI). We find that sales uncertainty, measured by the conditional variance, has a negative impact on various investment decisions. We include an analysis of financial structure and firm size on the growth-uncertainty relation.

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1 Introduction

Since Kaldor (1934) and Coase (1937) economists are interested in the equilibrium and the nature of the firm. To what extent should economic activity be organized within a firm? What is the boundary or optimal size of the firm? What fractions of economic transactions should be carried out on markets? One crucial aspect of the nature of the firm is its growth rate. Is it true that *Gibrat's Law* holds: growth of the firm is irrespective of the size of the firm? In this paper we analyze a particular aspect of this topic: how does uncertainty affect the growth of the firm? The interest for the impact of uncertainty is raised by the recent advances of the literature on the investment-uncertainty relation (see Dixit and Pindyck, 1994). Uncertainty can lead to an increase of firm activity if managers are risk neutral and firms are operating under perfect competition. On the other hand with risk aversion and market power it is likely that uncertainty hampers growth. Investment in fixed assets is one indicator of firm growth. We use two additional variables, employment growth and expected maturity of the firm, to extend the analysis of the impact of uncertainty on general firm growth. Although we use these two additional indicators our main attention is directed to the investment decision.

The sign of the investment-uncertainty relation has attracted both theoretical and empirical attention in the last decades. Whereas the sign is ambiguous from a theoretical point of view, most empirical studies 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, Ferderer, 1993a, Ferderer 1993b, Leahy and Whited, 1996, Pattillo, 1998, Pindyck, 1986, Pindyck and Solimano, 1993, and Price, 1996). The sign as well as the size of the effects not only depends on the theoretical assumptions made, but is also contingent on econometric issues and data availability.

Most studies use historical data to proxy future uncertainty. However, it is likely that an ex post measure of uncertainty does not reflect entrepreneurs' subjective perception of risk. To come around this problem, Guiso and Parigi (1999) proposed to proxy the firms' perception of risk by using results of an interview study. Managers of firms are asked for their subjective ideas on the variability of future demand for their products. Pattillo (1998) uses a similar strategy in her study on the investment-uncertainty relationship for Ghana. In this paper we follow a similar approach for Dutch firms. More specifically, we interview Dutch firms about their investment plans, their expectations regarding future sales, expected return on investment, employment growth, the financial position, etc. in order to investigate whether uncertainty has a positive or negative effect on firm growth in general and investment in particular. We proxy firm growth using three variables: investment, growth of the number of employees and maturity of the firm. Moreover we have information on the financial positions of the firms (like solvability, current Return on Assets (ROA), and demand for external financing). This implies that we can test for financial imperfections. A special feature of our study is that we can use specific information on types of investment for the largest investment undertaken. This allows to be more precise on the nature of investment decisions.

The survey contains 1097 records of firms on the plant level. We include firms of various sizes. The majority of the firms have less than 100 employees, which indicates that we address a small firm's growth decision. The survey was carried out in 1999. Before we discuss the survey more extensively, we present in Section 2 a short survey of the literature on investment and uncertainty. The insights from this literature are valid for other growth indicators as well, so we concentrate on the investment literature to a large extent. Section 3 explains the interview study, including the measurement of indicators of uncertainty. Section 4 presents the estimation results. Section 5 analyses the special cases of the impact of financial structure and firm size. Section 6 summarizes and concludes.

2 The impact of uncertainty

We review the basic insights of the investment-uncertainty relation. We do not explicitly focus on a discussion of the employment decision of the firm. The 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 even to give a subjective probability function of all possible outcomes. This might easily lead to the well-known Keynesian animal spirits in investment. For modelling purposes the Knightian uncertainty is killing though, so we abstract from fundamental uncertainty. Here we do 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 a microeconomic optimisation exercise. It is about 40 years ago that the first microeconomic dynamic investment models 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.
2 The degree of returns to scale. With increasing returns to scale the entrepreneur will dislike uncertainty more, since there are decreasing marginal costs.

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

4 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.

5 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 risk-averse firms have a negative sign of the investment-uncertainty relation. The analysis of both Leland and Sandmo are static though. 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 of the investment-uncertainty relation.

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 illustrates that the investment-uncertainty relationship is still far from clear. Similar arguments hold for the other firm factor demand equation: the labour decision. The main difference between the investment and hiring decision is the nature of reversibility (although labour market regulation might also lead to irreversibility of hiring).

3 The survey

This paper uses data from an annual survey among a panel of Dutch firms. The survey is organized by the Department of Spatial Sciences of the University of Groningen. In the 1999 edition of this survey we added a number of questions on investment, employment growth, and expected uncertainty. The main topic of the survey is the analysis of location strategies. The survey was mailed to 1,967 panel members, of which 903 (45.9%) responded. In order to compensate for the “death” of panel member, unwillingness to continue panel participation, and retirement or job change of the contact person, another 2,695 firms were mailed in a second round of the survey. 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. Due to missing values not all of the 1,100 observations are useful. The question on sales expectations, a crucial item for our paper, had a response rate of 85%.

It is good to note that data are collected on the level of individual firm establishments as opposed to the company or other organisational level. This makes this survey valuable for the analysis of investment and growth, because the plant manager is most likely responsible for the investment decisions. 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%). Agricultural business and government agencies are not included. Moreover, the survey includes only a relative small number, 5%, of very small firms (less then 5 employees). Almost one out of every five firms has over 100 employees.

We have three indicators of growth of the firm in the survey. First, we have for 1998 data on investment, more specifically on:

1. Total investment;

2. Investment in dwellings;
3. Investment in fixed assets excluding dwellings;
4. The percentage of total investment used for replacement;
5. The largest investment project;
6. The nature of the biggest investment (expansion of dwellings, expansion of other fixed assets, replacement of other fixed assets, introduction of new technology, or investment in Information and Communication Technology (ICT)).

The second growth indicator of the firm is its expansion of demand for labour. We know the number of employees in 1995 and 1999. The third indicator is the maturity of the firm as perceived by the manager. We distinguish 8 possible states of the maturity of the firm, from birth, growth, stability, to slowdown after consolidation, steady growth, etc. Table 1 gives in three panels descriptive statistics on firm growth. Panel A gives investment data, Panel B the employment data, while Panel C illustrates the maturity of the firm. The investment data show that the sample is skewed with an overrepresentation of small firms. This is confirmed by the data on the distribution of employment. One can observe that large investment projects take a relative large fraction of total investment. The nature of the investment is mostly replacement instead of expansion. If firms expand it is in dwellings and not in fixed assets (at least for the largest project undertaken). Panel B shows that about 60 per cent of the firms have less than 50 employees. Employment growth is rather big. Panel C shows that most firms are rather optimistic concerning growth possibilities. There is a shift from stability to growth.

Next we turn to the financial soundness of the firm. We have the following information in the data: solvability (percentage of equity of total assets), judgement of current profitability, percentage of external finance of the largest investment project, and the problems of attracting external finance. Table 2 gives the descriptive statistics. Table 2 shows that the average solvability of firms is 35 to 40%. For the largest investment project 30 per cent of the firms tried to attract external finance. This is a remarkably low percentage, which indicates that firms tend to use internal finance. Internal finance is more likely to be available in a boom of the business cycle (which was true in 1998-1999). If they did attract external finance the fraction of external finance was large, namely a little under 80%. There is a significant negative correlation between solvability and external financing (partial correlation coefficient is –0.25). Most firms are happy with the current profitability, while only a very few firms did have trouble in external financing the investment project. This fact is again due to the boom of the business cycle in the Netherlands in 1998-1999.

Next we turn to measuring uncertainty. In line with Guiso and Parigi (1999) and Pattillo (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 3 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. 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 assume that the central values of the open intervals more than 20% and less than 20% are 50 and 30 percent, respectively. The distribution is assumed to be uniform within the intervals.

The conditional mean (*CMEAN*) and the conditional variance (*CVAR*) are measured by:

$$CMEAN = (1+d^e)S_0$$
$$CVAR = var^e\ (S_0\ )^2$$

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 answers given in Table 3.

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

COEFV= $\sqrt{}$ *CVAR/CMEAN*. Table 4 gives a frequency distribution of *COEFV* for all firms that have completed the questionnaire. In the remainder of this paper we will use the *COEFV* as well as the ratio of the conditional variance and the conditional mean *CVAR/CMEAN*. We label this ratio *COEFV2*. Guiso and Parigi (1999) use this ratio as well since it allows for more variation.

A second variable that carries information on expected uncertainty is expected return on the largest investment project. We have information on the expected mean of return on investment (*ROIMEAN*), the expected lower bound (*ROILOW*) and the upper bound (*ROIHIGH*). We assume that the density function is uniform between high and low and compute the variance by $ROIVAR = (ROIHIGH-ROILOW)^2/12$. We compute *COEFVROI* = $\sqrt{}$*ROIVAR/ROIMEAN*, and *COEFVROI2= ROIVAR/ROIMEAN*. Table 5 gives the descriptive statistics for the uncertainty variables. Panel A of Table 5 presents the data for sales uncertainty, Panel B for uncertainty of return on investment. As can be seen by comparing the mean and the median, the distribution of all variables is skewed.

4 Model Specification and Estimation Results

In this section we present models that correlate growth of the firm with uncertainty. We have three indicators of growth of the firm: investment, growth of the number of employees, and the expected phase of maturity of the firm. We include two indicators of uncertainty: sales uncertainty and the uncertainty of return on investment. We discuss the three growth indicators each at a time.

We include two types of models. First we include regular equations that explain the level of investment. Secondly, we estimate investment choice models: what is the probability that the firm invests at all? These two approaches can lead to conflicting results. It might be so that firms are stimulated to invest, but at a lower level if uncertainty is prominent. So including both models might enhance our understanding of growth decisions.

4.1 Investment

Investment is our main indicator of growth of the firm. The literature offers a wide range of investment models. The majority of these models cannot be used though, because our survey does not include balance sheet information. This excludes for instance the use of Tobin's Q. Moreover we have no information on the dynamics of investment (no information on adjustment costs), which seriously limits our class of applicable models. We therefore estimate a simple reduced-form accelerator type of investment model including an uncertainty term. The expected change in the sales represents future profitability of the firm. The model is specified as follows:

$$INV = a_1\, DSAL + a_2\, UNC + a_3 \qquad (1)$$

where *INV* is the ratio between a certain measure of investment and sales. *DSAL* is the ratio between the change in sales (measures as the conditional mean of sales, *CMEAN*, minus the 1998 value of sales) and sales. *UNC* is the uncertainty proxy. All variables are scaled by sales to avoid heteroskedasticity (moreover we use the White-corrected standard errors). A usual possibility to come around the heteroskedasticity problem is to scale all variables with the value of the capital stock. Unfortunately, we do not have information on the capital stocks for the firms in our sample, so that we decided to scale all variables by sales.

Table 6 presents the first set of results. We include four definitions of investment:

1) *INV1* refers to the total value of investment;
2) *INV2* refers to investment in dwellings;
3) *INV3* refers to investment in machinery;
4) *INV4* refers to the largest investment project of the firm.

Note that $INV1=INV2+INV3$. We exclude extreme observations by assuming that $INVi/SALES<0.5$, for i=1,…,4.. We include two indicators of uncertainty: sales uncertainty and uncertainty with respect to Return on Investment (ROI). For both variables we include the coefficient of variation and the conditional variance over the conditional mean. The latter definition allows more variance. Note that Guiso and Parigi proxy uncertainty by by the conditional variance (and not the standard deviation) of the form *CVAR/K*, where *K* is the value of the capital stock.

What can be concluded from Tables 6? First we note that the uncertainty variables defined by the conditional variance over the conditional mean perform by far better than the coefficient of variation (the latter is not significant in any regression). This is in line with the results of Guiso and Parigi (1999). Secondly, the accelerator model is relevant in all regressions. Thirdly, the disaggregation of total investment into separate equations for investment in dwellings and investment in machinery does not improve the fit of the model. Fourthly, the sales uncertainty variable affects investment decisions more than the ROI uncertainty. And lastly, uncertainty has a negative impact on the size of investment, no matter what the type of investment is.

In Table 7 we present results from the estimation of a logit-specification. We define the dependent variable to be equal to 1 if the firm invests, and to be zero in other cases. This type of modelling is an approximation of the discrete investment choice. Table 7 again includes the four investment types: total investment, investment in dwellings, investment in machinery, and the largest investment project. We use again a simple accelerator specification. Since Table 6 shows that the conditional variance of expected sales gives the best results we only use *COEFV2* as a proxy of uncertainty. Table 7 shows that uncertainty with respect to future sales has a negative effect on investment (total, machinery, and largest investment project), but has a positive impact on the decision to invest in dwellings. The group of firms that does not invest in dwellings is relatively large (compared to the other investment categories). A priori it does not seem likely that investment in dwellings is not subject to irreversibility. It might be troublesome to sell firm-specific buildings. Since investment in dwellings is less common, it is likely that the threshold idea applies. As Sarkar (2000) shows an increase in uncertainty increases the probability of hitting the threshold (which itself depends on uncertainty), which would stimulate investment to a certain extent. To summarize, the results of the logit-estimation confirm generally the negative impact of uncertainty on investment.

For the largest investment project undertaken we have more information. We know the type of investment and the financing of investment for this class (see Section 5.1 for the latter aspect). Here we analyze the type of investment. Table 8 presents results for:

- *INVED*: Expansion of dwellings;
- *INVEM:* Expansion of machinery;
- *INVRM*: Replacement of machinery;
- *INVNT*: New production technology;
- *INVICT*: Information and communication technology.

We use the sales uncertainty measure again in the form of the conditional variance over the conditional mean of expected sales (*COEFV2*). Panel A of Table 8 shows again that we find support for a negative relation between sales uncertainty and the level of investment (for all types). For some of the investment categories the number of observations is low though. Panel B shows the logit regressions for the binary investment choices (for investment in new production technology the number of observations is insufficient). Here it is remarkable that if we find a significant effect of uncertainty on binary investment choices it has a positive sign. This holds for expansion of machinery and ICT investment. So again this might hint at the observation that more uncertainty may lead to a higher probability of reaching the investment hurdle. Again we note that the number of observations is low.

The general conclusion from the investment regressions is that sales uncertainty has a negative impact on the level of investment and the decision to invest. Only for dwellings and large projects on expansion in machinery or ICT we find a positive impact of uncertainty on reaching the investment hurdle.

4.2 Employment growth

Next we turn to the other factor demand: labour. The growth of employment can be seen as a second indicator of firm growth. Suppose that we start from the notion that the long-run labour-output ratio is constant. In that case we can use an accelerator equation for labour demand. We use the following form:

DEMPL/SALES = a0 DSAL/SALES + a1 UNC +a2 INV/SALES + intercept

where *DEMPL* is the difference between the number of employees on January 1999 and January 1995. *DSAL* is again the expected change of sales, *UNC* is an uncertainty measure. We include investment in the equation to test for complementarity of production factors, which might be true if we assume a fixed long-run capital to income ratio as well.

Table 9 presents estimation results for the employment equation. We include the four measures of uncertainty: two for sales uncertainty (*COEFV* and *COEFV2*) and ROI uncertainty (*COEFVROI* and *COEFVROI2*). Table 9 reveals that again the *COEFV2* gives the best results. It is clear that the higher uncertainty with respect to expected sales, the lower the employment growth is. The uncertainty of the return on investment is less relevant. The accelerator is a significant determinant as well as the investment indicator of complementarity of labour and capital. So both factor demands seem to be negatively influenced by sales uncertainty.

4.3 Maturity of the firm

Next we estimate the probability that the firm expects to grow. In Table 1 we presented the indicators of maturity of the firm. They stretch out from the birth and start of the firm to consolidation after a slump. We concentrate first on the unconditional expectation of the maturity. We estimate a logit model on the probability that the firm answers that it expects to grow, independently of the previous phase of maturity. We use the accelerator again to correct for the impact of expected future profitability. Moreover we include our four measures of uncertainty. Table 10 presents the results. Table 10 shows that the expected probability of growth of the firm is positively influenced by the conditional variance of sales expectations *COEFV2*. The other uncertainty measures are not found to be significant. This is a remarkable finding, since our previous results on factor demands show the opposite results. It should be noted here that our expected maturity measure is a rather subjective variable: it expresses growth expectations. Apparently growth expectations are positively correlated with sales uncertainty expectations. These expectations need not to be in line with actual factor demand decisions though.

Next we turn to conditional probabilities of growth. So for each of the three growth phases we include only those observations that have a current maturity of the firm that naturally proceed the growth phase. So for phase 2 we include phase 1, for phase 4a phase 3 and for phase 5d phase 4c. Our uncertainty measure is *COEFV2* throughout. Table 11 includes the results. The results show that starting firms might suffer from sales uncertainty, while more mature firms expect to benefit from sales variance. Again it is good to note that the number of observations is low.

Concluding this section we note that in general factor demands are decreased by higher expected sales uncertainty. So the growth rate of the firms is lower the higher sales uncertainty is. A higher sales uncertainty though seems to coincide with a little more optimism on the future maturity of the firm. This might lead to the conclusion that the probability of reaching the subjective investment hurdle might be higher due to the optimistic impression of growth possibilities.

5 The impact of financial structure and size of the firm

In the previous section we analysed the impact of sales and ROI uncertainty on investment, employment growth, and expected maturity development of the firm. The main conclusions are that especially the conditional variance to mean ratio affects investment, labour demand and expected maturity of the firm. In this section we proceed to analyse investment, labour demand and expected maturity and sales uncertainty. We analyse the impact of financial structure and size of the firm. It might be that firms in financial problems behave differently from healthy firms. It might also be true that small firms behave differently. We first discuss the financial structure, next we analyze the size effects.

5.1 Financial structure

We have two general indicators of financial structure available: solvability and current return on assets. Moreover for the largest investment project we know the percentage of external finance and the trouble in getting finance for about 30 percent of the firms. We therefore proceed with estimating logit equations for the largest investment project, employment demand (we use 4 employees as a cut-off rate) and probability of growth of the firm using *COEFV2* and financial indicators. We use a cut-off rate for solvability of 30 per cent on the lower bound and 40 per cent on the upper bound (median value is 35 per cent). Table 12 gives estimation results for the three equations. Panel A describes the results for the low solvability firms. Here we see that investment demand is reduced through uncertainty, but the employment and expected phase of maturity of the firm show more growth due to sales uncertainty. So here we might observe that investment is more affected by irreversibility than the labour demand decision. For high solvability firms we observe that all uncertainty has positive value for the decision to factor demands. Apparently these firms are able to take the risk of expansion a little more. Panels C and D show results for the same logit-models for low and high current profitability. Firms with high current return on assets are more likely not to invest, but hire more workers if sales uncertainty increases. Firms with low profitability invest more with a higher sales uncertainty. Firms with a high current return on assets are more reluctant to invest.

Table 13 gives the results for investment and external financing. We include two types of regressions. The first two results relate to the fraction of external finance. Note that 278 of the 1097 firms reported that they used external finance for their largest investment project. For those firms who reported that they used external finance we split the sample into a class that used less than 80 percent and a class that used more than 80 percent external finance for their largest project. Here we see that uncertainty has a positive impact on firms that invest and do not externally finance investment by more than 80 per cent. Firms that do use large external financing sources show no impact of uncertainty. We also include two results for firms reporting problems in attracting external finance. There is no serious distinction between these two classes. This again confirms the notion that problems in attracting external finance are not influential and do not interfere with the investment-uncertainty relation.

5.2 Size

Next we analyse the impact of firm size. Table 14 gives the logit-regressions for investment, labour demand, and expected maturity for large and small firms. We split firms into classes based on the number of employees (less than 50 or greater or equal to 50). Table 14 again shows that the probability to invest decreases for small firms if sales uncertainty increases, while the demand for employees is positively influenced. For large firms we find that all factor demand is stimulated by an increase in sales uncertainty.

This result is somewhat in contradiction with the general notion that young small firms are risk neutral and are operating in highly competitive markets, which would make them to depend positively on sales uncertainty. For older, more mature firms the opposite would hold. Here we find basically the same result for small firms as for firms with a low solvability. In our sample larger firms have a lower solvability though (the median solvability for firms with more than 50 employees in 1995 is 32.5% as opposed to 35% for the whole sample). So smaller and low solvability firms seem to suffer from an increased sales uncertainty.

In general we can argue that there is no complete clear picture that emerges from the analysis of firm size. This is in line with *Gibrat's Law*: firm growth is independent of firm size.

6 Conclusions.

In this paper we analyze the relation between growth of the firm and uncertainty. A special feature of the study is that it uses data from a survey amongst a panel of 1097 Dutch firms. This allows us to measure uncertainty ex ante. We develop two indicators of uncertainty: sales uncertainty and uncertainty with respect to Return on Investment (ROI). We proxy growth of the firm by various forms of investment, employment growth, and the expected phase of maturity of the firm (is there any future growth expected?).

We conclude that uncertainty measured by the conditional variance over the conditional mean of expected sales has a significant impact on growth decisions made by firm managers. For investment we mainly find a negative impact of uncertainty. There are some cases that we find support for a positive impact of sales uncertainty on the decision to invest, but a negative impact on the level of investment. For employment decisions we find a negative impact of sales uncertainty. Finally for the subjective impression of the expected maturity of the firm we find a positive correlation between sales uncertainty and the probability of growth.

Finally, we conclude that low solvability and a high current return on assets make it more likely that the firm will respond negatively in its investment decision to an increase in sales uncertainty. Smaller firms also have a lower probability to invest if uncertainty increases.

For future research it is useful to get more insight into investment dynamics. This requires that we use the same survey for the analysis of future decisions of the firms. Moreover we are able to track the forecasting ability of the managers and see whether managers show learning behaviour.

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Table 1 – Growth of the firm: Descriptive statistics

Panel A – Investment data (million guilders)

	Mean	Median	σ
Total investment	2.062	0.350	6.649
Investment in dwellings	1.681	0.000	26.354
Investment in fixed assets	1.403	0.247	7.139
Replacement investment (%)	57.436	60.000	32.025
Expansion (%)	41.729	40.000	31.792
Largest investment project	1.399	0.204	5.406

Nature of largest investment project (percentages of total):

- Expansion of dwellings	14.7
- Expansion of fixed assets	2.5
- Replacement of fixed assets	21.3
- Introduction of new technology	2.1
- ICT	29.7
- Other	19.7

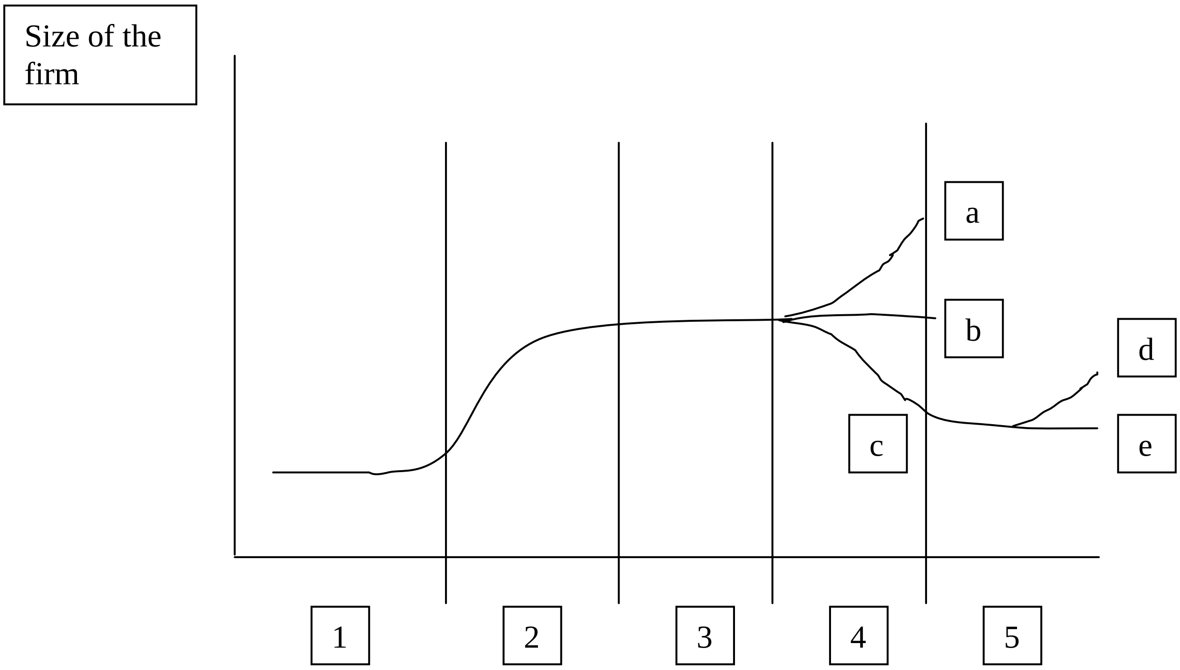
Panel B – Employment data

	Mean	Median	σ
Number of employees 1995	87.586	30.000	255.163
Number of employees 1999	102.059	35.000	318.569
Growth rate 1995-1999	29.703	14.286	75.513

Distribution of firm size in terms of employment

0<employees<10	9.16
10<employees<25	28.88
25<employees<50	23.08
50<employees<100	22.34
employees>100	18.22

Panel C – Maturity of the firm



Phase of growth (in percentages)

		1998	Expectation in 2000
Phase 1	Start	2.28	0.50
Phase 2	Growth	18.33	18.51
Phase 3	Stable	23.36	14.55
Phase 4a	Growth after stability	23.55	34.26
Phase 4b	Extended stability	16.52	17.43
Phase 4c	Decline	5.70	2.48
Phase 5d	Stability after decline	5.41	3.47
Phase 5e	Growth after decline	4.84	8.81

Table 2 – Financial soundness of the firm

	Mean	Median	σ
Solvability (%)	40.587	35.000	26.726
External finance (%, for n=278)	77.229	80.000	23.949
Current profitability (n=1064, %)			
- too low	19.27		
- reasonable	31.95		
- good	42.86		
- not applicable	5.92		
Problems in getting external finance (n=271, %)			
- many	2.21		
- some	6.27		
- indifferent	19.56		
- a few	38.75		
- very few	33.21		

Table 3 – Subjective density of expected growth of sales

Sales development 1998-2002	Probability
Increase of more than 20%	
Increase of 15%-20%	
Increase of 10%-15%	
Increase of 5%-10%	
Increase of 0%-5%	
Decrease of 0%-5%	
Decrease of 5%-10%	
Decrease of 10%-15%	
Decrease of 15%-20%	
Decrease of more than 20%	
Total amount of points	100

Table 4 - Frequency Distribution of the coefficient of variation

The conditional mean (*CMEAN*) and the conditional variance (*CVAR*) are measured by:

$CMEAN = (1+d^e)S_0$

$CVAR = var^e\ (S_0\ )^2$

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 answers given in Table 3. *COEFV* is defined as the standard deviation divided by the mean of the distribution: $COEFV = \sqrt{CVAR/CMEAN}$.

Interval	Number of firms	Frequency
0	167	19.8
0<*COEFV*<0.1	179	21.3
0.1<*COEFV*<0.2	93	11.0
0.2<*COEFV*<0.5	64	7.6
0.5<*COEFV*<1	63	7.5
1<*COEFV*<1.5	94	11.2
1.5<*COEFV*<2	61	7.2
COEFV>2	121	14.4
Total	842	100

Table 5 – Descriptive statistic of uncertainty variables

Panel A – Sales uncertainty

$CMEAN = (1+d^e)S_0$

$CVAR = var^e\ (S_0\ )^2$

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 answers given in Table 3. *COEFV* is defined as the standard deviation divided by the mean of the distribution: *COEFV*= √ *CVAR/CMEAN*. *COEFV2 = CVAR/CMEAN.CMEAN*, *CVAR* in million guilders, *COEFV* and *COEFV* in percentages. Number of observations is 841.

	Mean	Median	σ
CMEAN	68.079	12.485	459
CVAR	6.76E+5	6.32E+5	1.84E+7
COEFV	0.767	0.166	1.031
COEFV2	127	0.477	1590

Panel B – Uncertainty of Return on Investment (ROI)

ROIMEAN = expected return on investment;
ROILOW = expected lower bound of return on investment;
ROIHIGH = expected upper bound of return on investment;
ROIVAR = $(ROIHIGH\text{-}ROILOW)^2/12$;
COEFVROI = √*ROIVAR/ROIMEAN*;
COEFVROI2 = *ROIVAR/ROIMEAN*
Number of observations is 304.

	Mean	Median	σ
ROIMEAN	*21.671*	*15.000*	*21.055*
ROILOW	14.285	10.000	17.476
ROIHIGH	29.648	20.000	26.228
ROIVAR	39.304	8.333	154.964
COEFVROI	0.259	0.217	0.179
COEFVROI2	1.420	0.817	2.615

Table 6 – Investment under uncertainty

The model estimated reads:

INVi/SALES=a1 DSAL/SALES + a2 UNC + intercept

where *i*=1,..,4 and *UNC* is the uncertainty measure. *INV1* = total value of investment; *INV2* = to investment in dwellings; *INV3* = investment in machinery; *INV4* = largest investment project; *DSAL* = *CMEAN*-sales in 1998, *F* is F-value, R^2 is the adjusted determination coefficient. White-consistent standard errors are in parentheses. The sample is restricted to *INVi/SALES<0.5.*

Panel A – Sales uncertainty measured by *COEFV*

	INV1	*INV2*	*INV3*	*INV4*
DSAL	0.077	0.045	0.035	0.072
	(0.022)	(0.018)	(0.016)	(0.020)
COEFV	-0.003	0.001	-0.001	-0.003
	(0.003)	(0.002)	(0.002)	(0.003)
Intercept	0.053	0.016	0.040	0.036
	(0.004)	(0.003)	(0.003)	(0.003)
R^2	0.017	0.011	0.004	0.022
F	7.597	4.981	2.541	8.805
# observations	744	749	755	697

Panel B – Sales uncertainty measured by *COEFV2*

	INV1	*INV2*	*INV3*	*INV4*
DSAL	0.079	0.050	0.038	0.071
	(0.021)	(0.017)	(0.015)	(0.018)
COEFV2	-0.288	-0.121	-0.208	-0.160
	(0.062)	(0.036)	(0.044)	(0.069)
Intercept	0.053	0.017	0.040	0.035
	(0.004)	(0.003)	(0.003)	(0.003)
R^2	0.028	0.014	0.014	0.026
F	11.724	6.181	6.365	10.347
# observations	744	749	755	697

Panel C – Return on Investment uncertainty measured by *COEFVROI*

	INV1	*INV2*	*INV3*	*INV4*
DSAL	0.091	0.046	0.062	0.084
	(0.033)	(0.025)	(0.028)	(0.028)
COEFVROI	0.010	0.004	0.008	-0.007
	(0.003)	(0.019)	(0.019)	(0.019)
Intercept	0.051	0.015	0.039	0.039
	(0.010)	(0.007)	(0.008)	(0.008)
R^2	0.020	0.005	0.010	0.022
F	3.790	1.573	2.464	4.211
# observations	281	285	286	277

Panel D – Return on Investment uncertainty measured by *COEFVROI2*

	INV1	*INV2*	*INV3*	*INV4*
DSAL	0.091	0.046	0.061	0.085
	(0.033)	(0.025)	(0.027)	(0.028)
COEFVROI2	-0.002	-0.001	-0.001	-0.002
	(0.002)	(0.001)	(0.001)	(0.001)
Intercept	0.056	0.017	0.042	0.040
	(0.007)	(0.005)	(0.005)	(0.006)
R^2	0.020	0.005	0.011	0.031
F	4.171	1.647	2.584	5.372
# observations	281	285	286	277

Table 7 – Investment under uncertainty: logit specification

The model estimated reads:

Prob(*INVi=1*)=*a1 DSAL/SALES* + *a2 COEFV2* + intercept

where *i*=1,..,4 and *UNC* is the uncertainty measure. *INV1* = total value of investment; *INV2* = to investment in dwellings; *INV3* = investment in machinery; *INV4* = largest investment project; *DSAL* = *CMEAN*-sales in 1998, LL is the loglikelihood. Sales uncertainty measured by *COEFV2*: the conditional variance

	INV1	*INV2*	*INV3*	*INV4*
DSAL	0.769	1.383	0.360	0.769
	(0.750)	(0.462)	(0.932)	(0.750)
COEFV2	-0.878	7.230	-0.917	-0.878
	(0.153)	(3.100)	(0.158)	(0.153)
Intercept	1.784	-0.390	2.222	1.784
	(0.150)	(0.101)	(0.186)	(0.150)
LL	-371.19	-519.26	-305.86	-371.19
# Prob(*INVi*)=0	135	402	99	135
# observations	842	762	842	842

Table 8 – Largest investment types of investment

Panel A – Least squares

The model estimated reads:

INVj/SALES=a1 DSAL/SALES + a2 COEFV2 + intercept

where *j* = *ED* (expansion of dwellings), *EM* (expansion of machinery), *RM* (replacement of machinery), *NT* (new technology), or *ICT* (Information and Communication Technology), and COEFV2 is the conditional variance os expected sales over the conditional mean of expected sales; *DSAL* = *CMEAN*-sales in 1998, *F* is the F-value, R^2 is the adjusted determination coefficient. White-consistent standard errors are in parentheses. The sample is restricted to *INVj/SALES<0.5*.

	INVED	*INVEM*	*INVRM*	*INVNT*	*INVICT*
DSAL	0.180	0.111	0.016	0.012	0.008
	(0.063)	(0.035)	(0.032)	(0.113)	(0.006)
COEFV2	-0.697	-0.638	-0.366	-0.581	-0.042
	(0.248)	(0.534)	(0.126)	(0.229)	(0.012)
Intercept	0.064	0.028	0.044	0.070	0.013
	(0.013)	(0.006)	(0.008)	(0.029)	(0.002)
R^2	0.097	0.101	0.000	0.000	0.007
F	5.761	6.512	1.002	0.481	1.701
# observations	90	99	157	18	213

Panel B – Logit specification

	INVED	*INVEM*	*INVRM*	*INVNT*	*INVICT*
DSAL	-1.120	-0.882	-0.564	-	2.232
	(1.922)	(2.093)	(2.577)	-	(1.053)
COEFV2	-1.080	10.700	-7.860	-	9.730
	(1.290)	(3.900)	(7.180)	-	(2.430)
Intercept	3.077	2.769	3.087	-	2.978
	(0.634)	(0.622)	(0.538)	-	(0.450)
LL	-28.070	-27.543	-37.758	-	-36.156
# Prob(Invj=1)	8	8	10	-	9
# observations	106	100	166	-	222

Table 9 – Labour demand and uncertainty

The model estimated reads:

DEMPL/SALES=a1 DSAL/SALES + a2 UNC + a3 INV/SAL + intercept

Where *DEMPL* is the difference between employment on January 1999 and January 1995; *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *UNC* is an uncertainty measure, *INV* is total investment. *F* is the F-value, R^2 is the adjusted determination coefficient. White-consistent standard errors are in parentheses.

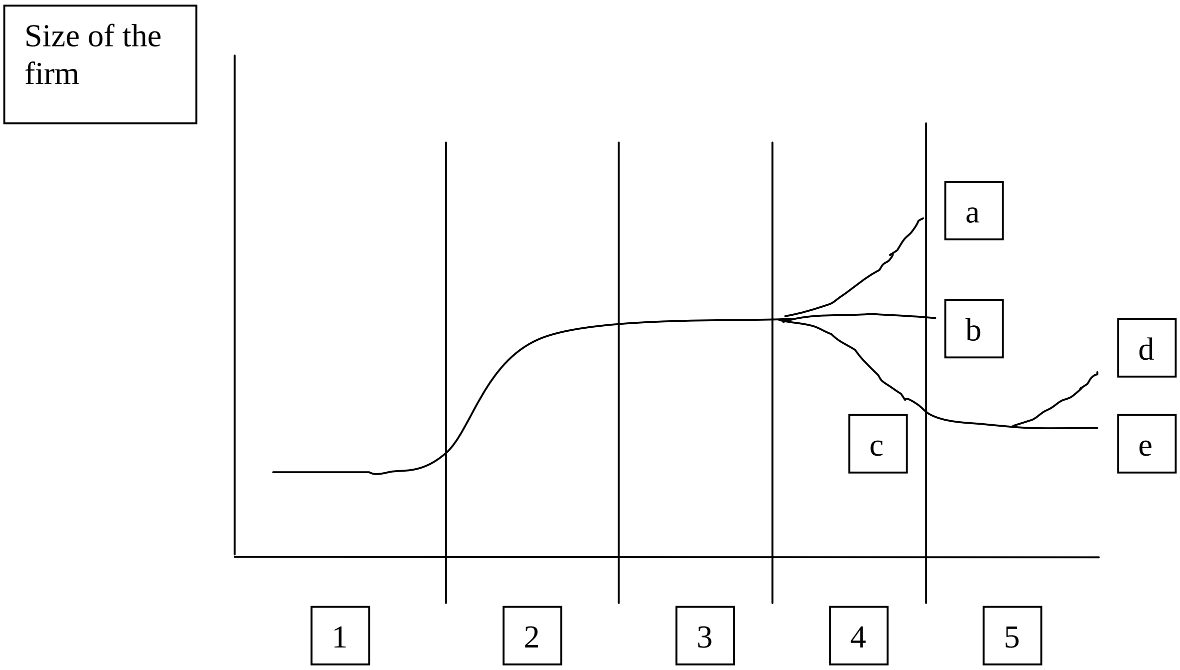
	COEFV	*COEFV2*	*COEFVROI*	*COEFVROI2*
DSAL	0.210	0.213	0.150	0.143
	(0.066)	(0.064)	(0.120)	(0.119)
UNC	-0.002	-0.257	0.056	0.004
	(0.008)	(0.101)	(0.068)	(0.003)
INV/SAL	0.243	0.239	0.257	0.259
	(0.684)	(0.068)	(0.090)	(0.091)
Intercept	0.013	0.013	0.008	0.018
	(0.013)	(0.012)	(0.004)	(0.025)
R^2	0.062	0.063	0.065	0.065
F	17.146	17.482	7.641	7.628
# observations	739	739	287	287

Table 10 – Unconditional maturity of the firm

We estimate that the firm is either in phase 2, 4a or 5d. The model reads:

Prob(*Phase = 2, 4a, or 5d*) = *a1 DSAL/SALES + a2 UNC*

Where *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *UNC* is an uncertainty measure. LL is the log-likelihood.



	COEFV	*COEFV2*	*COEFVROI*	*COEFVROI2*
DSAL	2.382	2.823	3.309	3.119
	(0.460)	(0.400)	(0.848)	(0.733)
UNC	0.060	0.758	0.133	0.046
	(0.073)	(0.309)	(0.471)	(0.041)
LL	-553	-553	-187	-187
# Prob*(phase=0)*	355	355	107	107
# observations	842	842	295	295

Table 11 – Conditional maturity of the firm

We estimate that the firm is either in phase 2, 4a or 5d. The model reads:

Prob(*Phase = 2, 4a, or 5d* | Previous phase) = *a1 DSAL/SALES + a2 COEFV2*

Where *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *UNC* is an uncertainty measure. LL is the log-likelihood.

	Phase 1	*Phase 3*	*Phase 4c*
DSAL	7.186	5.081	4.354
	(1.392)	(1.546)	(2.848)
COEFV2	-0.355	0.162	-0.221
	(0.170)	(0.084)	(1.160)
LL	-6.167	-112	-33.6
# Prob*(phase=0)*	7	70	28
# observations	20	186	52

Table 12 – Financial structure of the firm

Panel A – Low solvability firms (Solvability<30 per cent)

We estimate that the firm invests in a large project, hired more than 4 additional employees or expects to enter a growth phase. The model is of the type:

Prob(*INV4*,*DEMP*, *Phase =1*) = *a1 DSAL/SALES + a2 COEFV2*

Where *INV4*=1 if the firm notifies a large investment, *DEMP*=1 if the difference between the number of employees in 1999 and 1995 is over 4 (the median value), and *Phase=1* if the firm reports that it expects to grow in two years. *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *COEFV2* is the uncertainty measure. LL is the log-likelihood.

	INV4	*DEMP*	*Phase*
DSAL	5.541	0.035	2.528
	(1.157)	(0.556)	(0.675)
COEFV2	-0.774	1.580	0.719
	(0.150)	(0.209)	(0.165)
LL	-131	-160	-153
# Prob*(x=0)*	46	121	102
# observations	233	233	233

Panel B – High solvability firms (Solvability>40 per cent)

	INV4	*DEMP*	*Phase*
DSAL	7.706	0.034	3.286
	(1.803)	(0.686)	(0.970)
COEFV2	2.950	1.490	0.304
	(0.666)	(0.681)	(0.494)
LL	-113	-161	-153
# Prob*(x=0)*	33	114	94
# observations	236	236	236

Panel C – Low current return on assets

We estimate that the firm invests in a large project, hired more than 4 additional employees or expects to enter a growth phase. The model is of the type:

Prob(*INV4*,*DEMP*, *Phase =1*) = *a1 DSAL/SALES + a2 COEFV2*

Where *INV4*=1 if the firm notifies a large investment, *DEMP*=1 if the difference between the number of employees in 1999 and 1995 is over 4 (the median value), and *Phase=1* if the firm reports that it expects to grow in two years. *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *COEFV2* is the uncertainty measure. LL is the log-likelihood.

	INV4	*DEMP*	*Phase*
DSAL	5.141	-0.508	2.949
	(0.980)	(0.489)	(0.594)
COEFV2	3.300	0.445	-0.082
	(0.505)	(0.632)	(0.299)
LL	-245	-298	-283
# Prob*(x=0)*	71	264	193
# observations	431	431	431

Panel D– High current return on assets

	INV4	*DEMP*	*Phase*
DSAL	6.897	1.894	2.775
	(1.058)	(0.461)	(0.559)
COEFV2	-0.808	1.160	0.092
	(0.151)	(0.233)	(0.023)
LL	-206	-272	-264
# Prob*(x=0)*	62	195	159
# observations	404	404	404

Table 13 – External finance

We estimate that the firm invests in a large project. The model is of the type:

Prob(*INV4 =1*) = *a1 DSAL/SALES* + *a2 COEFV2*

Where *INV4*=1 if the firm notifies a large investment. *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *COEFV2* is the uncertainty measure. LL is the log-likelihood.

	Less than 80%	More than 80%	Problems	No problems
DSAL	9.655	8.770	6.603	7.475
	(2.593)	(3.347)	(3.472)	(2.168)
COEFV2	4.120	2.170	7.100	3.660
	(0.967)	(1.870)	(2.500)	(1.580)
LL	-37.5	-43.3	-29.7	-69.9
# Prob*(x=0)*	7	4	5	9
# observations	113	90	63	158

Table 14 – Size of the firm

Panel A – Small firms (number of employees less than 50 in 1995)

We estimate that the firm invests in a large project, hired more than 4 additional employees or expects to enter a growth phase. The model is of the type:

$$\text{Prob}(INV4, DEMP, Phase = 1) = a1\ DSAL/SALES + a2\ COEFV2$$

Where *INV4*=1 if the firm notifies a large investment, *DEMP*=1 if the difference between the number of employees in 1999 and 1995 is over 4 (the median value), and *Phase=1* if the firm reports that it expects to grow in two years. *SALES* represents sales in 1998, *DSAL* is the differences between the expected sales mean for 2002 and actual sales in 1998, *COEFV2* is the uncertainty measure. LL is the log-likelihood.

	INV4	*DEMP*	*Phase*
DSAL	7.668	3.609	4.286
	(1.456)	(0.812)	(0.822)
COEFV2	-0.073	0.067	0.058
	(0.020)	(0.029)	(0.025)
LL	-136	-169	-162
# Prob*(x=0)*	33	107	113
# observations	266	266	266

Panel B – Large firms (number of employees more than 50 in 1995)

	INV4	*DEMP*	*Phase*
DSAL	5.474	-0.274	2.214
	(0.859)	(0.401)	(0.476)
COEFV2	2.650	1.390	-0.001
	(0.985)	(0.656)	(0.559)
LL	-305	-375	-266
# Prob*(x=0)*	95	327	228
# observations	545	545	545