Irreversible Investment and Uncertainty: An Empirical Study of Rice Mills in the Mekong River Delta, Vietnam

Le Khuong Ninh, Niels Hermes and Ger Lanjouw[#]

SOM theme E: Financial Markets and Institutions

Abstract

This paper investigates the irreversibility of investments and the impact this has on the nature of the relationship between investment and uncertainty. The empirical analysis uses firm-level data and is based on a survey of 210 rice-milling firms in the Mekong River Delta in Vietnam, which was carried out during the year 2000. We show that the relationship between investment and uncertainty is influenced by the extent to which investments are irreversible. In particular, the results indicate that when the degree of irreversibility increases, this increases the negative association between uncertainty and investment.

(also downloadable) in electronic version: http://som.rug.nl/

JEL Classification: D81, D92

Key Words: Firm-level Investment, Uncertainty, Irreversibility, Vietnam

---

[#] We thank Frans Tempelaar, Robert Lensink and an anonymous referee for useful comments on earlier versions of this paper. Niels Hermes is at the Faculty of Management and Organisation, University of Groningen, PO BOX 800, 9700AV Groningen, The Netherlands. Ger Lanjouw is at the Faculty of Economics of the same university. Le Khuong Ninh is at SEBA, University of Cantho, Cantho, Vietnam. Please send comments to the following email address: C.L.M.Hermes@bdk.rug.nl

1. Introduction

Investment decisions of firms depend on a large number of factors, one of which may be the extent of uncertainty about future events. Uncertainty may be an especially relevant factor in environments in which investors have difficulties in making predictions about the future, since the environment may be highly volatile and/or information, which is necessary to make predictions, is difficult to obtain. In this light, uncertainty may be a particularly relevant factor determining investment in developing and transition economies. These economies are generally more volatile by nature and information problems in these economies are more prevalent due to deficient markets and institutions.

There is a huge theoretical literature discussing the relationship between firm investment decisions and uncertainty. One part of the literature concludes that, under certain circumstances, uncertainty stimulates investment. Yet, another part of the literature contends that the sign of the relationship is the opposite. Since theory remains inconclusive, empirical research is needed to better understand the relationship between investment and uncertainty.

This paper empirically analyses the relationship between investment and uncertainty with respect to the future growth rate of sales, using information from rice mills in the Mekong River Delta (MRD) in Vietnam, and particularly focuses on the impact of the irreversibility of investments on the nature of the relationship between investment and uncertainty. In our view, this issue, which has been discussed in the theoretical literature, does play an important role in the context of the rice milling industry in the MRD.

The analysis uses information on investment decisions, as well as on perceptions of uncertainty regarding future growth rates of sales from a survey study among 210 rice-milling firms in the MRD. The survey was carried out during the year 2000 and covers questions about expected investment decisions of 2001, as well as about investors' perceptions of expected growth rates of sales of 2001 and perceptions on the possibilities to resell used machinery. The information on investors' perceptions on expected sales growth is used to construct our measure of uncertainty;

information on perceptions on the possibilities to resell used machinery enables us to measure the extent of irreversibility of investment at the individual firm level.

The econometric analysis provides evidence for the fact that the irreversibility of investment by rice mills is important in determining the nature of the investment-uncertainty relationship. In particular, the results show that when the degree of irreversibility increases, this increases the negative association between uncertainty and investment.

The remainder of the paper is organised as follows. Section 2 briefly summarises the theoretical and empirical literature that discusses the relationship between investment and uncertainty. Section 3 provides a description of the rice-milling industry in the MRD of Vietnam and discusses the potential sources of uncertainty for the firms in this industry. Section 4 goes into the data set used for the empirical analysis. Section 5 describes how uncertainty has been measured. Section 6 goes into the measurement of irreversibility of investment. Section 7 discusses the empirical model. Section 8 presents the results of the empirical analysis. Section 9 concludes.

2. Investment and Uncertainty: Review of the Literature

2.1 Theoretical contributions

The nature of the relationship between investment and uncertainty has received quite some attention in the literature in recent years. The theoretical literature on this issue is not conclusive on the sign of the relationship between investment and uncertainty. Standard investment theory states that the strategy of the firm is to invest in a project only if the present value of expected cash flows from the investment exceeds the total costs. The value of total costs may be referred to as the threshold value of investment. In principle, it can be shown that the threshold value is increasing with the degree of uncertainty with respect to the future growth rate of sales, which means that greater uncertainty leads to less willingness to invest. Yet, the exact nature of the relationship crucially depends on the model specification used and the underlying assumptions with respect to the risk behaviour of the investor, the extent of competition in his

output markets, the characteristics of the production technologies used, and the shape of the adjustment costs.[1]

Since the late 1980s several authors have stressed the importance of the possibility that investment is irreversible (*i.e.* taking into account the shape of the adjustment costs) and the impact of this on the investment-uncertainty relationship (Bernanke, 1983; McDonald and Siegel, 1986; Bertola and Caballero, 1994; Dixit and Pindyck, 1994). The irreversibility of investment refers to the situation that machinery and equipment the firm uses may be difficult to resell and/or to the fact that the resale price is substantially below the replacement costs. The fact that investment is (partly) irreversible increases the user cost of capital, thereby also leading to an increase of the threshold value of investment. This can be shown by applying the option pricing model of investment. When investment in capital stock is (partly) irreversible, this introduces a so-called option value to postpone investment until later, when more information about relevant future events is available. If uncertainty is higher the value of the option to wait also increases, thus leading to lower current investment outlays.

Abel and Eberly (1994) and Caballero (1991) stress that, under the assumption of competitive markets and constant returns to scale, uncertainty may not necessarily lead to lower investment, even in the presence of irreversibility. They show that the relationship between investment and uncertainty depends on both the degree of irreversibility and competition, and more particularly on the way these two factors are interrelated. Abel and Eberly (1999), elaborating on this issue, argue that the relationship between investment and uncertainty may be presented by an inverted-U curve: at low levels of uncertainty, the investment-uncertainty may show a positive relationship, whereas at high levels of uncertainty the relationship starts to become negative. This is due to the fact that uncertainty has both a user-cost and a so-called hangover effect on investment. On the one hand, uncertainty increases the user cost of capital in the short run, which reduces investment in the presence of uncertainty. On the other hand, however, if disinvestments during adverse shocks (for instance in demand) are difficult due to the irreversibility of the investments, a firm will have

[1] Broad surveys of the literature on the relationship between investment and uncertainty can be found in Lensink, Bo and Sterken (2001) and Carruth, Dickerson and Henley (2000).

higher than desired levels of investment in the longer run, i.e. the hangover effect. Thus, the user-cost and hangover effects influence the investment-uncertainty relationship in opposite directions and Abel and Eberly show – by providing a numerical analysis of their model – that this may result in an inverted-U shaped relationship.

The above short discussion of the main theoretical contributions to the literature on the relationship between investment and uncertainty and the role played by the irreversibility of investment shows that this relationship may go either way, and that the actual relationship will vary depending on firm-specific circumstances regarding competition, risk behaviour and technology. Therefore, empirical research is needed to analyse how investment, uncertainty and irreversibility are related. Yet, empirical evidence on this issue is scarce.

2.2 Empirical studies

Empirical papers studying the relationship between investment and uncertainty have used different methods to measure uncertainty. In some cases, authors have used measures of volatility – such as the standard deviation, variance or coefficient of variation – of a variable that is considered to be crucial for investment decisions as their measure of uncertainty. Other authors have taken ARCH or GARCH estimates of conditional variances of such crucial variables as their proxy for uncertainty. Yet another group of authors have measured the volatility of a particular variable using AR model residuals. Finally, a few studies have used firm's perceptions about future developments of a particular variable determining investment as their uncertainty measure. Variables that have been considered as being crucial in empirical studies are, among other things, exchange rates, input prices, share returns, output demand and output prices (Carruth, Dickerson and Henley, 2000).

Empirical studies also differ with respect to whether they use an aggregate or disaggregate empirical analysis. Several studies in the field use aggregate data, either at the macro or industrial sector level. Most aggregate studies available in the literature focus on the US. Examples of aggregate studies on the US are Goldberg (1993), Ferderer (1993), and Ghosal and Loungani (1996). Some studies focus on

other OECD countries, such as Driver and Moreton (1991) and Price (1995), who focus on the UK. Lensink (2002) uses a panel of developed countries to study the investment-uncertainty nexus. These studies either focus on the direct relationship between investment and a measure of uncertainty, or analyse this relationship by explicitly taking into account the role of irreversibility of investment. Almost all studies find a negative relationship between investment and uncertainty, either directly or indirectly once irreversibility is taken into account.

Yet, a proper analysis of the relationship between investment and uncertainty should make use of firm-level data, since theoretical models indicate that the relationship between investment and uncertainty depends on firm-specific characteristics. Moreover, at least part (if not most) of the uncertainty affecting a firm's investment decisions will be due to idiosyncratic events, which will disappear when uncertainty is considered at the aggregate level due to cancelling out of different shocks for different firms. Yet, in many cases, it is difficult to analyse the investment-uncertainty relationship using a disaggregate approach due to a lack of information on uncertainty at the firm level.

Some studies use disaggregate data, based on panels of firms from specific industrial sectors. Leahy and Whited (1996), using a panel of manufacturing US firms find a weakly negative relationship between investment and uncertainty. They measure uncertainty by taking a forecast of the share return volatility. Guiso and Parigi (1999) use data based on a survey among Italian manufacturing firms. They measure uncertainty based on the perception of firms about future product demand. They also find a negative relationship between investment and uncertainty. Moreover, they show that the degree of irreversibility influences this relationship: the negative relationship is stronger for firms for which the degree of irreversibility is higher. This supports the option approach to investment under uncertainty. Bo and Lensink (2003) use a Dutch panel of manufacturing firms and explicitly investigate the shape of the relationship between investment and uncertainty, using share return volatility forecasts as their measure of uncertainty. They find evidence for the existence of an inverted-U shaped relationship between investment and uncertainty. Ogawa and Suzuki (2000) investigate the relationship between investment and uncertainty for a

panel of Japanese firms. They measure uncertainty by the conditional standard deviation of the sales growth rate and find that uncertainty has a negative effect on investment. Moreover, they show that this negative relationship is related to the degree of the irreversibility of investment.

Only few empirical studies analyse the investment-uncertainty relationship in the setting of a transition or developing economy. Pattillo (1998) uses firm-level data from a panel of manufacturing firms in Ghana and focuses on the role the irreversibility of investment plays in determining the relationship between investment and uncertainty. She finds evidence for the fact that the irreversibility of investment holds an option to wait, leading to lower investment under uncertain conditions. Bo and Zhang (2002) investigate the impact of uncertainty on firm investment, using firm-level information from the machinery industry in Liaong province, China. They find that demand and labour cost uncertainties do not influence investment in case of state-owned firms. Yet, for so-called collective firms, labour cost uncertainty positively affects investment.

The above brief discussion of the empirical literature suggests that, although there is quite some research for developed countries on the relationship between investment and uncertainty, there is less empirical evidence for transition and developing economies. Yet, in our view uncertainty may be a particularly relevant factor determining investment in developing and transition economies. These economies are generally more volatile by nature, since usually their economic activities are less diversified, both at the macro and micro level. This reduces possibilities to hedge against adverse shocks. Moreover, information problems in these economies are more prevalent due to deficient markets and institutions. Additionally, as will be argued below, investment in such economies may be more irreversible, due to underdeveloped (or even missing) markets for used capital.

In the empirical analysis of this paper we will investigate the nature of the relationship between investment and uncertainty and focus on the extent to which irreversibility of investment does play a role in this relationship.

3. Economic Reforms and the Rice Milling Sector in the MRD, Vietnam

In 1986 the Vietnamese government started a process to transform the country from a centrally planned to a market-oriented economy when it launched a programme of economic reform, also called *doi moi*. One of the aims of this programme was to promote private initiative, since it was recognised that the private sector may play an important role in boosting investment and spurring economic growth. In the agricultural sector the reforms provided farming households more autonomy and proper incentives, thereby encouraging them to work harder and to invest in their land and crops. As a result, rice production grew steadily during the 1990s and by the year 2000 rice production was almost three times the level of 1976 (Table 1).

<Insert Table 1 here>

The reforms in the agricultural sector, together with the reforms in international trade policies, also created an exportable surplus. From 1989, Vietnam started to export rice and has since then remained one of the leading rice exporters in the world. However, over the years, these exports have also shown great variability, both in terms of quantity and value (see Table 2). For the period 1989-2000 the coefficient of variation of the quantity of rice exported was 45 per cent, and that of the value of rice exports was 51 per cent. This variability is attributable to the instability of the world rice market and, to a lesser extent, Vietnam's government policies on food security.[2]

<Insert Table 2 here>

The increase of rice production and rice exports also led to an increased demand for rice milling services in Vietnam. Consequently, from the late 1980s the number of rice mills

[2] These government policies mainly consist of determining annual export quota's in order to safeguard sufficient domestic supply of rice. Yet, these policies have shown to be rather unpredictable over the last few years, adding to the variability of prices and quantities of traded rice. This variability has influenced the demand for and the price of rice in the domestic

started to grow fast.[3] By 1999, almost 7,500 rice mills were established in the MRD of which more than 90 per cent were privately owned (Vietnam Economic Times, April 5th 2000). Most rice mills are small-scale in nature and use relatively simple milling techniques.

Rice mills take a central position in the rice marketing channel in the MRD. They buy unprocessed rice, or paddy, mostly from traders/assemblers who collect the paddy from (small) farmers in rural areas, they mill the paddy to produce rice that is fit for consumption, and sell it to rice traders (such as retailers and wholesalers), state-owned food companies, or foreign buyers. The most important buyers of milled rice are wholesalers and state-owned food companies (Minot and Goletti, 2000, p.27). Rice traders function as important intermediaries in the rice market of the MRD. Such intermediaries are necessary given the high level of transaction and information costs in the rice market.

Since, as was discussed above, domestic rice markets seem to follow developments in the world rice market and since this market is unstable, rice milling farms are confronted with uncertainty regarding future trends in demand for and prices of their output. This uncertainty is exacerbated by the fact that they have problems in obtaining information that might help them to make good predictions about future trends. Given the rudimentary state in which many markets and institutions have been developed in Vietnam, relevant information is available only on a limited scale and/or is of low quality. Moreover, low levels of education hamper the ability of owners of rice mills to digest the information that is available. In order to be able to make good predictions about future trends, information about the world rice market should be analysed. Yet, most of this information will be in English. Finally, such information is costly to obtain.[4]

Rice milling firms cannot easily hedge against fluctuations in demand and prices of their output. First, storing milled rice is only possible to a limited extent due to the high risk of infestation by insects, rodents and birds. Second, synchronization of input and output is difficult due to the uncertainty about developments in the output markets. Third, rice milling

---

rice market because the domestic rice market closely follows the developments in the world rice market (IFPRI, 1996; Minot and Goletti, 2000).

[3] Information from our own survey reveals that over 70 per cent of all rice mills were established after 1989.

[4] In particular, internet, an important source of information on trends in the world rice market, seems to be unaffordable for rice milling firms because of high service charges of 2 USD cents for each minute on line (Harvie, 2001).

firms have weak market power with respect to rice traders and state-owned food companies, which reduces possibilities to set output prices. Finally, they cannot easily pass on changes in output prices to the prices they pay for their input, again due to the weak market power they have vis-à-vis paddy rice traders.

Information from a survey among 210 rice milling firms in the MRD reveals that uncertainty about changes in their output markets are indeed of great concern to them. We asked firms to indicate on a three-point scale the importance of a number of factors in considering an investment decision. As Table 3 reveals, whereas financial factors such as access to loans, interest rates and collateral (usually seen as major constraints on investment in emerging economies), and factors related to uncertainty with respect to their inputs received an average score of 2.4, the average score for factors related to uncertainty with respect to their output, such as changes in output demand and prices, was even higher, reaching 2.8 on average.

<Insert Table 3 here>

The above discussion has made clear that uncertainty with respect to the output of rice milling firms is an important issue. Moreover, the information presented so far seems to suggest that this uncertainty may impede investment decisions of these firms. Therefore, further empirical investigation of the relationship between investment and uncertainty seems to be warranted.

4. The survey

In the year 2000, we carried out a survey among 210 rice milling firms in the MRD. In this survey we asked a number of questions regarding their investment behaviour and its determinants. The questions were asked to the owner(s) of the rice mill to ensure that the answers we obtained were coming from those who make investment decisions. Among other things, we asked questions about firm perceptions of uncertainty with respect to future developments of their input and output. Moreover, we asked questions related to the irreversibility of investments made. In particular, the survey contained questions about actual investment and investment plans, past sales

and expectations about the future growth rate of sales (so, basically, we have information about the perceived uncertainty with respect to changes in output demand), the possibility to resell used milling machinery and the resale price of used milling machinery expressed as a percentage of the purchase price (these two aspects reflect irreversibility), and the degree of competition the firm is faced with in its output market. Next to these issues, the survey also contains questions about individual firm characteristics such as year of establishment, location, educational training of the owner of the rice mill, past profitability, borrowing, and fixed assets.[5]

The questions in our survey allow us to investigate the investment-uncertainty relationship at the firm level. As was indicated earlier, such a firm-level analysis has advantages over macro or industry level studies, since it enables the measurement of idiosyncratic perceived uncertainty, which may be more important to firm investment decisions than aggregate uncertainty (Guiso and Parigi, 1999). Moreover, a firm-level survey allows us to more carefully investigate the impact of irreversibility, which according to theory plays an important role in determining the relationship between investment and uncertainty. Additionally, whereas many other studies use ex post measures of uncertainty, the questions we have in our survey enable us to examine the effect of *ex ante* uncertainty on firm investment. The data set with which we carried out the empirical analysis contains 204 firms.[6]

5. Measuring uncertainty

In order to measure uncertainty, we use the information from the survey about the expectations of rice millers about the future growth rates of sales of their businesses. We asked them to specify in which direction sales would change in 2001.[7] Each rice miller was requested to assign weights, which sum to 100, to a set of intervals of growth rates of sales (see Appendix I for the exact wording of the question as well as the structure of this question). This approach has been adopted from Guiso and Parigi

[5] See Appendix I for a detailed description of the survey used in this study.
[6] Six rice mills were deleted from the data set due to missing values with respect to variables included in our analysis.
[7] We also asked them to specify expected sales for the year 2003. However, only few rice millers responded to this question.

(1999), Pattillo (1998) and Lensink, Van Steen and Sterken (2003). A summary of the information obtained using this question is given in Table 4. In general, this table shows that 74 per cent of the sample's population expected sales to rise and 26 per cent expected sales to fall. Most firms expect small (negative or positive) changes of sales. More than half of all firms indicate they expect positive sales changes ranging from 1 to 5 per cent for 2001. The information in this table can be used to create the uncertainty variable.

<Insert Table 4 here>

Given the information in Table 4 we compute the conditional mean (*CM*) and variance (*CV*) of the growth rate of sales in 2001 as perceived in 2000. *CM* and *CV* are given by (Guiso and Parigi, 1999; Lensink, Van Steen and Sterken, 2003):

$$CM = (1 + d^e)S_0 \quad (1)$$

$$CV = (\sigma^2)^e S^2_0 \quad (2)$$

where S_0 is the sales in the base year (1999), d^e is the expected mean of the growth of sales in 2001 and $(\sigma^2)^e$ is the expected variance of the growth rate of sales in 2001. Based on these two variables we are able to calculate the coefficient of variation of expected sales (*CEV*), which is our measure of uncertainty, as follows:

$$CEV = (\ CV)/CM \quad (3)$$

The higher the value of *CEV*, the higher the degree of uncertainty.

Table 5 shows the frequency distribution of *CEV*. This table reveals that for more than 90 per cent of the sample's population *CEV* has values of 10 per cent or higher (lines 4-7). The proportion of the sample corresponding to *CEV* of less than 10 per cent accounts for as only 9 per cent of the sample (lines 1-3), indicating that the distribution of the uncertainty variable is rather skewed.

<Insert table 5 here>

We will use *CEV* as our measure of uncertainty in the empirical analysis of this paper. To investigate the robustness of our estimates concerning the relationship between uncertainty and investment, we will also use an alternative measure of uncertainty. In particular, based on the information in our survey we calculate the ratio of the (subjective) standard deviation of the expected sales to total fixed assets (*SDSALAS*), which is measured as follows:

$$SDSALAS = (\ CV)/FA \qquad (4)$$

where *FA* is total fixed assets. This variable relates the variability of sales of firms to their size, measured by total assets. Again, the higher the value of *SDSALAS*, the higher the degree of uncertainty.

6. Measuring irreversibility

As discussed, when investment in capital stock is (partly) irreversible, this introduces a so-called option value to postpone investment until later, when more information about relevant future events is available. If uncertainty is higher the value of the option to wait also increases, thus leading to lower current investment outlays. Therefore, irreversibility may be an important factor that should be taken into account when studying the investment-uncertainty relationship. Irreversibility is higher if it is more difficult to sell used machinery and/or if the resale price of machinery is considerably lower than the purchase price. In the context of the rice mills in the MRD irreversibility may be an important issue for a number of reasons.

First, irreversibility of investment is more severe when an industry is hit by a common shock (Guiso and Parigi, 1999; Ogawa and Suzuki, 2000). Such a shock may lead to the co-movement with respect to sales, resulting in (substantially) lower demand for second-hand machinery. Common shocks may be important in the rice milling industry, since the industry as a whole is influenced by the volatility in the

demand for and price of rice, making the problem of irreversibility substantial for individual rice mills.

Second, selling used machinery by rice mills appears to be difficult due to the high specificity of these machines. The only component of the machines used in rice milling that can easily be used for other purposes is the engine. Other components can be transformed for different uses but the transforming costs may be prohibitively high, according to our observation. The high specificity of machinery makes investments in these machines (highly) irreversible.

Third, even if rice millers are able to resell their machinery, they have to resell it in unorganised second-hand markets. As remarked above, Vietnam is still characterised by deficient markets and institutions; second-hand markets for used machinery are but one example in this context. Reselling used rice-milling machinery will be subject to a "lemons" problem as well as to high transaction costs, which will increase the irreversibility of their investments.

Our survey contains two questions related to the irreversibility of investment by rice mills. One question asked rice millers to indicate how easy it is for them to sell their machinery on a four-point scale (see appendix I for the exact wording of the question).[8] Based upon the information obtained from this question we construct a measure of irreversibility, which we call *REV1*. Table 6 presents information on this variable (upper part of the Table). Note that *REV1* measures perceptions of rice millers on the likelihood to resell machinery. Although rice millers indicate that they are able to resell used machinery, possibilities to do so seem to be limited. Almost 90 per cent of the sample reported that it was not easy to resell used machinery.

A second question asked rice millers to indicate that, if they can resell their machinery, at what price they can do this on a four-point scale (again, see appendix I for the exact wording of the question).[9] The lower the ratio of the resale price to the purchase price, the higher the degree of irreversibility. Based upon the information obtained from this question we construct *REV2* as our second measure of irreversibility. Table 6 (lower part of the Table) presents information on this variable.

[8] This approach is taken from Guiso and Parigi (1999)
[9] This approach is taken from Pattillo (1998).

Again, the variable measures the perception of rice millers about resale prices rather than actual resale prices. According to the data, half of the millers in our sample indicate expect to sell their machinery at a price below 50 per cent of the purchase price; only 5 per cent expects to receive a price that is 75 per cent or more of the purchase price. This indicates that, based on this measure, irreversibility of investment of rice millers is relatively high.

<Insert table 6 here>

Since both the possibility to resell and the price at which milling machinery can be sold are important in determining the degree of irreversibility with which rice millers are confronted, we aim at using the information of both questions in our empirical analysis. We have used the following approach. First, as shown in column [2] of Table 6, we transform the information on *REV1* and *REV2* into dummy variables with values of 1 to 4. The way we have defined both dummy variables suggests that the higher the value, the lower the problem of irreversibility. Next, we use the principal components technique to construct a new irreversibility variable based on *REV1* and *REV2*, which we call *REV*. This newly constructed variable will be used in the empirical analysis of this paper.[10] Yet, as a robustness check on our findings with respect to the importance of irreversibility for the relationship between investment and uncertainty, we will also use *REV1* and *REV2* separately when analysing the investment-uncertainty link.

7. The empirical model

In order to empirically investigate the relationship between investment and uncertainty we use a simple accelerator investment model to which we add our measure of uncertainty, along with a variable that measures the existence of financial

[10] The principal components technique is a technique that helps to construct a new variable based on information of two or more highly correlated variables. This technique may be appropriate since, if variables are highly correlated, it may not be efficient to use all variables separately in the empirical analysis. The new variable provides a weighted average of the correlated variables.

constraints with which rice millers are confronted, as well as a variable that either measures the agency costs of debt or the access to external finance. We use the following specification:

$$I_i = \alpha_1 + \alpha_2 SAL_{i,1999} + \alpha_3 PRO_{i,1999} + \alpha_4 CEV_i + \alpha_5 BOR_{i,1999} + \varepsilon_i \quad (5)$$

where:

- I_i is total planned investment divided by total fixed assets in 1999
- SAL_{1999} is total sales in 1999 divided by total fixed assets in 1999 and reflects the accelerator model of investment, since past sales may reflect future investment opportunities; therefore, we expect α_2 to be positively related to planned investment
- PRO_{1999} is total profit in 1999 divided by total fixed assets in 1999 and measures the existence of financial constraints with which rice milling firms may be confronted; we expect α_3 to be positive to reflect the importance of the availability of internal funds in determining investment decisions, which is taken as evidence for the existence of financial constraints for rice milling firms when deciding on future investment[11]
- *CEV* is the uncertainty variable as discussed in section 4 of this paper; based on the theoretical literature as discussed in section 2 of this paper, α_4 may be either positive or negative
- BOR_{1999} is the amount of money a rice miller borrowed in 1999 divided by total fixed assets in 1999; α_5 may either be negatively (reflecting agency cost related to outstanding external debt) or positively (reflecting that for those rice millers who have access to external sources, these sources contribute to finance their investments) related to planned investment
- *i* the individual firm index

[11] There is a large literature on the role of financial constraints in determining investment decisions of firms. These studies measure the existence of financial constraints by taking a proxy for the availability of internal funds, like for instance total profits to assets. A comprehensive overview of empirical studies on this issue can be found in Lensink, Bo and Sterken (2001).

- ε is an error term

Based on equation (5) we may investigate the relationship between investment and uncertainty for the rice mills in our data set. Yet, based on the discussions in section 2 and 6 of this paper, we argue that the irreversibility of investment may have an impact on the nature of the relationship between investment and uncertainty for rice mills in the MRD. This is the main issue we want to address in our analysis. Therefore, we also use the following specification of investment behaviour:

$$I_i = \alpha_1 + \alpha_2 SAL_{i,1999} + \alpha_3 PRO_{i,1999} + \alpha_4 CEV_i + \alpha_5 BOR_{i,1999} + \alpha_6 REV_i + \varepsilon_i \qquad (6)$$

where *REV* is our measure of irreversibility as discussed in section 6 of this paper; the way we have defined *REV* leads us to expect α_6 to be positive: the higher *REV*, the lower the irreversibility of investment, which according to the real option approach to investment decisions would suggest higher levels of planned investment.

Empirical models (5) and (6) are estimated using the simple OLS technique based upon information of 204 rice milling firms that we obtained from the survey.[12]

8. Empirical results

Table 7 provides descriptive statistics of the variables used in the model specifications of equations (5) and (6). Table 8 presents the correlation matrix of these variables. The information in Table 8 shows that investment and the uncertainty variable *CEV* are negatively correlated, although the correlation coefficient is relatively low (-0.165). Yet, this at least suggests that there may be a negative association between investment and uncertainty, a result that is found in most empirical studies on this issue. Note also

[12] We acknowledge that with respect to equation (6) there may be a problem of multicollinearity with respect to *CEV* and *REV*. This problem may at least partially be solved by using instrumental variables. However, the data set we have does not allow us to make use of valid instrumental variables. Moreover, we have cross-section data, which makes it impossible to use lagged independent variables, a standard solution used in the literature to create instruments. Future work on this issue for the rice milling industry will among other things focus on building a panel data set.

that the alternative measure of uncertainty, *SDSALAS*, is positively correlated with investment; yet the correlation coefficient is very low (0.059).

<Insert Table 7 here>

<Insert Table 8 here>

8.1 Investment and uncertainty

Column [2] of Table 9 shows the outcomes of the OLS estimations of equation (5). The results indicate that the uncertainty variable (*CEV*) has a statistically significant negative coefficient, suggesting that higher uncertainty is associated with reduce investment plans. This is supportive evidence for the view that uncertainty leads to lower investment. The other variables included in the model are statistically significant and have the expected signs. In particular, the positive sign of PRO_{1999} indicates that the rice mills are confronted with financial constraints, a result that we also found in an earlier study (Le, 2003). Moreover, also BOR_{1999} has a positive sign, reflecting that for those rice millers who have access to external sources, these sources contribute to finance investments.

To investigate the robustness of the outcomes regarding the relationship between investment and uncertainty, we also use our alternative measure of uncertainty, *SDSALAS*, and re-estimate equation (5). The results presented in column [3] are generally similar to those in column [2]. Again, uncertainty is clearly negatively related to investment. Moreover, the values of all other coefficients change only marginally when using the alternative measure of uncertainty. This lends support to the view that our finding of a negative association between investment and uncertainty is robust.

<insert Table 9 here>

8.2 Investment, uncertainty and irreversibility

In our empirical analysis, we particularly focus on the irreversibility of investments and the impact this has on the nature of the relationship between investment and uncertainty. Column [4] of Table 9 presents the results of estimating equation (6). The outcomes show a statistically significant positive relationship between reversibility (measured using *REV*) and investment of rice millers; stated differently, there is a negative association between irreversibility and investment. At the same time, *CEV* remains negative and is statistically significant. We get similar results if we replace *CEV* by our alternative measure of uncertainty, *SDSALAS* (see column [5]). These results indicate that uncertainty reduces investment of rice millers in the presence of irreversibility, as is predicted by the real options approach to investment. All other variables included in the model are statistically significant and have the expected sign.

To investigate the robustness of the outcomes regarding the role of irreversibility in the relationship between investment and uncertainty, we replace *REV* by *REV1* and *REV2* separately as alternative measures of irreversibility. The results of re-estimating equation (6) using these alternative measures are presented in columns [6] and [7] of Table 9. These results are generally similar to those presented in column [4]: both alternative measures are statistically significant and have a positive sign; at the same time, uncertainty (again measured using *CEV*) is negatively related to investment. Moreover, the values of all other coefficients change only marginally when using the alternative measures of irreversibility. This lends support to the view that our finding of a negative association between investment and uncertainty, given the presence of irreversibility (as predicted by the real options approach to investment), is robust.

We further analyse the nature of the relationship between investment, uncertainty and irreversibility by investigating how the degree of irreversibility affects the uncertainty-investment relationship. Empirical analyses by Guiso and Parigi (1999) and Ogawa and Suzuki (2000) suggest that a higher degree of irreversibility will make it more difficult for investors to resell used machinery, which may exacerbate the negative relationship between uncertainty and investment. We are interested in knowing whether this also holds in the case of the rice millers in the

MRD. In order to investigate this hypothesis, we test the following model specification:

$$I_i = \alpha_1 + \alpha_2 SAL_{i,1999} + \alpha_3 PRO_{i,1999} + \alpha_4 CEV_i + \alpha_5 BOR_{i,1999} + \alpha_6 REV_i + \alpha_7 CEV_i \cdot REV_i + \varepsilon_i \quad (7)$$[13]

By differentiating equation (7) with respect to *CEV*, we get:

$$\frac{\partial I_i}{\partial CEV_i} = \alpha_4 + \alpha_7 REV_i \quad (8)$$

From equation (8) we may conclude that the degree of irreversibility affects the sensitivity of investment to uncertainty. In particular, we expect that $\alpha_4 < 0$ and $\alpha_7 > 0$. If this is the case, then as the degree of irreversibility decreases, investment is less negatively sensitive to uncertainty.

Column [8] of Table 9 shows the outcomes of the estimations of equation (7). The outcomes confirm our expectation about the relationship between investment, uncertainty and irreversibility: whereas the coefficient of *CEV* has statistically significant negative sign, the interactive term (*CEV* · *REV*) has a statistically significant positive sign. All the other variables included in the model have significant coefficients with the expected signs. This result leads us to conclude that when the degree of irreversibility increases this increases the negative association between uncertainty and investment.

To test the robustness of this result, we redo the previous analysis using *SDSALAS* instead of *CEV* as our measure of uncertainty. The results are shown in column [9] of Table 9. They confirm our previous findings suggesting that our findings regarding the nature of the relationship between investment, uncertainty and irreversibility are robust.

[13] The caveat we made with respect to equation (6) also holds for this equation. See footnote 12.

9. Concluding remarks

As noted in the introduction of this paper, there is a huge theoretical literature discussing the relationship between firm investment decisions and uncertainty. The literature remains inconclusive on the nature of the sign of this relationship, however. It appears that the nature of the sign is strongly dependent on the assumptions made regarding the type of investment and the context in which investment takes place. This calls for research in different empirical settings to pin down the nature of this relationship.

This paper makes a contribution to the empirical literature on this issue by investigating the relationship between investment and uncertainty in the context of the rice milling industry in the MRD, Vietnam. We have argued that uncertainty regarding the future output growth rates is an important factor these rice mills are faced with when deciding on investments. In the empirical analysis we have focused on the importance of the irreversibility of investment.

We find supportive evidence for the fact that uncertainty is negatively associated with planned investment of rice millers in the MRD. Moreover, we show that this remains to be true given the presence of irreversibility. This finding can be explained by referring to the real options theory of investment, which states that firms may decrease or delay investment, if we assume they have flexibility regarding their investment decisions. When investment in capital stock is (partly) irreversible, this introduces a so-called option value to postpone investment until later, when more information about relevant future events is available. If uncertainty is higher the value of the option to wait also increases, thus leading to lower current investment outlays.

This theory also does seem to apply to rice millers in the MRD. In particular, the co-movement of the rice milling industry, the specificity of the rice milling equipment, and the absence of a formal market for used milling machinery are important factors causing their investment to be irreversible, which in turn determines the negative association between uncertainty and investment: since rice millers may expect irreversibility to be a binding constraint in the future, they plan to invest less and/or later.

Further investigation of the investment-uncertainty relationship and the role of irreversible investments reveals that the negative association between investment and uncertainty increases with the degree of irreversibility: the higher the degree of irreversibility, the more difficult the resale of the used milling machinery and/or the lower the resale price.

Although this paper has contributed to explaining the relationship between investment and uncertainty in the context of the rice milling industry in the MRD, focusing on an issue that has received prominent attention, at least in the theoretical literature, we also know from the literature that other aspects, such as the degree of competition in output markets, risk behaviour of the investor, and the characteristics of the production technologies used, may influence the investment-uncertainty relationship. Further research is needed to investigate whether and to what extent these other aspects have an impact on this relationship.

References

Abel, A.B. and Eberly, J.C. (1994). 'A Unified Model of Investment under Uncertainty', *American Economic Review*, 84, pp. 1369-1384.

Abel, A.B. and Eberly, J.C. (1999). 'The Effects of Uncertainty and Irreversibility on Capital Accumulation', *Journal of Monetary Economics*, 44, pp. 339-377.

Bernanke, B.S. (1983). 'Irreversibility, Uncertainty and Cyclical Investment', *Quarterly Journal of Economics*, 98, pp. 85-106.

Bertola, G. and Caballero, R.J. (1994). 'Irreversibility and Aggregate Investment', *Review of Economic Studies*, 61, pp. 223-246.

Bo, H. and Lensink, R. (2003). 'Is the Investment-Uncertainty Relationship Non-Linear: An Empirical Analysis for The Netherlands', Unpublished paper, University of Groningen, Groningen.

Bo, H. and Zhang, Z. (2002). 'The Impact of Uncertainty on Firm Investment: Evidence from Machinery Industry in Liaong Province of China', *Economic Systems*, 26, pp. 335-352.

Caballero, R.J. (1991). 'On the Sign of the Investment-Uncertainty Relationship', *American Economic Review*, 81, pp. 279-288.

Carruth, A., Dickerson, A. and Henley, A. (2000). 'What Do We Know About Investment Under Uncertainty?', *Journal of Economic Surveys*, 14, pp. 119-153.

Che, T.N., Kompas, T. and Vousden, N. (2002). 'Incentives and Static and Dynamic Gains from Market Reforms: Rice Production in Vietnam', *Australian Journal of Agricultural and Resource Economics*, 45, pp. 547-572.

Dixit, A.K. and Pindyck, R.S. (1994). *Investment Under Uncertainty*, Princeton: Princeton University Press.

Driver, C. and Moreton, D. (1991). 'The Influence of Uncertainty on Aggregate Investment: An Empirical Analysis', *Economic Journal*, 101, pp. 1452-1459.

Ferderer, J.P. (1993). 'The Impact of Uncertainty on Aggregate Investment Spending: An Empirical Analysis', *Journal of Money, Credit and Banking*, 25, pp. 30-48.

Ghosal, V. and Loungani, P. (1996). 'Product Market Competition and the Impact of Price Uncertainty on Investment: Some Evidence from U.S. Manufacturing Industries', *Journal of Industrial Economics*, 44, pp. 217-288.

Goldberg, L.S. (1993). 'Exchange Rates and Investment in United States Industry', *Review and Economics and Statistics*, 75, pp. 575-589.

Guiso, L. and Parigi, G. (1999). 'Investment and Demand Uncertainty', *Quarterly Journal of Economics*, 114, pp. 185-227.

Harvie, C. (2001). 'Competition Policy and SMEs in Vietnam', Working Paper Series 2001, WP 01-10, University of Wollongong, Wollongong.

International Food Policy Research Institute (1996). 'Rice Market Monitoring and Policy Options Study', Final Report, Institute Report 114, International Food Policy Research Institute, Washington DC.

Leahy, J.V. and Whited, T.M. (1996). 'The Effect of Uncertainty on Investment: Some Stylised Facts', *Journal of Money, Credit and Banking*, 28, pp. 64-83.

Le, K.N. (2003). 'Investment of Rice Mills in Vietnam: The Role of Financial Market Imperfections and Uncertainty', Unpublished PhD Thesis, Centre for Development Studies, University of Groningen, Groningen.

Lensink, R. (2002). 'Is the Uncertainty-Investment Link Non-Linear? Empirical Evidence for Developed Economies', *Weltwirtschaftliches Archiv*, 138, pp. 131-147.

Lensink, R., Bo, H. and Sterken, E. (2001). *Investment, Capital Market Imperfections, and Uncertainty: Theory and Empirical Results*, Cheltenham: Edward Elgar.

Lensink, R., Van Steen, P. and Sterken, E. (2003). 'Uncertainty and Growth of the Firm', *Small Business Economics*, 21, forthcoming.

McDonald, R. and Siegel, D. (1986). 'The Value of Waiting to Invest', *Quarterly Journal of Economics*, 101, pp. 707-728.

Minot, N. and Goletti, F. (2000). 'Rice Market Liberalization and Poverty Reduction in Vietnam', Institute Report 114, International Food Policy Research Institute, Washington DC.

Nguyen, T.K. (1996). 'Policy Reform and the Microeconomic Environment in the Agricultural Section', in Leung, S. (ed.), *Vietnam Assessment: Creating Sound*

Investment Climate, Singapore: Institute for Southeast Asian Studies, Singapore.

Ogawa, K. and Suzuki, K. (2000). 'Uncertainty and Investment: Some Evidence from the Panel Data of Japanese Manufacturing Firms', *Japanese Economic Review*, 51, pp. 170-192.

Pattillo, C. (1998). 'Investment, Uncertainty, and Irreversibility in Ghana', *IMF Staff Papers*, 45, pp. 522-553.

Price, S. (1995). 'Aggregate Uncertainty, Capacity Utilisation and Manufacturing Investment', *Applied Economics*, 27, pp. 147-154.

Vietnam Economic Times, April 5th, 2000.

Appendix I: The Survey

The empirical analysis in this paper is based upon data from a survey of 210 rice milling firms in the MRD and was conducted in 2000. The survey's backbone is an extensive questionnaire. The focus of the survey was on investigating investment and investment behaviour of rice mills. Part of the survey dealt with questions concerning investment, uncertainty and irreversibility. Eight out of twelve provinces in the MRD were selected for conducting the survey. Among the four provinces that were not included in the survey, three, *i.e.*, Bentre, Travinh, and Camau, are coastal provinces, which are less involved in the rice business. The fourth province, Longan, was left out since it has a market that is more unified with that of Ho Chi Minh City, rather than with the MRD. The survey was carried out by the School of Economics and Business Administration, Cantho University, Vietnam, in co-operation with the Faculty of Economics of the University of Groningen, The Netherlands. Note that the data obtained through the survey are not based on any official records; rice millers in Vietnam usually do not keep standard accounting books and regular business records. This should be taken into account when interpreting the empirical results.

The questions in the survey that have been used to conduct the research discussed in this paper are the following:

"In which direction would the sales of your business change?"

In one year (*2001*)	
Intervals	*Probability (between 1 and 100%)*
	Sales
Increase by 0-1%	
Increase by 1-5%	
Increase by 5-10%	
Increase by 10-25%	
Increase by >25%	
Decrease by 0-1%	
Decrease by 1-5%	
Decrease by 5-10%	
Decrease by 10-25%	
Decrease by >25%	
Total	100%

Information obtained through this question was used to construct our uncertainty measures *CEV* and *SDSALAS* as discussed in the main text.

"If you would not want to continue your business any longer, how easily could you sell your milling machinery?"

❶ *Impossible*
❷ *Not so easy*
❸ *Easy*
❹ *Very easy*

The information resulting from this question was used to construct *REV1*, one of our two proxies for the irreversibility of investment (see main text).

"If you could sell your rice milling machinery, what would be the price?"

❶*Between* 1-25% *of purchase price*
❷ *Between* 25-50% *of purchase price*
❸ *Between* 50-75% *of purchase price*
❹ *Between* 76-100% *of purchase price*

The information resulting from this question was used to construct *REV2*, the other proxy for the irreversibility of investment (see main text).

Table 1: Vietnam's rice production, 1976-2000

Year	*Amount* (1,000 *tons*)	*Annual growth rate* (*per cent*)	*Year*	*Amount* (1,000 *tons*)	*Annual growth rate* (*per cent*)
1976	11,827	*Na*	1989	18,996	11.7
1977	10,597	-10.4	1990	19,225	1.2
1978	9,789	-7.6	1991	19,622	2.1
1979	11,363	16.1	1992	21,590	10.0
1980	11,647	2.5	1993	22,837	5.8
1981	12,415	6.6	1994	23,528	3.0
1982	14,390	15.9	1995	24,964	6.1
1983	14,743	2.5	1996	26,379	5.7
1984	15,506	5.2	1997	27,533	4.4
1985	15,875	2.4	1998	29,146	5.9
1986	16,003	0.8	1999	31,394	7.7
1987	15,103	-5.6	2000	32,554	4.0
1988	17,000	12.6			

Source: Nguyen (1996); Che *et al*. (2002).
Note: *Na*: not available.

Table 2: Vietnam's rice exports, 1989-2000

Year	*Quantity*		*Value*	
	Amount (1,000 *tones*)	*Annual growth rate* (*per cent*)	*Amount* (*USD million*)	*Annual growth rate* (*per cent*)
1989	1,372	*Na*	310.2	*Na*
1990	1,478	7.7	275.4	-11.2
1991	1,016	-31.0	229.9	-16.5
1992	1,953	92.0	405.1	76.2
1993	1,649	-15.6	335.7	-17.1
1994	1,962	19.0	420.9	25.4
1995	2,025	3.2	538.8	28.0
1996	3,047	50.5	868.4	61.2
1997	3,682	20.8	891.3	2.6
1998	3,793	3.0	1,006.0	12.9
1999	4,550	20.0	1,035.0	2.9
2000	3,477	-23.6	668.0	-35.5

Source: http://www.saigonnet.vn.

Note: *Na* is not available.

Table 3: Importance of the factors affecting the investment decisions

Factors	*Average ranking point*
Financial market imperfections	
Access to bank loans	2.4
Interest rate charged by banks	2.0
Collateral for bank loans	2.6
Uncertainty	
Unanticipated changes in output demand	2.9
Unanticipated changes in output prices	2.7
Unanticipated changes in sales	2.9
Unanticipated changes in future prices of milling and polishing	2.8
Unanticipated changes in input supply	2.4
Unanticipated changes in input price	2.5

Source: Own survey (2000)

Table 4: Frequency distribution of the expected growth rate of sales

Interval	*Number of firms*	*Frequency*	*Interval*	*Number of firms*	*Frequency*
Negative (per cent)			*Positive (per cent)*		
More than 25	3	1.5	0–1	21	10.3
25–10	5	3.0	1–5	105	51.0
10–5	6	3.0	5–10	19	9.3
5–1	35	17.2	10–25	5	2.2
1–0	4	2.0	More than 25	1	0.5
Subtotal	53	26.0	*Subtotal*	151	74.0
			Total	204	100.0

Source: Own survey (2000)

Table 5: Frequency distribution of *CEV* of the expected sales in 2001

Line	*Interval* (*per cent*) [1]	*Number of firms* [2]	*Frequency* [3]
1	$0 \leq CEV < 1$	9	4.4
2	$1 \leq CEV < 5$	0	0
3	$5 \leq CEV < 10$	10	4.9
4	$10 \leq CEV < 15$	126	61.8
5	$15 \leq CEV < 20$	18	8.8
6	$20 \leq CEV < 25$	23	11.3
7	$25 \leq CEV$	18	8.8
	Mean (per cent):	17.3	
	Median (per cent):	14.1	
	Total	204	100

Source: Own survey (2000)

Note: *CEV* is the coefficient of variation of the expected sales

Table 6: Frequency distribution of *REV1* and *REV2*

Category [1]	*Dummy variable* [2]	*Number of observations* [3]	*Frequency distribution(%)* [4]
Possibility to resell (REV1)			
Nearly impossible to resell	1	13	6.4
Not so easy to resell	2	177	86.8
Easy to resell	3	14	6.8
Very easy to resell	4	0	0
Total		204	100
Resale price as a percentage of purchase price (*REV*2)			
Nearly zero	1	0	0
1–50 per cent	2	102	50.0
51–75 per cent	3	91	44.6
76–100 per cent	4	11	5.4
Total		204	100

Source: Own survey 2000.

Table 7: Descriptive statistics of variables

Variables	*Mean*	*Median*	*St. dev.*	*Minimum*	*Maximum*	*Obs.*
I	0.101	0	0.196	0	1.818	204
CEV	0.173	0.141	0.138	0	1.044	204
SDSALAS	0.171	0.136	0.160	0	1.080	204
REV	0.0003	-0.035	0.561	-0.74	1.650	204
REV1	2.029	2	0.383	1	3	204
REV2	2.529	2.5	0.556	2	4	204
PRO_{1999}	0.143	0.113	0.129	-0.260	0.700	204
SAL_{1999}	1.069	0.951	0.740	0.070	3.297	204
BOR_{1999}	0.110	0	0.213	0	1.818	204

Source: Own survey (2000)

Table 8: Correlation matrix

	I	*CEV*	*SDSALAS*	*REV*	*REV*1	*REV*2	PRO_{1999}	SAL_{1999}	BOR_{1999}
I	1								
CEV	-0.165	1							
SDSALAS	0.059	0.472	1						
REV	0.260	-0.031	0.014	1					
*REV*1	0.097	-0.027	-0.015	0.324	1				
*REV*2	0.254	-0.029	0.016	0.989	0.181	1			
PRO_{1999}	0.240	0.010	0.370	0.064	0.113	0.049	1		
SAL_{1999}	0.276	-0.117	0.659	0.024	0.056	0.016	0.469	1	
BOR_{1999}	0.371	0.034	0.160	0.054	-0.107	0.072	0.050	0.107	1

Source: Own survey (2000)

Table 9: Uncertainty, irreversibility and investment: estimation results

[1]	[2]	[3]	[4]	[5]
Constant	0.0296	-0.0111	0.0310	-0.0075
	(1.05)	(-0.50)	(1.14)	(-0.35)
SAL_{1999}	0.0386**	0.0932***	0.0397**	0.0933***
	(2.05)	(4.10)	(2.17)	(4.24)
PRO_{1999}	0.2361**	0.2510**	0.2122**	0.2273**
	(2.22)	(2.39)	(2.05)	(2.23)
BOR_{1999}	0.3255***	0.3429***	0.3144***	0.3316***
	(5.66)	(6.02)	(5.64)	(6.01)
CEV	-0.2293**		-0.2180**	
	(-2.57)		(-2.52)	
SDSALAS		-0.3602***		-0.3546***
		(-3.58)		(-3.64)
REV			0.0780***	0.0788***
			(3.71)	(3.81)
N	204	204	204	204
R^2	0.236	0.258	0.285	0.308

Notes: Dependent variable is I_i, which is total planned investment divided by total fixed assets in 1999. Independent variables are: SAL_{1999} = total sales in 1999 divided by total fixed assets in 1999; PRO_{1999} = total profit in 1999 divided by total fixed assets in 1999; BOR_{1999} = total borrowing in 1999 divided by total fixed assets in 1999; *CEV* = coefficient of variation of expected sales; *SDSALAS* = subjective standard deviation of expected sales divided of total fixed assets in 1999; *REV* = irreversibility variable (see main text); *REV1* = alternative irreversibility variable (see main text); *REV2* = alternative irreversibility variable (see main text). All equations have been estimated using simple OLS. *N* = number of observations; R^2 = adjusted R^2; * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.

Table 9 (continued): Uncertainty, irreversibility and investment: estimation results

[1]	[6]	[7]	[8]	[9]
Constant	-0.0807***	-0.1616***	0.0250	-0.0127
	(-3.62)	(-2.69)	(0.90)	(-0.58)
SAL_{1999}	0.0383**	0.0399***	0.0391**	0.0902***
	(2.04)	(3.18)	(2.09)	(4.04)
PRO_{1999}	0.2177**	0.2179**	0.2229**	0.2119**
	(2.04)	(2.10)	(2.11)	(2.04)
BOR_{1999}	0.3367***	0.3110***	0.3295***	0.3567***
	(5.85)	(5.55)	(5.80)	(6.37)
CEV	-0.2258**	-0.2190**	-0.1939**	
	(-2.55)	(2.53)	(-2.17)	
SDSALAS				-0.3098***
				(-3.10)
REV1	0.0549*			
	(1.72)			
REV2		0.0760***		
		(3.57)		
CEV·REV			0.2547**	
			(2.40)	
SDSALAS·REV				0.2541**
				(3.05)
N	204	204	204	204
R^2	0.248	0.282	0.257	0.291

Note: See previous page.