Chapter 9

Investment under uncertainty: an empirical study of rice mills

9.1 Introduction

As revealed in the theoretical literature, uncertainty is likely to affect firm investment through the channel of real options (see Chapter 6). However, the sign of the investment-uncertainty relationship appears to be theoretically ambiguous: greater uncertainty can lead to either less or more investment. Therefore, in order to understand the relationship between uncertainty and firm investment in a particular setting, empirical studies are needed. As a matter of fact, only few empirical studies on this topic have been done. In particular, empirical studies that concentrate on firm investment under uncertainty in developing and transition countries are even more scant, according to our best knowledge. Thus, this empirical study, which aims to examine the relationship between uncertainty and firm investment in the context of private RMs in the MRD, can be seen as a useful contribution to the literature. It may also help to improve the understanding of the investment behaviour of RMs under uncertainty and provide explanations for the observation that in Vietnam rice milling is done by a number of small RMs using obsolete, inefficient machinery (Chapter 1).

This chapter is structured as follows. An overview of the empirical study and the data set is given in Section 9.2. Sections 9.3 and 9.4 focus on the measurement of uncertainty and irreversibility, respectively; these subsections help to create uncertainty and irreversibility variables for the empirical study in this chapter. Section 9.5 discusses our empirical findings. Finally, Section 9.6 concludes the chapter.

9.2 An overview of the empirical study and the data set

There are four aspects of the empirical study in this chapter that are worth mentioning. First, this empirical study uses firm-level data. Firm-level data enable the measurement of idiosyncratic (perceived) uncertainty that may be more important to firm investment decisions than aggregate uncertainty (see, *e.g.*, Guiso and Parigi, 1999).

Second, the literature, as reviewed in Chapter 6, indicates that characteristics such as irreversibility, competition, and firm size are relevant to firm investment decisions under uncertainty. Irreversibility makes it difficult or even impossible for firms to dispose of their used machinery in order to cope with a downturn of the economic environment, thereby discouraging them from investing. In contrast to irreversibility, it is likely that competition will boost investment because competition induces firms to invest so as to preempt competitors. The investment-uncertainty relationship may also be linked to firm size. However, the direction of this link is not clear. Our cross-section data set enables us to deal with these characteristics. Particularly, we focus on the links between irreversibility, competition, firm size and the investment-uncertainty relationship.

Third, since it is likely that firms take the future into account when making investment decisions, this empirical study examines the effect of *ex ante* uncertainty on firm investment. The uncertainty is measured using the expected growth rates of sales of private rice millers in the MRD.

Fourth, our empirical study uses uncertainty variables constructed based on the expectations about future sales. In order to be sure about the relevance of the uncertainty variable, we deliberately asked rice millers for their judgement of the importance of changes in sales to their investment decisions. Table 7.6 of Chapter 7 revealed that unanticipated changes in sales were among the most important factors affecting their investment decisions.

The survey that we carried out in 2000 aids in establishing a set of firm-level data over 204 private RMs, containing the following aspects:[148]

- investment projections;
- past sales and expectations about the future growth rate of sales;
- 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;
- the degree of competition;
- past profitability;
- the amount of money that private RMs borrowed; and

[148] According Chapter 7, our data set includes 210 private RMs. In this chapter, we use information of only 204 RMs because of missing values.

- total fixed assets.

These variables together are sufficient in terms of helping to create variables necessary for the empirical study in this chapter.

9.3 Measuring uncertainty

In order to measure uncertainty, we have to obtain information about the expectations of private rice millers about the future growth rates of sales of their businesses. Following Guiso and Parigi (1999), Question 27 of our questionnaire asked: "*in which direction would the sales of your business change in* 2001*?*"[149] Each rice miller was requested to assign weights, which sum to 100, to a set of intervals of growth rates of sales. A summary of the information obtained using this question is given in Table 9.1. In general, this table shows that 74 per cent of the sample's population expected sales to rise and 26.0 per cent expected sales to fall. The information obtained using Question 27 enables us to create our uncertainty variables, which will be described below.

Table 9.1 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 in 2000.

9.3.1 *Coefficient of variation of the expected sales* (*CEV*)

The coefficient of variation of expected sales (*CEV*) is one of the measures of uncertainty that we use in this chapter. Appendix 9.1 at the end of this chapter shows how to calculate this variable from survey data. The greater the value of *CEV*, the higher the

[149] As you can see from the questionnaire (attached at the end of this dissertation), we deliberately asked the private rice millers for this information for the year of 2003 as well. However, only few rice millers responded to this question because most of them find it very difficult to make judgments of distant future.

degree of uncertainty is.

In order to provide the reader with an overview of the degree of uncertainty facing private rice millers, we show the frequency distribution of the *CEV* in Table 9.2. This table reveals that around 90.7 per cent of the sample's population expected values of *CEV* of 10 per cent or higher (Lines 4-7); the portion of the sample corresponding to *CEV* of less than 10 per cent accounts for as only little as 9.3 per cent of the sample (Lines 1-3).

Table 9.2 Frequency distribution of the coefficient of variation of the expected sales (*CEV*)

No.	*Interval* (*per cent*) [1]	*Number of RMs* [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 in 2000.

9.3.2 *Another uncertainty variable: DEVAS*

According to our understanding, no consensus about what variable is the best measure of uncertainty has been reached. Therefore, apart from the *CEV* the empirical study in this chapter uses another uncertainty variable: *DEVAS*. This variable is defined as the ratio of the (subjective) standard deviation of the expected sales to total fixed assets in 1999. Appendix 9.1 also shows how to calculate the *DEVAS* from the subjective probability distribution. The aim of using this variable is twofold. First, this variable will be used to check the robustness of the findings based on the *CEV*. Second, it is clear from the definition that this variable helps to avoid scale effects. This may be good because although we do not know in which dimension size of a RM would influence the uncertainty facing its owner, the influence may exist (see Chapter 6).

9.4 Measuring irreversibility

As we have discussed in Chapter 6, since irreversibility cuts short the possibility for firms to dispose of used physical capital in order to cope with a downturn of the economic environment, it may lead to postponed and/or suppressed investment under uncertainty. Therefore, irreversibility is an important factor that should be taken into account when studying the investment-uncertainty relationship. This section aims to reveal the causes of irreversibility facing private rice millers and deal with the question of how to measure the irreversibility confronting private rice millers using the data that we collected.

9.4.1 *Causes of irreversibility for private rice millers in the MRD*

Like other firms, private rice millers in the MRD may be confronted with some degree of irreversibility because of impediments to reselling their used machinery. There are some factors that impede the possibility to resell the used rice-milling machinery:

- First, an important cause of irreversibility may be the co-movement with respect to sales of RMs. If the whole industry were in a downturn, no one would risk buying second-hand machinery. The co-movement of the rice-milling industry is likely to occur because the rice-milling industry as a whole is largely influenced by the volatility of the demand for and price of rice. Therefore, common shocks may be important in this industry, making (aggregate) irreversibility substantial.[150]
- Second, as for private RMs irreversibility may arise from the fact that it is difficult to use rice-milling machinery for other purposes because of its specificity. As a matter of fact, the only component that can easily be used for other purposes is the engine. Some other components can be transformed for different uses, but the transforming costs may be prohibitively high, according to our observation.
- Third, private rice millers are able to resell their machinery, but they may have to resell it in unorganised second-hand markets. Therefore, reselling used rice-milling machinery will be largely subject to the "lemons" problem as well as high transaction costs.

In sum, used rice-milling machinery may be hard to resell, meaning that irreversibility is relevant for private rice millers. This suggests that our empirical study should allow for irreversibility. We combine the methods used by Guiso and Parigi

[150] According to Guiso and Parigi (1999), there are two types of shocks: common shocks and idiosyncratic shocks. Common shocks are far more important in creating irreversibility than idiosyncratic shocks (that is specific to individual firms) because the former hit the whole industry in which individual firms operate. Ogawa and Suzuki (2001) also give similar arguments (see Chapter 6).

(1999) and Pattillo (1998) to construct a proxy for irreversibility facing private rice millers in the MRD. Guiso and Parigi use the possibility to access second-hand markets, and Pattillo employs the resale value of the capital to its real replacement value.

9.4.2 *Possibility to resell rice-milling machinery*

Our questionnaire has two questions asking for information about the irreversibility facing private rice mills. Question 28, which is based on Guiso and Parigi (1999), asked: "*if you would not want to continue your business, how easily could you resell your machinery?*" This question envisages four possibilities: (1) = nearly impossible to resell, (2) = not so easy to resell, (3) = easy to resell, and (4) = very easy to resell. The respondents were requested to mark one out of these four possibilities.

The information obtained using this question, which is provided in the upper part of Table 9.3, reveals the self-perception of how likely private rice millers are able to reverse their investment. If a rice miller releases a higher number, her/his milling

Table 9.3 Frequency distribution of the possibility to resell rice-milling machinery and the resale price

Category [1]	*Dummy variable* [2]	*Number of observations* [3]	*Frequency distribution* (*per cent*) [4]
Possibility to resell (*REV*1)			
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 in 2000.

factory, as perceived by her/himself, is of a higher degree of reversibility. Table 9.3 suggests that the second-hand market for used rice-milling machinery somehow exists in the MRD because the rice millers stated that they could resell their used machinery. Yet, the possibility to reverse investment seems to be limited. A large proportion of the

sample reported that it was not so easy to resell the used machinery. For instance, as much as 86.8 per cent of the sample reported "*not so easy to resell*" while only 6.8 per cent reported "*easy to resell*". Notably, 13 rice millers, amounting to 6.4 per cent of the sample, found it nearly impossible to resell their used machinery.

The information on the possibility to resell used rice-milling machinery is useful in helping to construct the irreversibility variable. Yet, it may not provide a complete picture about the irreversibility facing rice millers. Another aspect of irreversibility that is likely to be pertinent to investment decisions of a private rice miller concerns the perceived value of its used machinery.

9.4.3 *Resale price (as percentage of purchase price) of used rice-milling machinery*

In order to complete the information about irreversibility, Question 29 of our questionnaire, which is based on Pattillo (1998), asked: "*if you could resell your milling machinery, what would be the price as percentage of the purchase price?*" Each respondent was requested to mark one out of four scales formulated as follows: (1) = almost zero, (2) = 10-50 per cent, (3) = 51-75 per cent, and (4) = 76-100 per cent of the purchase price. The higher the ratio of resale price to purchase price, the higher the degree of reversibility (or the lower the degree of irreversibility).

The lower part of Table 9.3 shows the frequency distribution of the resale price as percentage of the purchase price. Notably, all the respondents reported that used rice-milling machinery is worth something because none of them confirmed a zero resale price. However, a large portion of the sample revealed that the resale price was not so high. Fifty per cent of the sample reported the resale price would be between 1 and 50 per cent of its purchase price; 44.6 per cent of the sample thought that their used machinery could get a price between 51 and 75 per cent of its purchase price; and only 5.4 per cent of the sample could think of a price of more than 75 per cent of its purchase price.

9.4.4 *Proxy for irreversibility of used rice-milling machinery*

As noted we asked Question 28 and Question 29 separately because combining them, like what Guiso and Parigi (1999) did, produces so many possibilities that the respondents may find it very difficult to answer.[151] However, the separation has its shortcoming. Suppose one rice miller gives "*not so easy to resell*" to Question 28 and "10-50 *per cent*" to Question 29, and another rice miller gives "*not so easy to resell*" to Ques-

[151] In this case, it is very likely that the respondent refuse to give answers.

tion 28 and "51-75 *per cent*" to Question 29. If only the answers to Question 28 are examined, both rice millers will be thought of as facing the same degree of irreversibility. This may be misleading because rice millers also consider the resale prices of their rice-milling machinery. Since the resale prices are different for these two rice millers, their machinery will not have the same degree of irreversibility. However, using only the resale price to measure irreversibility makes the degrees of irreversibility encountered by the former rice miller largely different from that encountered by the latter. This difference may not be reasonable. Therefore, an appropriate irreversibility variable should be able to encompass both above-mentioned aspects of irreversibility.

Since neither of the two variables can be the appropriate irreversibility proxy separately, we derive our proxy for irreversibility using these two variables simultaneously. A simple way of coming up with one variable that may cover both aspects of irreversibility is to take the average of the two variables. Here, we follow a bit more sophisticated approach by performing a principal components analysis of the two. The procedure that we apply to construct our proxy for irreversibility as follows:

- First, for each RM we code the possibility to resell used rice-milling machinery and the resale price (as a percentage of the purchase price) as dummy variables (see Column [2] of Table 9.3). Then, each RM has two dummy irreversibility variables, *i.e.*, *REV*1 (the possibility to resell rice-milling machinery) and *REV*2 (the resale price of rice-milling machinery).
- Second, we use the principal components technique to construct our irreversibility variable based on *REV*1 and *REV*2. We name this new irreversibility variable as *REV* and use it in the empirical study of this chapter.[152]

  In general, the principal components technique is a technique that helps to construct a variable out of correlated variables. If these variables are correlated, using all of them may be redundant. The new variable is actually a kind of a weighted average of the variables in consideration, and it can pick up most of the essence of these variables.

  *REV*1 and *REV*2 appear to be correlated with each other. The correlation coefficient between these two variables is 0.18. It is understandable that *REV*1 and *REV*2 are positively correlated because one can imagine that a used rice-milling machine that is difficult to be resold may not be resold at a high price. We think that this positive correlation coefficient is sufficient to guarantee the use the principal components technique to construct our irreversibility variable. A descriptive statistics of *REV* is given in Table 9.4.

[152] In Appendix 9.2, we replace *REV* by *REV*1 and *REV*2 in order to test if the results found using *REV* are robust.

9.5 Results and discussions

In this section, we first study the effect of uncertainty on investment for the entire sample in Subsection 9.5.1. Afterwards, we investigate the variation of the investment-uncertainty relationship with regard to the degree of uncertainty and the degree of irreversibility in Subsections 9.5.2 and 9.5.3, respectively. We will go further to examine how competition and size affect the investment-uncertainty relationship in Subsection 9.5.4 and Subsection 9.5.5, respectively. The analysis in the remainder of this chapter employs the ordinary least squares technique.

9.5.1 *Entire sample*

Model specification

In this subsection, we use the following specification:

$$I_t = \alpha_1 + \alpha_2 \cdot UNCER + \alpha_3 \cdot REV + \alpha_4 \cdot PRO_{t-1} + \alpha_5 \cdot SAL_{t-1} + \alpha_6 \cdot BOR_{t-1} \quad (9.1)$$

where:

- I_t, *i.e.*, the dependent variable, represents total planned investment (see Subsection 7.3.7 of Chapter 7) divided by total fixed assets in 1999.
- *UNCER* is the uncertainty variable, which can be either *CEV* or *DEVAS*. Based on the arguments of the real options approach to investment, we expect that α_2 is negative.
- *REV* is the (ir)reversibility variable (see Subsection 9.4.4). This variable is included based on the hypothesis that uncertainty may have a negative effect on firm investment in the presence of irreversibility. We expect α_3 to be positive.
- PRO_{t-1} is the profit realised at the end of 1999 divided by total fixed assets in 1999. The inclusion of this variable is suggested by the outcome in Chapter 8 that private rice millers are financially constrained. We expect α_4 to be positive because we assume that planned investment of a rice miller is also positively sensitive to its internal funds.
- SAL_{t-1} is sales in 1999 divided by total fixed assets in 1999. This variable helps to control for investment opportunities. α_5 should be positive.
- Finally, BOR_{t-1} is the amount of money that the rice millers borrowed in 1999 divided by total fixed assets in 1999. α_6 is also expected to be positive because rice millers may plan their investment based on the amount of money that they borrow currently.

Results and discussions

In this subsection, we investigate the investment-uncertainty relationship for the entire sample using Specification (9.1). The technique that we use is ordinary least squares. Descriptive statistics of the variables used in this subsection are given in Table 9.4.

Table 9.4 Descriptive statistics of variables: entire sample

Variables	*Mean*	*St. dev.*	*Skewness*	*Kurtosis*	*Obs.*
I_t	0.101	0.196	4.158	28.900	204
CEV	0.173	0.138	3.476	14.420	204
DEVAS	0.171	0.160	2.531	9.609	204
*REV*1	2.029	0.383	0.297	3.878	204
*REV*2	2.529	0.556	0.403	0.888	204
REV	0.0003	0.561	0.497	0.410	204
PRO_{t-1}	0.143	0.129	1.508	3.818	204
SAL_{t-1}	1.069	0.740	0.833	0.134	204
BOR_{t-1}	0.110	0.213	3.820	22.270	204

Source: Own survey in 2000.

Table 9.5 shows the outcomes of the empirical investigation with the uncertainty variable being *CEV* (Column [2]) and *DEVAS* (Column [3]). We first discuss the outcome in Column [2]. This outcome shows that the uncertainty variable (*CEV*) has a significantly negative coefficient at the 5 per cent level. Column [2] also discloses a positive relationship between reversibility and investment of rice millers: the reversibility variable (*REV*) has a significantly positive coefficient at the 1 per cent level; this would mean a negative relationship between irreversibility and investment. These outcomes suggest that uncertainty reduces RMs' investment in the presence of irreversibility, as predicted by the real options approach to investment. Profit in 1999 (PRO_{t-1}) has a significantly positive coefficient at the 10 per cent level, implying the importance of internal funds to planned investment. Sales in 1999 (SAL_{t-1}) has a positive effect on investment because it has a significant coefficient at the 1 per cent level. Borrowing in 1999 (BOR_{t-1}) also has a positive coefficient at the 1 per cent level.

In Columns [3] of Table 9.5 we use the *DEVAS* instead of the *CEV*. The aim of this replacement is to test the robustness of the previous finding. This column shows that all the coefficients have the same signs as those in Columns [2], and they all remain significant. These results appear to support the previous finding.

Table 9.5 Uncertainty and investment of rice millers
Dependent variable: Ratio of planned investment for 2000 and 2001 to total fixed assets in 1999

	UNCER = CEV	*UNCER = DEVAS*
[1]	[2]	[3]
Constant	0.0310	-0.0075
	(1.1357)	(-0.3485)
UNCER	-0.2180**	-0.3546***
	(-2.5219)	(-3.6395)
REV	0.0780***	0.0788***
	(3.7074)	(3.8072)
PRO_{t-1}	0.2122**	0.2273**
	(2.0507)	(2.2298)
SAL_{t-1}	0.0397**	0.0933***
	(2.1726)	(4.2402)
BOR_{t-1}	0.3144***	0.3316***
	(5.6351)	(6.0064)
N	204	204
R^2	0.285	0.308

Note: * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.
CEV = the coefficient of variation of the expected sales; *DEVAS* = the subjective standard deviation of the expected sales divided of total fixed assets; *REV* = the reversibility variable; PRO_{t-1} = profit in 1999; SAL_{t-1} = the sales in 1999 variable; and BOR_{t-1} = borrowing in 1999.

In sum, we find that given the presence of the irreversibility of rice-milling machinery the uncertainty with respect to future sales does have a negative effect on investment of private rice millers in the MRD. Since the uncertainty discourages investment of private rice millers, it may hold back them from expanding and adopting better rice-milling technology. Thus, apart from financial market imperfections (see Chapter 8) the uncertainty provides another explanation for the observation that in Vietnam rice milling is done by a number of small RMs using obsolete, inefficient machinery (see Chapter 1).

9.5.2 *High uncertainty versus low uncertainty*

In this subsection, we will test the hypothesis that the uncertainty only has an adverse effect on investment of private rice millers in the MRD if its magnitude reaches a certain level. There is a reason behind this hypothesis. For a given rice miller, if the uncertainty is sufficiently low, it would mean that according to him/her the probabilities

associated with the expectation that the future sales of his/her business will fall down to extreme levels is very low. One can imagine that if this is the case, the uncertainty is not likely to come into the investment decisions of the rice miller. In contrast, the rice miller definitely takes the uncertainty into account if the degree of the uncertainty is high because he/she wants to avoid making costly irreversible decisions. Then, the uncertainty may adversely affect the rice miller's investment as usually explained in the literature.[153]

In this subsection, we divide the sample according to the median of *CEV*.[154] The high-uncertainty group consists of rice millers that have a *CEV* equal or larger than the sample's median. This group (consisting of 103 rice millers) accounts for around 51 per cent of the sample's population. The low-uncertainty group (101 rice millers), including all rice millers having *CEV* smaller than the sample's median, makes up the remaining 49 per cent. Table 9.6, which gives descriptive statistics of the variables we use in this subsection, shows that the planned investment was largely different across these two groups of rice millers. The planned investment ratio (I_t) of the former group was of 0.070, and the corresponding figure for the latter group was of 0.132. The difference in these two investment rates is significant. This hints to this point that the degree of uncertainty may affect investment of rice millers.

We are to test the above-mentioned hypothesis. Table 9.7 shows the finding with the uncertainty variable being the *CEV*. Columns [2] and [3] of Table 9.7 lend support to our hypothesis on the difference of the investment-uncertainty relationship between the two groups of rice millers. The first impression is that investment of low-uncertainty rice millers is not significantly correlated with the uncertainty variable (*CEV*): the *CEV* has no significant coefficient (Column [2]). The reversibility variable (*REV*) has a significant positive coefficient at the 5 per cent level (Column [2]). Similarly, profit in 1999 (PRO_{t-1}) has a significant coefficient at the 5 per cent level. Sales in 1999 (SAL_{t-1}) does not a have significant coefficient. Borrowing in 1999 (BOR_{t-1}) has a significant coefficient at the 1 per cent level.

[153] Some studies on the uncertainty-investment relationship, *e.g.*, Sarkar (2000), Bo (2001), show that this relationship can be described with an inverted U-curve. An inverted U-curve relationship between uncertainty and investment means that low uncertainty has a positive effect on firm investment, and high uncertainty has a negative effect on firm investment. This may be explained if one assumes that there is a sort of risk-loving behaviour over the domain of small losses. However, in the context of private RMs on which our study focuses we do not have any reason to believe in this assumption.

[154] We divide the sample according to median since the median, but not the mean, allows for subsamples with relatively even populations. The median of the sample is 0.141.

Table 9.6. Descriptive statistics of variables: high and low uncertainty

Variables	*Mean*	*St. dev.*	*Skewness*	*Kurtosis*	*Obs.*
		High-uncertainty group			
I_t	0.070	0.136	2.554	7.392	103
CEV	0.235	0.169	2.726	7.520	103
REV	0.021	0.563	0.402	-0.445	103
PRO_{t-1}	0.150	0.126	1.488	3.144	103
SAL_{t-1}	0.993	0.715	0.875	0.250	103
BOR_{t-1}	0.120	0.194	2.282	6.354	103
		Low-uncertainty group			
I_t	0.132	0.239	3.930	23.880	101
CEV	0.110	0.037	-2.280	4.327	101
REV	-0.021	0.563	0.603	-0.304	101
PRO_{t-1}	0.136	0.133	1.564	4.675	101
SAL_{t-1}	1.146	0.761	0.791	0.056	101
BOR_{t-1}	0.100	0.231	4.872	31.00	101

Source: Own survey in 2000.

Table 9.7 Investment-uncertainty relationship and degree of uncertainty

Dependent variable: Ratio of planned investment 2000 and 2001 to total fixed assets in 1999

	Low uncertainty	*High uncertainty*
[1]	[2]	[3]
Constant	-0.0122	0.0241
	(-0.1718)	(0.8737)
CEV	0.0525	-0.1157*
	(0.0984)	(-1.6452)
REV	0.0790**	0.0665***
	(2.2141)	(3.1361)
PRO_{t-1}	0.3800**	-0.0010
	(2.3618)	(-0.0088)
SAL_{t-1}	0.0350	0.0632***
	(1.2409)	(3.0220)
BOR_{t-1}	0.4849***	0.0757
	(5.6132)	(1.2187)
N	101	103
R^2	0.362	0.275

Note: * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.
CEV = the coefficient of variance of the expected sales; *REV* = the reversibility variable; PRO_{t-1} = profit in 1999; SAL_{t-1} = the sales in 1999 variable; and BOR_{t-1} = borrowing in 1999.

The story is different for the group of private rice millers that face a high degree of uncertainty. The uncertainty variable (*CEV*) has a negatively significant coefficient at the 10 per cent level (Column [3]). This means that if uncertainty is high, it will affect investment negatively. As anticipated, the reversibility variable (*REV*) has a significant positive coefficient at the 1 per cent level. Profit in 1999 (PRO_{t-1}) has no significant coefficients. Sales in 1999 (SAL_{t-1}) has a significant coefficient at the 1 per cent level. Borrowing in 1999 (BOR_{t-1}) has no significant coefficient.

9.5.3 *High irreversibility versus low irreversibility*

As revealed in Chapter 6, irreversibility may play an important role in generating the negative effect of uncertainty on investment. In subsection 9.5.1, we find that under the presence of irreversibility uncertainty has a negative effect on investment of rice millers. However, it has not been shown how the degree of irreversibility affects the uncertainty-investment relationship. Since higher irreversibility makes it more difficult for rice millers to get rid of their used machinery, irreversibility may exacerbate the negative relationship between uncertainty and investment. In this subsection, we investigate the connection between the degree of irreversibility and the uncertainty-investment relationship. In order to do this, we test the following specification:

$$\begin{aligned} I_t &= \alpha_1 + \alpha_2 \cdot UNCER + \alpha_3 \cdot UNCER \times REV + \\ &+ \alpha_4 \cdot PRO_{t-1} + \alpha_5 \cdot SAL_{t-1} + \alpha_6 \cdot BOR_{t-1} \end{aligned} \tag{9.3}$$

By differentiating Specification (9.3) with respect to *UNCER*, we get:

$$\frac{\partial I_t}{\partial UNCER} = \alpha_2 + \alpha_3 \cdot REV \tag{9.4}$$

Expression (9.4) divulges that the degree of irreversibility affects the sensitivity of investment to uncertainty. We expect that $\alpha_2 < 0$ and $\alpha_3 > 0$. If this is the case, as the degree of reversibility increases, investment becomes less negatively sensitive to uncertainty. Table 9.8 shows the findings with the uncertainty variable being *CEV* and *DEVAS*, respectively.

Table 9.8 shows that both uncertainty variables (*CEV* and *DEVAS*) have a significantly negative effect on investment at the 5 per cent level. As expected, the interactive term (*UNCER*REV*) has a significant, positive coefficient at the 5 per cent level in both Columns [2] and [3]. All the other variables have significant coefficients with expected signs. This finding suggests that irreversibility increases the negative

effect of uncertainty on investment.

Table 9.8 Investment-uncertainty relationship and irreversibility
Dependent variable: Ratio of planned investment 2000 and 2001 to total fixed assets 1999

	UNCER = CEV	*UNCER = DEVAS*
[1]	[2]	[3]
Constant	0.0250	-0.0127
	(0.8970)	(-0.5821)
UNCER	-0.1939**	-0.3098**
	(-2.1728)	(-3.0970)
*UNCER*REV*	0.2547**	0.2541**
	(2.4032)	(3.0491)
PRO_{t-1}	0.2229**	0.2119**
	(2.1147)	(2.0412)
SAL_{t-1}	0.0391**	0.0902***
	(2.0942)	(4.0440)
BOR_{t-1}	0.3295***	0.3567***
	(5.7988)	(6.3692)
N	204	204
R^2	0.257	0.291

Note: * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.
CEV = the coefficient of variation of the expected sales; *DEVAS* = the subjective standard deviation of the expected sales divided by total fixed assets; *REV* = the reversibility variable; PRO_{t-1} = profit in 1999; SAL_{t-1} = the sales in 1999 variable; and BOR_{t-1} = borrowing in 1999.

9.5.4 *Competition*

As we have discussed in Chapter 6, competition may affect the investment-uncertainty relationship. The main argument emerging from the discussion in Chapter 6 is that since competition may induce firms to invest quickly so as to preempt competitors, it contributes to reducing the adverse effect of uncertainty on firm investment.

Before testing this argument using the data set, we like to reveal that the degree of competition may vary across private rice millers. There may be some kinds of private rice millers that face less competition. One probably includes those rice millers producing rice for home consumption (of farming households); they face less competition because farming households usually choose those rice millers located nearby. Another may consist of those rice millers producing cargo rice for the traders who prefer not to change suppliers because doing so would result in high search and transportation costs for them. The last one regards those rice millers specializing in polishing

and supplying milled rice directly to rice exporters, *i.e.*, pure polishers and millers-cum-polishers; since it is often difficult for rice exporters to locate polishers capable of providing rice qualified for export and also difficult for polishers to find exporters, who are few, both of them want to maintain the relationships that have been established.[155] Other private rice millers may face higher competition because they do not have such special relationships.

Since it is not possible for us to directly identify rice millers with respect to the degree of competition, we assume that those rice millers whose sales decrease as they increases their output prices will face higher degrees of competition than those whose sales increase or remain unchanged as they increase their output prices. Our data set records information on those rice millers having decreasing sales as they raise their output price and on those rice millers having increasing or unchanged sales as they increase their output price. The former group, which we called high-competition group includes 67 rice millers, accounting for 32.8 per cent of the sample's population. The low-competition group consists of 137 rice millers and makes up 67.2 per cent. Table 9.9 gives descriptive statistics of the variables used in this subsection with regard to these two groups of rice millers.

Table 9.9 Descriptive statistics of variables: high and low competition

Variables	*Mean*	*St. dev.*	*Skewness*	*Kurtosis*	*Obs.*
			High-competition group		
I_t	0.049	0.111	3.005	10.330	67
CEV	0.185	0.158	2.351	6.278	67
REV	-0.034	0.502	-0.101	-1.840	67
PRO_{t-1}	0.125	0.129	1.517	6.158	67
SAL_{t-1}	0.830	0.662	1.317	1.413	67
BOR_{t-1}	0.109	0.212	2.678	7.748	67
			Low-competition group		
I_t	0.126	0.222	3.830	24.030	137
CEV	0.168	0.127	4.413	23.160	137
REV	0.017	0.590	0.649	-0.196	137
PRO_{t-1}	0.152	0.129	1.547	2.999	137
SAL_{t-1}	1.178	0.748	0.691	-0.020	137
BOR_{t-1}	0.111	0.214	4.375	29.510	137

Source: Own survey in 2000.

[155] Regarding other Vietnamese enterprises, McMillan and Woodruff (1999) give an identical argument: "… the product is specialized and not available in the market so both the enterprise and its customers have to depend on each other…"

Table 9.10 shows the result of the test. It reveals that for the low-competition group the uncertainty variable (*CEV*) has a significant negative coefficient at the 1 per cent level. In addition, the irreversibility variable (*REV*) has a significant positive effect at the 1 per cent level. Profit in 1999 (PRO_{t-1}), sales in 1999 (SAL_{t-1}), and borrowing in 1999 (BOR_{t-1}) all have significant coefficients with expected signs.

It appears that the negative effect of uncertainty on investment is absent for the high-competition group: the uncertainty variable (*CEV*) has no significant coefficient while all the other variables have insignificant coefficients.

Table 9.10 Investment-uncertainty relationship and competition

Dependent variable: Ratio of planned investment 2000 and 2001 to total fixed assets 1999 (I_t)

[1]	*Low competition* [2]	*High competition* [3]
Constant	0.0183	0.0569**
	(0.4895)	(2.0033)
CEV	-0.3365***	-0.0709
	(-2.7772)	(-0.8073)
REV	0.0762***	0.0396
	(2.9948)	(1.3803)
PRO_{t-1}	0.4096***	0.0476
	(3.0878)	(0.3813)
SAL_{t-1}	0.0400*	-0.0041
	(1.7306)	(-0.1674)
BOR_{t-1}	0.4807***	0.0370
	(6.8492)	(0.5314)
N	137	67
R^2	0.416	0.052

Note: * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.
CEV = the coefficient of variance of sales; *REV* = the reversibility variable; PRO_{t-1} = profit in 1999; SAL_{t-1} = the sales in 1999 variable; and BOR_{t-1} = borrowing in 1999.

In sum, the finding in this subsection only shows that investment of the group of private rice millers who face low competition is negatively affected by uncertainty, and there is no clear conclusion for the other group. Since this finding implies that uncertainty, together with low competition, holds back pure polishers and millers-cum-polishers, who actually own and may be more able to acquire better rice-milling technology, from investing, it probably provides an explanation for the observation that better rice-milling technology has been absent in Vietnam (Chapter 1).

9.5.5 *Large RMs versus small RMs*

As discussed in Chapter 6, there are few studies that investigate the link between firm size and the investment-uncertainty relationship. These studies have come up with different findings about this link. Inspired by these studies, we devote this subsection to examining if the effect of uncertainty on investment varies with firm size in the context of private RMs in the MRD. In this subsection, we partition the sample into two groups: (i) large-RM group, which includes all RMs having total fixed assets in 1999 of VND 400 million or larger, and (2) small-RM group, which includes all the remaining RMs. Table 9.11 gives descriptive statistics of the variables used in this subsection with respect to these two groups of RMs.

Table 9.11 Descriptive statistics of variables: large and small RMs

Variables	*Mean*	*St. dev.*	*Skewness*	*Kurtosis*	*Obs.*
		Large RMs			
I_t	0.063	0.106	1.808	2.382	96
CEV	0.181	0.139	3.711	18.310	96
REV	0.007	0.535	0.363	-0.705	96
PRO_{t-1}	0.114	0.097	0.875	1.059	96
SAL_{t-1}	0.935	0.704	1.119	0.999	96
BOR_{t-1}	0.096	0.147	1.704	2.670	96
		Small RMs			
I_t	0.135	0.246	3.557	19.830	108
CEV	0.167	0.137	3.310	11.500	108
REV	-0.006	0.587	0.596	-0.223	108
PRO_{t-1}	0.169	0.148	1.393	2.881	108
SAL_{t-1}	1.187	0.754	0.634	-0.220	108
BOR_{t-1}	0.123	0.258	3.719	18.530	108

Source: Own survey in 2000.

Columns [2] and [3] of Table 9.12 report the finding on the variation in the effect of uncertainty on investment across the two size groups of RMs. As for the large-RM group, the uncertainty variable has no significant coefficient although the coefficient has the expected negative sign. The reversibility variable (*REV*) has a significant positive coefficient at the 5 per cent level. Sales in 1999 (SAL_{t-1}) also has a significant coefficient at the 1 per cent level, implying that sales as a variable controlling investment opportunities is important for large RMs' investment.

The story is remarkably different for small RMs. The uncertainty variable has (*CEV*) a significantly negative coefficient at the 10 per cent level. Similarly, the reversibility variable (*REV*) has a significant coefficient at 1 per cent level. Both profit

in 1999 (PRO_{t-1}) and sales in 1999 (SAL_{t-1}) have significantly positive coefficients at the 10 per cent level. Borrowing in 1999 (BOR_{t-1}) has a significant coefficient at the 1 per cent level.

The findings suggest that uncertainty is harmful for small RMs while it is not the case for large RMs. In Vietnam, large RMs tend to have direct connections with a wider range of clients than small RMs. Although these direct connections do not eliminate uncertainty, they enable large RMs to diversify risk and may thus reduce the adverse effect of uncertainty on their investment.

Table 9.12 Investment-uncertainty relationship and firm size

Dependent variable: Ratio of planned investment 2000 and 2001 to total fixed assets 1999

[1]	*Large RMs* [2]	*Small RMs* [3]
Constant	0.0432*	0.0284
	(1.7335)	(0.6449)
CEV	-0.0204	-0.2686*
	(-0.2589)	(-1.9240)
REV	0.0382**	0.1114***
	(1.9401)	(3.4174)
PRO_{t-1}	-0.0739	0.2440*
	(-0.6402)	(1.6292)
SAL_{t-1}	0.0445***	0.0507*
	(2.6962)	(1.7155)
BOR_{t-1}	-0.1080	0.4101***
	(-1.4597)	(5.5405)
N	96	108
R^2	0.137	0.392

Note: * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.
CEV = the coefficient of variance of sales; *REV* = the reversibility variable; PRO_{t-1} = profit in 1999; SAL_{t-1} = the sales in 1999 variable; and BOR_{t-1} = borrowing in 1999.

9.7 Conclusions

This chapter finds that the uncertainty with respect to the future sales has a negative effect on irreversible investment of private rice millers in the MRD. This finding can be explained by referring to the real options approach to investment: firms in general may delay investment to wait for more information because of irreversibility and thanks to the flexibility regarding their investment decisions; this may also be applicable to private rice millers in the MRD. In addition, the irreversibility stemming from

the co-movement of the rice milling industry, the specificity of the rice-milling machinery, and the absence of a formal market for used milling machinery may add to the negative relationship between uncertainty and investment of private rice millers. Since rice millers may view that irreversibility would be binding in the future, they plan to invest less and/or later.

This chapter also reveals that the investment-uncertainty relationship varies depending on the degree of uncertainty. We find that investment of rice millers who encounter low uncertainty does not appear to be sensitive to uncertainty, and investment of rice millers facing high uncertainty is adversely affected by uncertainty. This is because low uncertainty may not come into the investment decisions of the rice millers, but they must consider the uncertainty if it is high in order to avoid making costly irreversible investment decisions. Then, the uncertainty will have a negative effect on investment of the rice millers. We also discover that the negative effect of uncertainty on investment increases with the degree of irreversibility. This may be understandable because the higher the degree of irreversibility, the more difficult the resale of the used milling machinery and/or the lower the resale price.

As argued in the literature, competition may play a role in shaping the relationship between investment and uncertainty. We find that investment of rice millers who encounter a high degree of competition is not correlated with uncertainty while investment of the others is. Investment of rice millers who face a higher degree of competition is not affected by uncertainty because these rice millers may have to invest to preempt competitors.

Finally, this empirical study investigates the link between size of RMs and the uncertainty-investment relationship. This study finds that the uncertainty has an adverse effect on the investment of small RMs but not on that of large RMs. Our explanation is that large RMs may manage to avoid the effect of uncertainty due to their direct connections with a wider range of clients established through their business relationships. Since small RMs may not have such connections, the negative effect of uncertainty on their investment is present.

Appendix 9.1 **Calculating uncertainty variables**

This appendix provides a quick reference of how we calculate our uncertainty variables. The uncertainty variables include *CEV* and *DEVAS*. These variables are calculated from our survey data as follows:

a. *Calculating the mean and variance of the expected growth rate of sales*

The mean of the growth rate of the sales (*CM*) is given by:

$$CM = \frac{\sum_{i=1}^{n} x_i p_i}{\sum_{i=1}^{n} p_i} \tag{9.5}$$

For example, if a respondent anticipates that in 2001 sales would increase by 5 per cent (x_1) at a probability of 0.2 (p_1) and by 15 per cent (x_2) at a probability of 0.8 (p_2) as compared with sales in 1999 (SAL_{1999}), then

$$CM_{2001} = \frac{\sum_{i=1}^{n} x_i p_i}{\sum_{i=1}^{n} p_i} = \frac{5 \times 0.2 + 15 \times 0.8}{0.2 + 0.8} = 13\%.$$

The variance of the growth rate of sales (*CV*) is given by:

$$CV = \frac{\sum_{i=1}^{n} (x_i - CM)^2 \times p_i}{\sum_{i=1}^{n} p_i} \tag{9.6}$$

Using the above information, we can calculate the variance of the growth rate of sales as follows:

$$CV_{2001} = \frac{\sum_{i=1}^{n}(x_i - CM)^2 \times p_i}{\sum_{i=1}^{n} p_i} = \frac{(5-13)^2 \times 0.2 + (15-13)^2 \times 0.8}{0.2 + 0.8} = 14.4\%.$$

b. *Calculating the mean, the variance, and the standard deviation of the expected sales*

The mean of the expected sales is given by:

$$E(SAL_{2001}) = (1 + CM) \times SAL_{1999} \tag{9.7}$$

The variance of the expected sales is given by:

$$VAR(SAL_{2001}) = CV \times SAL_{1999}^2 \tag{9.8}$$

The standard deviation of the expected sales is given by:

$$DEV(SAL_{2001}) = \sqrt{VAR(SAL_{2001})} \tag{9.9}$$

Assume that SAL_{1999} = 100, then

$$E(SAL_{2001}) = (1 + 0.13) \times 100 = 113$$

$$VAR(SAL_{2001}) = 0.144 \times 100^2 = 1{,}440$$

$$DEV(SAL_{2001}) = \sqrt{VAR(SAL_{2001})} = \sqrt{1{,}440} = 38.$$

c. *Calculating the coefficient of variation of the expected sales*

The coefficient of variation of the expected sales is given by:

$$CEV = \frac{\sqrt{VAR(SAL_{2001})}}{E(SAL_{2001})} = \frac{DEV(SAL_{2001})}{E(SAL_{2001})} \tag{9.10}$$

Based on the above information, we have:

$$CEV = \frac{\sqrt{VAR(SAL_{2001})}}{E(SAL_{2001})} = \frac{\sqrt{1{,}440}}{113} = 33.6\% .$$

d. *Calculating DEVAS*

DEVAS (in a certain year) is given by:

$$DEVAS = \frac{DEV(SAL)}{FA}$$

where: *FA* stand for total fixed assets.

The greater the value of these uncertainty variables (*i.e.*, *CEV* and *DEVAS*), the higher the degree of uncertainty is.

Appendix 9.2 **Robustness of the irreversibility proxies**

As revealed in the literature, irreversibility is one of important factors that influence the investment-uncertainty relationship. Therefore, it is essential to select proper irreversibility variable. In this chapter, we have used *REV* as the measure of irreversibility facing private rice millers in the MRD. We like to test the robustness of this measure by introducing alternative measures of irreversibility. The result of the test is shown in Table 9.13.

Table 9.13 shows that all the signs and magnitudes of the coefficients remain nearly the same when these two irreversibility variables are used. This suggests that using *REV* to study investment of private rice millers is plausible.

Table 9.13 Uncertainty and investment of rice millers

Dependent variable: Ratio of planned investment 2000 and 2001 to total fixed assets in 1999

[1]	[2]	[3]
Constant	-0.0807	-0.1616***
	(-3.6212)	(-2.6848)
CEV	-0.2258**	-0.2190**
	(-2.5458)	(-2.5286)
*REV*1	0.0549*	
	(1.7184)	
*REV*2		0.0760***
		(3.5661)
PRO_{t-1}	0.2177**	0.2179**
	(2.0431)	(2.1020)
SAL_{t-1}	0.0383**	0.0399**
	(2.0388)	(3.1752)
BOR_{t-1}	0.3367	0.3110***
	(5.8490)	(5.5529)
N	204	204
R^2	0.248	0.282

Note: * significant at the 10 per cent level; ** significant at the 5 per cent level; and *** significant at the 1 per cent level.
CEV = the coefficient of variation of the expected sales; *REV*1 = the reversibility variable 1; *REV*2 = the reversibility variable 2 (see Section 9.4); PRO_{t-1} = profit in 1999; SAL_{t-1} = the sales in 1999 variable; and BOR_{t-1} = borrowing in 1999.