PRIVATE INVESTMENT, UNCERTAINTY, AND IRREVERSIBILITY IN UGANDA

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ABSTRACT

The paper uses panel data on Ugandan firms and a measure of idiosyncratic uncertainty to determine the nature of investment sensitivity to changes in perceived uncertainty among firms with different degrees of investment reversibility.

Using a sample selection technique to fit a modified version of an accelerator model, the paper yielded results consistent with predictions of theories of irreversible investment. The results indicate a negative relationship between uncertainty and investment. Findings also indicate that uncertainty has a greater negative effect on investment for firms with less reversible investment.

INTRODUCTION

The importance of investment behaviour of firms to economic growth cannot be overemphasized. However, economic literature has not been able to offer a clear explanation of why some countries invest more than others, or why within a particular country some industries invest more than others.

Recognizing that there is little empirical evidence of the impact of uncertainty and irreversibility in investment decisions, this study attempts to investigate the nature of the relationship between investment, uncertainty, and irreversibility in Uganda. The study hypothesizes that changing levels of uncertainty and different degrees of reversibility of investment, are key to whether or not firms make fixed commitments about investments. Specifically, the main aim of the study is to determine how the decision to invest and the level of investment are influenced by uncertainty, and how the relationship between uncertainty and investment changes when irreversibility of investment is considered.

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The study uses data from 1998 survey on Ugandan firms[1]. A two-year panel data (1996 and 1997) were used due to data availability. A salient feature of the survey is, among other things, the collection of data on firms' conditional probability of future demand for their product. From the responses, a measure of firms' perceived uncertainty (risk) and expected mean growth of demand could be derived and their effect on investment investigated particularly when there is considerable irreversibility.[2] Two separate models are used: Firstly, a probit model of decision to invest is estimated to determine the effect of uncertainty variables and irreversibility proxy in the decision to invest after controlling for other factors representing firm characteristics. Secondly, a sample selection technique (conditional on firms investing over the period) is used to fit an augmented version of a simple accelerator model to determine how a firm's perceived uncertainty and irreversibility influence the rate of investment.[3]

The rest of the paper is organized as follows: Section 1 presents a brief review of both the theoretical and empirical literature. It establishes the nature of the investment, uncertainty and irreversibility relationships. Section 2, which presents the empirical analysis of the study, comprises of two parts. The first part compares investment variables of Uganda with other sub-Saharan countries where firm level investment data is available. It also uses estimates of central tendency to establish the existence of a considerable level of uncertainty among firms. The second part of the section uses an econometric model to test the hypothesis of the study. Section 3 draws policy implications and recommendations.

1. RELATED LITERATURE

1.1 Theoretical

In the traditional capital theory, investment is costlessly reversible, and the optimal investment rule is for the firm to equate marginal revenue product of capital with the Jogensonian user cost of capital. In the case when investment is completely irreversible, recent literature has shown that the nature of the optimal investment rule differs. In between the two cases is the case of costly reversibility.

The theoretical literature on investment can be grouped into two: the adjustment cost literature and the irreversibility literature. In the adjustment cost literature, the adjustment cost function is typically assumed to be convex with no fixed cost[4]. In the 1970s and 1980s, the adjustment cost literature began to merge with the Tobin's "q" literature. Tobin (1969), argued that the optimal rate of investment is an increasing function of the ratio of the market value of the firm to the replacement of the firms capital-the "q" ratio (the shadow price of capital).

Using a deterministic model, Musa (1977) showed that the optimal rate of investment is the rate that equates the marginal adjustment cost with the marginal value of installed

[1]The 1998 survey collected data on 1997, 1996, and 1995.
[2] A measure of the ability of firms to reverse their investment when the need arise.
[3] The model is augmented by uncertainty variables and other characteristics of firms.
[4] However, a few studies such as Nickell (1978) and Rothschild (1971) mentioned the possibility of fixed cost.

capital. Abel (1983) using a stochastic model reached the same result. Others such as Eisner and Strotz (1963), Lucas (1967), Gould (1968), and Treadway (1969) have also examined investment and the cost of adjustment. By not including the cost of purchasing capital and by specifying the marginal adjustment cost to be zero at zero investment those models are set up so that a positive rate of investment is always optimal. Andrew and Eberly (1993) presented a unified model of investment under uncertainty. They incorporated both adjustment cost and irreversibility in an extended model of adjustment cost. Although their model is similar to that of Lucas (1981) they explicitly incorporated into their model Arrow's observation that resale price of capital may be below the price of new capital[5].

While the models above at best show how difficult it is to determine the relationship between investment and uncertainty, other strand of literature initiated by Hartman (1972) and followed by Abel (1983, 1985) show that greater uncertainty will increase the investment of a risk-neutral competitive firm. Assuming constant return to scale in production and a convex marginal revenue product of capital function which depends on the uncertain price of the firm's product, they argued that greater uncertainty raises the marginal valuation of one additional unit of capital thereby increasing investment.

Other literature focuses on some particular aspect of investment. Replacement investment decision models, such as the one by Emery and Finnerty (1991), use the standard textbook method to analyze replacement investment decision, implicitly assuming complete certainty[6]. Fortunately, contingent claims methods from the real option literature provide the necessary techniques to incorporate uncertainty into replacement investment decision models. Mauer and Ott (1995) studying replacement investment decisions under uncertainty concluded that uncertainty about cost and technology increases the value of waiting to replace and thereby discourages replacement investment. Many projects such as in the aircraft and pharmaceutical industries require sequential investment, and sometimes the payoffs from or the costs of completing each stage are uncertain. These investments have been viewed as compound options in the literature[7]. Majd and Pindyck (1987), using a model, which allows a firm to invest continuously, show how time to build magnifies the effect of irreversibility and uncertainty. In their sequential investment model with stochastic price and cost (which stresses the role of learning over time), Roberts and Weitzman (1981), show how information gathering can reduce the uncertainty-investment relationship[8].

1.2 Empirical

There are remarkably few empirical studies on the impact of uncertainty and irreversibility on investment. Among the few studies available, those using firm level data are even fewer. Brainard, Shoven and Weiss (1980), using a sample of 187 firms to access the effect of a Capital Asset Pricing Model (CAPM) based measure of risk of investment as a

[5] The model includes a special case in which resale price is zero.
[6] They used the Equivalent Annual Cost (EAC) technique for replacement investment decision.
[7] Each stage of the project completed gives the firm an option to complete the next stage.
[8] Each stage of investment yields information that reduces the uncertainty over the value of the project.

proxy for uncertainty found mixed results. Their cross-sectional regressions yielded both positive and negative coefficients on risk. Ferderer (1993) used risk-premium to measure uncertainty and arrived at two principal conclusions. Firstly, uncertainty has a negative and statistically significant effect on investment spending. Secondly, he concluded that uncertainty has a larger effect than does the cost of capital ratio or average q.

Other studies have used backward looking measures for uncertainty. For instance, Pindyck (1986) used variances of lagged stock returns as uncertainty proxy. He found a negative relationship between uncertainty and investment. Working with a panel data on United States firms, Leahy and Whited (1996) used as uncertainty proxy, a volatility forecast from the variance of the firm's daily stock returns to confirm that uncertainty of expected asset value is negatively related to firm investment. Their argument for the choice of their uncertainty proxy is that, the variance of the firm daily stock correlate with product demand or factor price volatility.

Testing their theoretical model of replacement investment, Mauer and Ott (1995) concluded that uncertainty about a technological innovation that will reduce maintenance and operation costs results in a significantly reduction in replacement investment. On the contrary, they found that tax policy uncertainty could result in either an increase or a decrease in replacement investment. Uncertainty in a tax law change that would discourage investment increases current investment, and uncertainty in a tax law change that would encourage investment decreases current investment. Price (1995) examined the effect of aggregate uncertainty on manufacturing investment. Using the conditional variance of GDP as a proxy for uncertainty, he found a significant negative effect of uncertainty on manufacturing investment.

Other empirical studies using firm-level data have tested the implication of irreversibility investment. Caballero and Pindyck (1993, 1996) and Pattillo (1998) have tested the idea of investment trigger and the investment-uncertainty relationship when investment is irreversible. Caballero and Pindyck (1993, 1996) used the maximal observed value of the marginal revenue product of capital within a country or an industry as a proxy for the investment trigger, and the variance in the marginal revenue product of capital as a proxy for uncertainty. Their cross-sectional equation yielded a positive relationship between uncertainty and the trigger. However, they hinted on the drawback of their method, since the maximum and the variance of a sequence of random variables would naturally be correlated. Pattillo (1998) also found a positive relationship between uncertainty and the investment trigger using panel data on Ghanaian firms. She further concluded that uncertainty has a greater negative effect on investment of firms with irreversible investment. Bertola and Caballero (1991) using a model with both idiosyncratic and aggregate sources of uncertainty studied the postwar United States investment behavior. They found that irreversibility of investment decision increases the negative relationship between uncertainty and investment.

Though the theoretical literature on the relationship between investment and uncertainty is not conclusive, the empirical evidence establishes a negative relationship between investment and uncertainty and even stronger negative relationship when irreversibility of investment is accounted for. The empirical analysis that follows determines the nature of this relationship for Ugandan firms.

2. EMPIRICAL ANALYSIS

2.1 Description of data

Data for the study was obtained from the 1998 firm survey conducted by the World Bank and the Uganda Manufacturing Association Consultancy and Information Services (UMACIS). The sample constituted 243 firms. The size distribution constitutes small firms with less than 21 employees, medium firms with between 21 and 100 employees, and large firm with more than 100 employees. The five geographical regions covered are Kampala, Jinja/Iganga, Mbale/Tororo, Mukono, and Mbarara (the geographical and size distributions of the data are reported in appendix tables A1 and A2 respectively). The survey questionnaire collected data on some characteristics of the firm (ownership structure, year of commencement of business, geographical location, branch of industry), infrastructure, investment and investment confidence, cost and sales, and competition. There were also a limited number of economic variables including firm's perception of government privatization, trade liberalization, access to credit market, taxes, and expectations of future demand for their products, exchange and interest rates. Since all the information needed for the present study was available for the 1996 and 1997 years, a two-year panel data was used. However, after deleting missing values on most of the variables a final reference sample of 299 observations was obtained.

Table 1 contains some of the investment variables of Uganda compared to a number of comparator countries (Cameroon, Ghana, Kenya and Zimbabwe). Overall, an average of 51 percent of firms invested in machinery and equipment during a two-year period of 1996-1997. Whereas large firms have greater likelihood to invest, they have a low investment to capital ratio. The investment capital ratio for firms investing is 30 percent for small firms and 11 percent for large firms. This pattern is not much different from that of the comparator countries.

Table 1: Investment in Machinery and Equipment by firms across countries

Investment by Country. Means	Proportion of firms investing	Investment/ Capital if firms invest	Investment/ Capital all firms
Cameroon			
1993/94	0.125	0.479	0.059
1994/95	0.347	0.382	0.132
Ghana			
1992	0.363	0.428	0.090
1993	0.536	0.254	0.136
Kenya			
1993	0.357	0.202	0.072
1994	0.459	0.277	0.127
Zimbabwe			
1993	0.621	0.111	0.069
1994	0.738	0.193	0.142
Comparator Country Average	**0.535**	**0.239**	**0.128**
Uganda			
1996	0.506	0.263	0.134
1997	0.527	0.208	0.111
Investment by Firm size. Means			
Firm size			
Comparator Countries			
Large firms (>=100 employees)	0.738	0.152	0.113
Small firms (< 100 employees)	0.458	0.291	0.134
Uganda			
Large firms (100+ employees)	0.765	0.109	0.083
Small firms (< 100 employees)	0.445	0.30	0.133

Source: Author's calculation using survey data on Uganda, and for comparator countries from Bigsten et al (1997)

2.2 Definition of Variables

The investment rate used in the regression is investment in plant and equipment in year "t" divided by the value of plant and equipment in year "t_{-1}". Using the 1997 (base year) value for the replacement value of plant and equipment and net investment (investment less disinvestment), the perpetual inventory method was used to create the capital stock series for 1996 and 1995. The size of the firm is proxied by the number of employees and age is the number of years the firm has been in business. The profit rate is relative to the capital stock and is defined as sales less total operation cost, less interest payment. Value added is defined as sales less total operating cost (net of wages). The non-food CPI was used to deflate both the capital stock and value added when calculating change in real value added relative to the capital stock. Finally, irreversibility proxy is defined as the ratio of the re-sales value of the capital stock to its replacement value.

2.3 Measurement of Uncertainty

The survey questionnaire asked firms about their subjective probability distribution of the evolution of future demand for their product (refer to Appendix table A3 for the specific question asked). Firms were asked to assign probabilities (totaling a 100) to a range of possible percentage changes in demand, both in one year and in next three years[9]. Given the distribution, a measure of subjective uncertainty (perceived risk) of future demand and central tendency indices were derived as below.

Let D_i represent the growth rate of the demand for the firm's product in the 5th year following the survey year. Using the base year sales value "S_o"(in Ugandan Shillings), conditional mean and variance of future demand as perceived by the firms were calculated respectively as follows;

$$E(S_i) = (1+D^e_i)\, S_o$$
$$\sigma^2 S_i = \sigma^2 D_i\, S^2_o$$

Where D^e_i and $\sigma^2 D_i$ are the conditional mean and variance of the growth rate of demand "i" years ahead[10].

Table 2 shows a frequency distribution of the coefficient of variation of expected demand. Overall, there is only a little difference between the mean value of the coefficient of variation for the two projected periods. The figure for three years ahead is 17.2 percent compared to 16.1 percent for the one-year expectation. The distribution in both periods is somewhat skewed to the left, however, there is an interesting pattern in the distribution among ranges and across firms to suggest a meaningful relationship between perceived uncertainty and investment.

[9] The implicit assumption is that the price of the product is kept constant.

[10] Pattillo (1998) used similar information on firms' subjective probability distribution in calculating conditional meand and variance of future demand for Ghanaian firms

or one-year demand expectations, the largest percentage of the firms had a coefficient of variation in the range of >25 percent and 15—20 percent ranges followed by the range of 10—13 percent. A reversed result is observed for the three years demand expectation.

The largest percentage of firms had a coefficient of variation in the range of 10—13 percent followed by the range of >25 percent. A greater percentage of firms had their coefficient of variation in intervals exceeding 10 percent.

Table 2: Frequency Distribution of the Coefficient of Variation of Future Demand

	one year ahead		three years ahead	
Interval	Number of firms	Frequency	Number of firms	Frequency
0--1	15	7	11	4.9
1--3	10	4	0	0
3--5	15	7	16	7.1
5--8	25	11	23	10.2
8--10	14	6.2	14	6.2
10--13	39	17.2	47	20.9
13--15	13	5.8	8	3.5
15--20	40	17.8	37	16.4
20--25	14	6.2	31	13.9
>25	40	17.8	38	16.9
Mean	16.1		17.2	
Total	225	100	225	100

Source: Author's calculation using survey data.
Note: All frequencies are in percentages.

For instance, 71.6 percent and 64 percent of firms had their coefficient of variation exceeding 10 percent for the three years ahead and one year ahead respectively. This illustrates that a significant percentage of firms are not certain of future demand since they distributed their percentage points across a large number of different interval of possible demand changes. It also indicates that firms are more uncertain over a longer horizon (by a small amount).

The uncertainty variable used for the regression analysis is that of the three-years ahead since that comes close to uncertainty perceived over the entire planning period. However, estimates using the one-year uncertainty measures are reported to facilitate coefficient comparisons between the two time horizons. Table 3 shows the frequency distribution of the expected growth rates of demand one and three years ahead. The longer horizon expected growth rate (three-years ahead) is 13.5 percent as compared to the one-year average of 8.2 percent. The pattern of expectations demonstrates optimism among entrepreneurs. For the one-year ahead, 25.3 percent of firms expect an exceptional growth rate of more than 20 percent, whiles 32 percent of firm expect such exceptional growth rate in three-year period. For most firms one-year expected growth rate and three-year

expected growth rates fall in the interval of 0—20 percent. The number of firms expecting a decline in demand falls over the two period horizons: 25.6 percent of firms expect demand to fall one year ahead, whereas only 14.2 percent of firms expect demand to fall in three years ahead.

Table 3: Frequency Distribution of Expected Demand Growth

Event	one year ahead	three years ahead
	Frequency	Frequency
Positive		
>20	25.3	32
Between 0 to 20	30.8	36.8
0	18.3	17
Negative		
Between 0 to 20	17.3	7.3
>20	8.3	6.9
Mean	8.15	13.5

Source: Author's calculation using survey data.
Note: All frequencies are in percentages.

Both the expected mean demand growth and the subjective variance of expected demand variables used in the regressions are normalized by the previous year's capital stock to account for the wealth and size differences across firms. The normalization also attempts to control for differences in risk aversion across entrepreneurs. Appendix A4 contains basic summary statistics of variables.

2.4 The Basic Model

The empirical analysis addresses three main issues; (1) Does uncertainty and irreversibility affect the decision to invest? (2) Does uncertainty affect the rate of investment? (3) Does the relationship between uncertainty and investment rate change when irreversibility of investment is considered? To address the first issue a reduced-form probit model would be estimated to explain that the probability of a firm investing in a particular period depends on the perceived uncertainty and other control variables.

To address the second and third issues, a modified version of a simple flexible accelerator model would be used[11]. Most theoretical models used to explain the effect of uncertainty on investment yielded closed form solutions to the general optimization problem with certain restrictive assumption on technology, degree of competitiveness in products market and the nature of adjustment cost the firm faces. This study does not follow any of those specifics. It uses the basic idea of firm optimization problem only at the general level.

[11] This model has also been used by Luigi and Parigi (1996), and Pattillo, (1998)

Following Caballero (1991), it is assumed that the representative firm uses capital and other input to produce non-storable output. At each point in time, the firm chooses its inputs to maximize its value (total revenue less total cost).

Let $\Omega(K_t, X_t, Z_t)$ denote the maximized value of the firm's instantaneous operating revenue at time t where K_t is the capital stock at time t, X_t is a random variable representing the demand facing the firm, and Z_t represent firm specific characteristics, which includes a measure of irreversibility faced by the firm. Assume that $\Omega_k(K_t, X_t, Z_t)>0$ and $\Omega_{kk}(K_t, X_t, Z_t)<0$, and the X_t evolves exogenously according to the geometric Brownian motion

$$dX_t/ X_t = \alpha dt + \sigma dzt \quad (1)$$

where α is the instantaneous drift, σ is the instantaneous standard deviation and dzt is an increment to a standard Wiener process with $E\{dz\}= 0$, and $d(z)^2 = dt$. Capital is acquired by undertaking gross investment at rate I_t, but depreciate at a fixed proportional rate of δ, so the capital stock evolves according to the following;

$$dK_t =(I_t-\delta K_t) \quad (2)$$

The total operating cost is $c(K_{t+1}, I_{t+1}, X_t)$. The firm is faced with choosing the capital stock over the infinite time horizon to maximize the expected present value of it operating net profit. The value of the firm is thus

$$V(K_t, X_t, Z_t) = \text{Max}_{(It+1)} \int_{t=0}^{\infty} e^{-rt}\{\Omega(K_t, X_t, Z_t)-c(K_{t+1}, I_{t+1}, X_t)\} \quad (3)$$

Where r>0 is the discount rate and the evolution of $V(K_t, X_t, Z_t)$ is subject to the evolution of X_t and K_t described before. The above maximization problem could be solved using the Bellman equation (after dropping the time subscript)

$$rV(K, X, Z) = \text{Max}_{(I)} [\Omega(K, X, Z)-c(K, I, X)+E(dV)(1/dt)] \quad (4)$$

The left-hand side of equation (iv) is the required return on the firm and the right-hand side is the maximized expected return which comprises of two components; operating net profit, and the expected "capital gain" represented by the change in the value of the firm E(dV)(1/dt). Deriving the first order conditions of equation (iv) and solving for I_t gives the general form of the investment demand function;

$$I_t = I^* (K, X, Z) \quad (5)$$

This depends on the stochastic demand facing the firm (represented as uncertainty in this study) and firm specific characteristics, which includes irreversibility. For the purpose of this study, the reduced form of the investment demand is;

$$I_{it}/K_{it-1} = \beta_0 + \beta_1 U_{it} + \beta_2 Y_{it} + \beta_3 Z_{it} + \beta_4 \lambda + \mu_{it} \quad (6)$$

Where U_{it} is uncertainty variables, Y_{it} is the last period profit rate, Z_{it} is a vector of additional control factors representing firm characteristics (including irreversibility), λ is the inverse Mills ratio included to adjust for the inclusion of only investing firms, and μ_i is a stochastic error term (assumed to be normally distributed). All variables are defined for the ith firm at time "t".

2.5 Results

Table 4 presents the estimates of the decision to invest model. Column 1 presents a simple version of the model to investigate the relationship observed by preliminary analysis of the data (refer to Table 1). The results confirm that size of firm and the profit rate are positively correlated with the probability to invest. On the other hand, the older a firm is, the less likely it is to invest. The negative relationship between firm age and the probability of investing could be attributed to change in policy regime in Uganda. Older firms in the sample commenced business in an environment with a very different incentive system in place (import substitution regime) compared to the present incentive structure (encouraging competition by liberalizing trade). They are therefore stuck with a capital stock, which is no longer viable, and therefore are less willing to invest. Column 2 extends the basic model to include uncertainty variables.

Table 4: Probit model of decision to invest

	Invd=1 if any Investment, 0 Otherwise (1)	Invd=1 if any Investment, 0 Otherwise (2)	Invd=1 if any investment, 0 otherwise (3)
Constant	-0.977	-1.122	-1.298
	(-4.32)	(-5.06)	(-5.45)
Ln(size)	0.342	0.321	0.326
	(5.83)	(5.50)	(5.53)
Firm age	-0.019		
	(-2.55)		
$Profit_{(-1)}$	0.107	0.035	0.033
	(2.18)	(0.53)	(0.49)
Δvalue added/ $capital_{(-1)}$		0.328	0.322
		(2.20)	(2.15)
Expected mean		0.011	0.013
Demand growth		(0.53)	(0.59)
Variance of		-5.97e-09	-6.41e-09
Expected demand		(-1.74)	(-1.89)
Revd*			0.348
			(2.26)
Number of Observation	299	299	299
Ln(likelihood)	-185.18	-183.71	-181.15

Notes: Revd*=1 if firm's resale value to replace value of capital is above the average of all firms (0.52), 0 otherwise. The figure in parenthesis are the absolute values of the t-statistics.

At 10 percent significant level, uncertainty has a negative effect on the decision to invest. Although the level of expected demand had the expected sign, it was not significantly different from zero. When the change in the ratio of value added to capital was included in the model it carried the right sign and is significantly different from zero. In order to investigate the effect of irreversibility on the decision to invest, a reversibility dummy, which takes the value of "1" if the firm's capital is relatively reversible, and "0" if it is relatively irreversible, was included in the model. The fundamental reason for the use of this measure is the "lemon" problem. Firms can only sell their installed capital in the second hand market at a discount over and above total depreciation to date. The smaller the margin the more liquid the asset of the firm is, and the more reversible its investment is. The result indicates that reversibility is significantly positively correlated with the decision to invest. That is, firms with easily reversible capital are more likely to invest than those with less reversible capital. An attempt to investigate how irreversibility affects the decision to invest through uncertainty did not yield any meaningful results. This may

suggest that irreversibility of capital may have a direct effect on the decision to invest, and that in a period of certainty, concerns about the reversibility of capital may significantly affect the decision to invest.

The first column of Table 5 presents the parameter estimates of the investment rate equation. The signs of the age and size coefficients are consistent with earlier results. For instance, it was concluded that older firms are less likely to invest due to changes in the incentive structure in the Ugandan economy. It is therefore no surprise that if they do invest, their investment rate will be less compared to a similar firm which is newly established. Though the coefficient of the size variable is not significantly different from zero it carried the right sign in confirmation with the results from Table 1. The profit rate has a positive and significant effect on the rate of investment[12]. The level of expected demand, even though did not significantly explain the probability that a firm invest, significantly explain the level of investment. Finally, the uncertainty proxy has a negative effect on investment rate and its coefficient is significantly different from zero. This contradicts theories that predict a positive investment-uncertainty relationship.

[12] It reflects the importance of internal liquidity in investment decisions.

Table 5: Investment under uncertainty model with irreversibility (three years perspective)

	Investment/ $Capital_{(-1)}$ Selection model	Investment/ $Capital_{(-1)}$ Selection model Revd = 1	Investment/ $capital_{(-1)}$ selection model Revd = 0
	(1)	(2)	(3)
Constant	-0.949	-1.226	-0.640
	(-1.40)	(-1.266)	(-0.540)
Size	-0.163	-0.339	-0.035
	(-1.58)	(-2.64)	(-0.19)
Firm age	-0.381	-0.185	-0.555
	(-2.45)	(-0.90)	(-2.58)
$Profit_{(-1)}$	0.165	0.214	0.076
	(2.32)	(1.77)	(0.58)
Expected mean Demand growth	0.658	0.522	0.722
	(4.74)	(2.67)	(3.23)
Variance of	-0.088	-0.027	-0.142
Expected demand	(-1.95)	(-0.41)	(-2.15)
Lambda	-0.106	-0.141	-0.288
	(-1.48)	(-2.01)	(-1.10)
Number of			
Observation	153	81	72
Adjusted R-squared	0.28	0.23	0.30
F-test (degrees of Freedom)	10.7 (6, 146)	5.0 (6, 74)	6.2 (6, 65)
Jarque-Bera	4.16	2.20	2.35
	(0.13)	(0.33)	(0.31)

Notes: Revd = 1 if the firm's resale value to resale value of capital is above the average of all (0.52) 0 otherwise. The figures in parentheses are the absolute values of the t-statistics. All variables are in logs except the profit rate. Standard errors are adjusted for heteroscedasticity [Heckman (1979)]. Jarque-Bera statistics for testing whether the residual vector is normally distributed, p-values of the null hypothesis of a normal distribution is in parentheses.

If the negative uncertainty-investment is true, then firms that can easily dispose off installed capital when the state of uncertainty arrives should be less responsive to uncertainty when deciding on the level of investment. To investigate this hypothesis the total sample was split according to the reversibility dummy. Column 2 and 3 show the results of the estimates. Even for firms with relatively high degree of investment reversibility, the effect of uncertainty is negative, though not significantly different from zero. The absolute value of the coefficient of the uncertainty variable is less than that of the overall sample. On the other hand, for the sub-sample of firms with relatively low investment reversibility, the coefficient of the uncertainty variable is not only highly significantly different from zero, but also five times greater than that of the relatively high investment reversible sub-sample. This result indicate that for Ugandan firms, uncertainty

has a greater negative effect on investment level for firms with high degree of investment irreversibility.

An interesting pattern in the coefficients of the other variables is observed when estimates of the two sub-samples are compared. The level of expected demand maintained its sign and significance in both equations. The profit rate coefficient is only significant in the high reversible sub-group equation. Since reversibility and profitability are positively correlated with the decision to invest, it is therefore expected that the high degree of reversibility sub-group equation will have a significant and greater coefficient of profit rate in explaining the level of investment. For the same equation, the coefficient of the size variable is negative and significant (consistent with the results from Table 1). On the other hand, the coefficient of the size variable is not significantly different from zero in the low degree of reversibility sub-group. Probably, when reversibility of capital is a problem, the role of the size of the firm in deciding on the level of investment is no longer important. To further validate the results above, all three equations in Table 5 were tested for normality. From the Jarque-Bera statistics, the null hypothesis of normally distributed errors cannot be rejected.

Recognizing that in the case of large firms the actual respondent may not be the one who takes investment decisions, the basic investment equation was estimated excluding large firms.

Table 6: Investment under uncertainty (small firms)

	Investment/ capital(-1) selection model (1)	Investment/ capital(-1) selection model (2)
constant	0.189	-1.356
	(0.17)	(-1.79)
size		-0.088
		(-0.23)
Firm age	-0.796	-0.404
	(-3.13)	(-1.48)
Profit(-1)	0.249	0.193
	(2.29)	(1.18)
Expected mean	0.719	0.601
demand growth	(3.44)	(4.22)
Variance of	-0.125	-0.066
Expected demand	(-2.12)	(-1.61)
Lambda	1.990	0.074
	(1.11)	(0.06)
Number of		
observation	101	149
Adjusted R-squared	0.32	0.26
F-test (degrees of Freedom)	10.4 (5, 95)	10 (6, 142)
Jarque-Bera	5.88 (0.052)	3.37 (0.19)

Notes: Column (1) is the regression equation excluding large firms.
Column (2) correspond to equation using one-year ahead measure of uncertainty.

Interestingly, the coefficients of all variables increased and their precision improved (with the exception of the expected demand growth variable). For further test of robustness of the results with respect to time horizon, the basic equation was re-estimated using one-year ahead measures of uncertainty and level of expected demand variables (result is in column 2 of Table 6). The coefficient of the uncertainty variable even though insignificantly different from zero, is smaller compared to the tree-year ahead estimate. The overall fit is also less powerful. This may throw light on the importance of the choice of time horizon when using a forward-looking measure of uncertainty. It may also indicate that there is a significant difference between the perceived uncertainty for the two time horizons and confirms the earlier conclusion that firms are more uncertain over a longer period. A further investigation revealed that the correlation coefficient between the two measures of uncertainty is equal to 0.41. Finally, the selection bias terms were not significant except for the regression involving only the more capital reversible firms. Further exploration of the selection mechanism would be useful.

Table 7 presents the results of another approach to addressing the main issues of the paper in addition to adding two firm category dummies (primary analysis of the data revealed that firms in tourism category and Mukono district invested significantly higher than firms

in other categories). Both Tourism and Mukono dummies entered significantly. This confirms the preliminary results, which indicated that firms in the tourism sector and Mukono district significantly invested more than all other firms. The overall properties of the results also improved. The second column includes the reversibility dummy as a regressor. This result implies that at 5 percent significant level we cannot accept the null hypothesis that investment rate is invariant to the degree of reversibility of capital. Hence, firms with more reversible capital stock invest more than firms with less reversible capital stock, even when faced with the same uncertainty.

The investigation of how reversibility affects the investment-uncertainty relationship is carried out in column 3. An interacted variable of reversibility and uncertainty is included as an additional regressor to the result in column 1. The interacted variable entered significantly. In this specification, the sum of the coefficients of the uncertainty variable and the interacted variable measures the effect of uncertainty on investment to firms with more reversible capital. The results show that uncertainty has a greater negative effect on investment rate for firms with less reversible capital. Put differently, the uncertainty coefficient for firms with more reversible investment is smaller, though still negative. The significance of the interacted variable confirm that, there is a significant difference in the uncertainty coefficients for firms with more reversible capital and firms with less reversible capital. An attempt to include other location and activity dummies in all the three regressions did not yield any significantly results either individually or jointly. The selection bias terms were significant only when reversibility of capital was controlled for.

A Chi-squared test confirmed that reversibility of capital does not completely make investment level decisions invariant to changes in uncertainty. The null hypothesis of zero coefficient of uncertainty for firms with more reversible capital stock could not be accepted at the 5 percent significant level. All three equations in Table 6 were tested for normality. From the Jarque-Bera statistics, the null hypothesis of normally distributed errors cannot be rejected.

Table 7: Investment under uncertainty model with irreversibility (three years perceptive)

	Investment/ capital(-1) selection model (1)	Investment/ capital(-1) selection model (2)	Investment/ capital(-1) selection model (3)
Constant	-1.788	-2.386	-2.02
	(-2.65)	(-3.25)	(-2.97)
Size	0.307	0.504	0.465
	(0.96)	(1.71)	(1.55)
Firm age	-0.558	-0.672	-0.656
	(-1.97)	(-2.59)	(-2.47)
Tourism	0.988	1.094	1.097
	(2.54)	(2.89)	(2.90)
Mukono	1.186	1.194	1.142
	(2.24)	(2.38)	(2.19)
Profit(-1)	0.249	0.324	0.315
	(2.11)	(2.79)	(2.69)
Expected mean	0.718	0.652	0.664
demand growth	(5.45)	(4.71)	(4.87)
Variance of	-0.123	-0.128	-0.154
expected demand	(-2.84)	(-3.07)	(-3.44)
Revdummy		0.665	
		(2.02)	
Revdummy*Variance			0.055
of expected demand			(2.18)
Lambda	1.001	1.452	1.363
	(1.34)	(2.18)	(1.98)
Number of observation	153	153	153
Adjusted R-squared	0.31	0.32	0.32
F-test (degrees of Freedom)	9.7(8, 144)	9.1(9, 143)	9.1(9, 143)
Jarque-Bera	4.36	3.74	4.04
	(0.11)	(0.15)	(0.13)
Chi-square test of restriction			5.06
$\beta_8 + \beta_9 = 0$			p = 0.02

Note: The figures in parenthesis are the absolute values of the t-statistics. All variables are in logs except the profit rate and the dummies. The standard errors are adjusted for heteroscedasticity [Heckman (1979)]. Jarque-Bera is the Jarque-Bera statistic for testing whether the residuals vector is normally distributed, p-value of the null hypothesis of a normal distribution in parenthesis.

2.6 CONCLUSION

The empirical analysis of the study was carried out in two parts. The first part uses the data from the investment survey to generate certain central tendency variables for Uganda and compared them with other sub-Saharan African countries where firm-level investment data is available. It established considerable similarities of the variables between Uganda and

the comparator countries. The section also derived an uncertainty proxy using firm's perception of future changes in the level of sales/demand of their product. The existence of a significant level of uncertainty was established after examining the data. The second part of the empirical analysis comprises of econometric analysis of the uncertainty-investment decision relationship. A probit model of decision to invest concluded a significant negative relationship between uncertainty and the probability of a firm investing, after controlling for other variables. Following that, a modified version of a simple accelerator model was used to determine if investment rate is sensitive to changes in uncertainty as perceived by firms. The results showed that firms with higher perceived uncertainty invest less and this relationship is stronger when investment is irreversible. It also showed that profit rate and expectations of future growth in demand are positive correlates to the rate of investment.

3. POLICY IMPLICATIONS

This study has contributed to the few empirical firm-level studies in signing the relationship between investment and uncertainty, particularly when investment is not easily reversible. Consistent with the irreversible literature, the study has affirmed that there is a negative relationship between uncertainty and investment decisions and confirmed the even stronger negative relationship when irreversibility of investment is considered.

From the conclusions of the study, certainty policy implications emerge. Firstly, the results cautioned that sentiments about signs of pick-up in the economy could lead to a significant response in the private sector. Hence, government in pursuing its growth objectives must find ways of boosting private sector confidence. This can be achieved by demonstrating policy commitment and consistent policy implementation that promises bright future for investment.

Secondly, the implied gains from macroeconomic policies to improve firm level perceived uncertainty has been affirmed by the results of the study. This implicitly implies that if uncertainty over the economic environment is high, investment incentives will have minimal impact on investment. Put differently, investment incentives may have to be very high to significantly impact on investment. The best way out is to ensure more policy credibility and stability that will lead to a reduction in firms' perceived uncertainty.

Finally, the investment irreversibility issue must be addressed to prevent a situation where local investors will be more interested in investing in more liquid assets such as foreign exchange and other liquid assets held abroad. If commitments in real assets (physical plant) has a small chance of reversibility, its opportunity cost increases, making investment in financial assets both home and abroad more attractive. Likewise, it may be difficult to attract foreign private capital if there is perception that it may be difficult to reverse investment once the commitment in real assets are made. This problem could be addressed by creating political environment, as well as designing and implementing investment policies that guarantees flexibility of investment, particularly to foreign investors whose menu of investment choices are diverse.

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Appendix Tables

Table A1. Structure of final sample by category and geographical location (no. of establishments)

Category	Iganga/Jinja	Kampala	Mbale/Tororo	Mukono	Mbarara	Total	Total (in %)
Commercial agriculture	0	8	1	12	10	31	13
Agro-processing	10	23	6	9	5	53	22
Other manufacturing	21	69	7	1	5	103	42
Construction	5	19	0	0	3	27	11
Tourism	9	11	5	2	2	29	12
Total	45	130	19	24	25	243	100
Total (in %)	19	53	8	10	10	100	

Table A2. Structure of final sample by category and size (no. of establishments)

Category	Small	Medium	Large	Total	Total (in %)
Commercial agriculture	15	11	5	31	13
Agro-processing	16	16	21	53	22
Other manufacturing	43	39	21	103	42
Construction	3	12	12	27	11
Tourism	17	8	4	29	12
Total	94	86	63	243	100
Total (in %)	39	35	26	100	

Table A3. Subjective Probability Distribution Question from Uganda Firm Survey

The following question was asked by the survey field staff;

"This question deals with your expectations about future demand/sales. We want to know what you think are the chances (or likelihood) of 5 possible events, where the chances of the different events must sum up to 100%".

		a: What are the chances (in %) that your production/ turnover in 1998 will be..	b: What are the chances (in%) that your annual change in production/ turnover in 1999 and 2000 will be..
INCREASE	A great deal higher (more than 20%)		
	Moderately higher (between 0 to 20%)		
NO CHANGE	0%		
DECREASE	Moderately lower (between 0 to 20%)		
	A great deal lower (more than 20%)		
TOTAL POINT (should add to 100%)		100%	100%

Table A4. Basic summary statistics of variables.

Variable	Observation	Mean	Median	Std. Deviation
Age	299	13.5	11	11
Investment rate	299	0.13	0.003	0.455
Size	299	110	28	256
Profit rate	299	0.82	0.30	1.61
expected mean demand growth-three years ahead	299	3.63	1.30	8.06
expected mean demand growth-one years ahead	299	3.52	1.28	7.17
Variance of expected demand growth-three years ahead	299	2.03E+16	1.01E+13	3.12E+17
Variance of expected demand growth-one years ahead	299	3.34E+15	3.84E+12	1.60E+16