

# Chapter I

## Introduction

### 1.1- Introduction

The bearing of uncertainty and instability on private investment, an issue of concern for policy-makers, has been given considerable attention in the analytical and empirical literature. The issue is important owing to the fact that the lessening of extended poverty and unemployment on the one hand and the achievement of sustainable development on the other hand depends on the increase in private investment. The World Development Report (World Bank, 2005b) says:

*Private firms—from farmers and micro-entrepreneurs to local manufacturing companies and multinational enterprises—are at the heart of the development process. Driven by the quest for profits, they invest in new ideas and new facilities that strengthen the foundation of economic growth and prosperity. They provide more than 90 percent of jobs, creating opportunities for people to apply their talents and improve their situations. They provide the goods and services needed to sustain life and improve living standards. They are also the main source of tax revenues, contributing to public funding for health, education, and other services. Firms are thus critical actors in the quest for growth and poverty reduction.*

Recent studies have shown that private investment is more efficient and productive than public investment (Serven and Solimano, 1991 and Kahn and Reinhart, 1990). For the same reasons, public investment cannot adequately resolve the

aforementioned problems. Due to mismanagement, public enterprises are plagued by inefficiency. World Development Report (2005) has quoted from Pinheiro et al. (2001) that growth without an enhanced private sector is possible but unlikely to be sustained. For instance, Pinheiro et al. characterize Brazil in the 1960s and 1970s:

*They experienced strong growth while closing domestic markets to international competition and pursuing **heavy public investment** through state-owned enterprises. The initial results were impressive, but the growth proved unsustainable. Protected firms lacked the incentives to improve their productivity and fell further behind international best practices. Other firms had less access to new technologies and had to pay higher prices for inputs supplied by protected sectors. Public investment to sustain growth led to severe debt problems— and ultimately to a macroeconomic crisis.*

Thus, the public sector not only is incapable of providing a permanent solution to problems but also adds to other difficulties. Conversely, private sector is driven by economic incentives. The significance of profitability constrains them to use scarce resources in the best way for production and investment; this often paves the way for an increase in employment, reduction of poverty, sustainable development and growth.

But, how should the private sector be encouraged to invest more? What causes differences in country wise participation of private sector in investment? Table-1.1 indicates private investment (percentage of GDP) and GDP per capita (constant 2000 U.S. \$) in 1980, 1990 and 1999 for six countries. It shows that in 1980, Argentina had the same private investment rate as Malaysia, but 4 times the per capita GDP. In this year, Iran at six times the per capita GDP of India had the same private investment rate. In

1990, Malaysia with 50% of the per capita GDP of Argentina had 2.3 times the private investment rate. Simultaneously, South Africa at ten times per capita GDP of India had a lower rate of private investment. There is an analogous comparison between Argentina and China in 1999. In 1999, India with a lower per capita GDP than Iran, Malaysia and South Africa had a higher rate of private investment. In 1999 Argentina had a lower private investment rate than in 1980 despite a higher per capita GDP.

Table-1.2 shows nominal and real interest rates and share of private investment in China and India for 1980, 1990 and 2000. China has increased 4.6 times the private investment rate despite a 6.8 times growth in its real interest rate between 1980 and 1999. Similarly, we observe an increase in the private investment rate in India in spite of the growth in the real interest rate in this period. Furthermore, private investment does not show reasonable reaction to nominal rate fluctuations from 1980 to 1990 and from 1990 to 2000. As Modigliani and Miller (1958) mention: *“at the macroeconomic level there are ample grounds for doubting that the rate of interest has as large and as direct an influence on the rate of investment...”*

	Year					
	1980		1990		1999	
	GDP per capita	Private Investment	GDP per capita	Private Investment	GDP per capita	Private Investment
Argentina	7551	19.2	5643	9.4	8062	16.1
China	173	3.7	364	8.3	798	17
India	222	10.1	316	13.9	440	14.9
Iran	1278	11.4	1196	8.5	1460	13
Malaysia	1848	19.5	2498	20.9	3653	11.3
South Africa	3436	13.3	3058	12.9	2881	10.3

**Table 1.1- Comparison of GDP per capita and private investment rates among selected countries.**

Initial theories of private investment emphasized the importance of reduction of interest rate and increase in output as channels in encouraging private investment. Keynes (1936) explicitly demonstrates that investment will occur to the level at which marginal efficiency equals the current rate of interest. Hence, a decrease in the rate of interest will increase investment. The flexible accelerator model is the departure point from a handful of investment behavior theories. Flexible accelerator mechanism shows that

$$K_t - K_{t-1} = [1 - \lambda][K_t^* - K_{t-1}]$$

Denoting the level of capital in period  $t$  by  $K_t$  and the desired level of capital by  $K_t^*$ , capital is adjusted toward its desired level by a fraction of the difference between desired and actual capital in each period. If  $\delta$  denotes the rate of replacement then we can have

$$I_t = [1 - \lambda][K_t^* - K_{t-1}] + \delta K_{t-1} \quad (1)$$

Accelerator theory, liquidity theory, expected profit theory differ in specification of the desired level of capital<sup>1</sup>. However, Jorgenson (1963) mentions that:

*It is difficult to reconcile the steady advance in the acceptance of the neoclassical theory of capital with the steady march of the econometric literature in a direction which appears to be diametrically opposite...Both profits and capacity theories have tried a rate of interest here or a price of investment goods there. By and large these efforts have been unsuccessful.*

In their search for an econometrically significant model, Jorgenson (1963) and Jorgenson and Siebert (1968 a, b) formulated a new neoclassical theory for investment. In this theory the desired capital stock is equal to the value of output deflated by the price of capital services where the later is denoted by  $C_t$ :

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<sup>1</sup> - Jorgenson and Siebert (1968a) might be studied for more details.

$$C_t = \frac{q_t}{(1-u_t)} [(1-u_t w_t) \delta + r_t - \frac{q_t - q_{t-1}}{q_t}] \quad (2)$$

where  $q_t$  is the investment good price index,  $\delta$  the rate of replacement,  $r_t$  the cost of capital,  $u_t$  the rate of taxation of corporate income, and  $w_t$  the proportion of depreciation at replacement cost deductible from income for tax purposes. This equation says that the price of capital services is equal to the depreciation at current cost minus tax saving due to depreciation plus the cost per unit capital minus the accrued capital gains. Then, the neo-classical model specifies

$$K_t^* = \alpha \frac{P_t Q_t}{C_t} \quad (3)$$

where,  $P_t Q_t$  is the value of output and  $\alpha$  is the elasticity of output with respect to capital. The desired level of capital is a function of value of output and the rental price of capital services calculated in equation (2). Then, with substitution of the expression for  $\delta$  from (2) and the expression for  $K_t^*$  from (3) in equation (1), investment is calculated as a function of output and *rental value of capital services*. This rental value is calculated through a *shadow* or accounting price for capital services that depends on the cost of capital, the price of investment goods, the rate of change of this price, and the tax structure for business income.

Romer (1996) mentions that this model does not consider any mechanism through which expectations affect investment demand. For instance, in developing countries, policies which seek to achieve aforementioned objectives (e.g. poverty, unemployment or growth) might end up boosting demand for money for consumption and not for investment. The result can be either a financial crisis (e.g. Latin America or Africa) or an increase in the inflation rate (e.g. Iran).

Such criticisms have caused researchers to recognize uncertainty as the third factor which affects private investment.

	Year								
	1980			1990			2000		
	interest	rate	private investment (%)	interest	rate	private investment (%)	interest	rate	private investment (%)
	real	nominal		real	nominal		real	nominal	
China	1.21	5.04	3.7	3.49	9.36	8.3	4.86	5.85	17
India	4.48	16.5	10.1	5.39	16.5	13.9	8.19	12.3	14.9

**Table 1.2- Real and nominal interest rates for India and China.**

As a starting point consider a conventional *NPV* model under certainty:

$$\overline{NPV} = -I_0 + \sum_{t=1}^N \frac{\overline{X}_t}{(1+i)^t}, \quad t = 1 \text{ to } N$$

where  $\overline{NPV}$  is expected net present value,  $\overline{X}_t$  denotes expected cash flow in period  $t$ <sup>1</sup>,  $i$  is the risk-free rate of interest,  $N$  is the time span of the project and  $I_0$  denotes the initial cash outlay. Investment is a long-run plan. The investor expects to maximize his profit during a defined lifetime. Therefore, he tries to predict the future flows of profits, and compute its present value. Only, projects with positive  $\overline{NPV}$  are candidates for acceptance. What happens if the investor cannot accurately forecast future flows and there is a difference between ex-ante and ex-post flows rendering the predictions

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<sup>1</sup> -  $\overline{X} = \sum_{i=1}^N p_i X_i$ , where  $\overline{X}$  denotes the expected value of cash flow,  $X_i$  is the possible amount of cash flow  $i$ , and  $p_i$  is the probability of cash flow  $i$  occurring.

unreliable? In this situation the investor adjusts his discount rate using the following formula:

$$\overline{ANPV} = -I_0 + \sum_{t=1}^N \frac{\overline{X}_t}{(1+k)^t}, t = 1 \text{ to } N$$

Where  $\overline{ANPV}$  is the adjusted net present value and  $k$  denotes the risk-adjusted interest rate based on the perceived degree of project risk. Therefore, higher the observed riskiness of a project, the greater the risk premium to be added to the risk-free interest rate. This results in a higher discount rate and, thus, a lower net present value. Because, relative to the initial situation, an investor looks for a higher expected rate of return, the number of positive  $\overline{ANPV}$  projects and therefore acceptable investment opportunities will be less than positive  $NPV$  projects. This occurs because the future is unclear. Takii (2004) demonstrates how the ability to predict positively affects the investment through its impact on adjustment cost of capital stock. But the problem is that there is a delicate difference between *risk* and *uncertainty*. According to Pike and Neal (1996):

***Risk** refers to the set of unique consequences for a given decision which can be assigned probabilities, while **uncertainty** implies that it is not fully possible to identify outcomes or to assign probabilities. Perhaps the worst forms of uncertainty are the **unknown** unknowns – outcomes from events that we did not even consider.*

In case of *risk* there is a probability distribution of future flows that form the basis of studies but there is no index showing the magnitude of *uncertainty*. How can we anticipate the probability of a coup, revolution or war in a country? How can we determine the effect of bad governance on our industry? We need to consider the factors,

which could generate such unknown circumstances to study the effect of these factors on aggregate private investment in a country.

I define an element of uncertainty as any factor by which distorts information and predictions about the future. Often, studies concentrate on uncertainty about prices, demand or costs and deal with them by maximizing the value of the firm's expectation of all future probable receipts. But, by foregoing definition, it embraces a wide range of factors that bring about not only unpredictable fluctuations in prices but also affect the state of confidence of entrepreneurs and their trust on information at hand. So, there must be a time horizon for each project within which entrepreneurs can rely on their information and assess their projects through the maximization of expected value of all probable future revenues. This time horizon depends on factors causing uncertainty that could result an optimistic or pessimistic atmosphere in business. Unpredictable changes in the macroeconomic environment, institutions and quality of governance could be a type of uncertainty. For instance, consider a case in which there is a potential of civil war in a country. The questions that can quickly emerge among investors are: would a civil war arise? If yes, would it be harmful to our business and investment or even our lives? Who will win the war? Would there be any change in the law, rights and bureaucracy procedures after civil war? All of these questions render investors more hesitant about undertaking investment. The role of uncertainty can be compared with environmental conditions (e.g. temperature or pressure) or catalysts in chemical reactions. These factors do not have any direct participation in a reaction, and there is no reaction without suitably high incidence of these factors. Therefore, instead of assessing the impact of

unpredictable future receipts on private investment, the direct effect of each possible factor of uncertainty on the private investment rate is examined in this study.

The objectives of the study are:

Main objective:

- To ascertain the impact of uncertainty on the private investment rate.

Sub-objectives:

- To identify the different types of uncertainty.
- To determine the significance of each type on private investment.

And based on these objectives the testable hypotheses are:

- $H_1$ : Uncertainty about macroeconomic outcomes and policy changes decreases private investment.
- $H_2$ : Uncertainty about quality of public governance has a negative effect on private investment.
- $H_3$ : Uncertainty about socio-political institutions and conflicts decreases private investment.

The remainder of the study is organized as follows. The second part of this chapter is dedicated to a literature review. In chapter two I elaborate in the economy of Iran. A new theory of uncertainty and investment is explained in chapter three. Methodology, estimation and outcome analysis are explained in chapter four. Chapter five concludes.

## 1.2- Literature Review

The classification of different theories of investment under uncertainty has been presented in chart-1.1. They diverge through their different definitions of uncertainty and different assumptions about conditions in which the investment decision is taken. The post-Keynesians and neo-classics differ essentially through their definition of uncertainty. I will explain precisely the post-Keynesian method and its difference with neo-classics later in chapter 3.

Neo-classical methods focus on uncertainty about the components of the profit function (e.g. demand and price of output, costs etc.) where profits are derived from the process of production while traditional finance has focused on streams of profits from securities (and not dividend) in stock markets. The neo-classical method takes two separate routes:

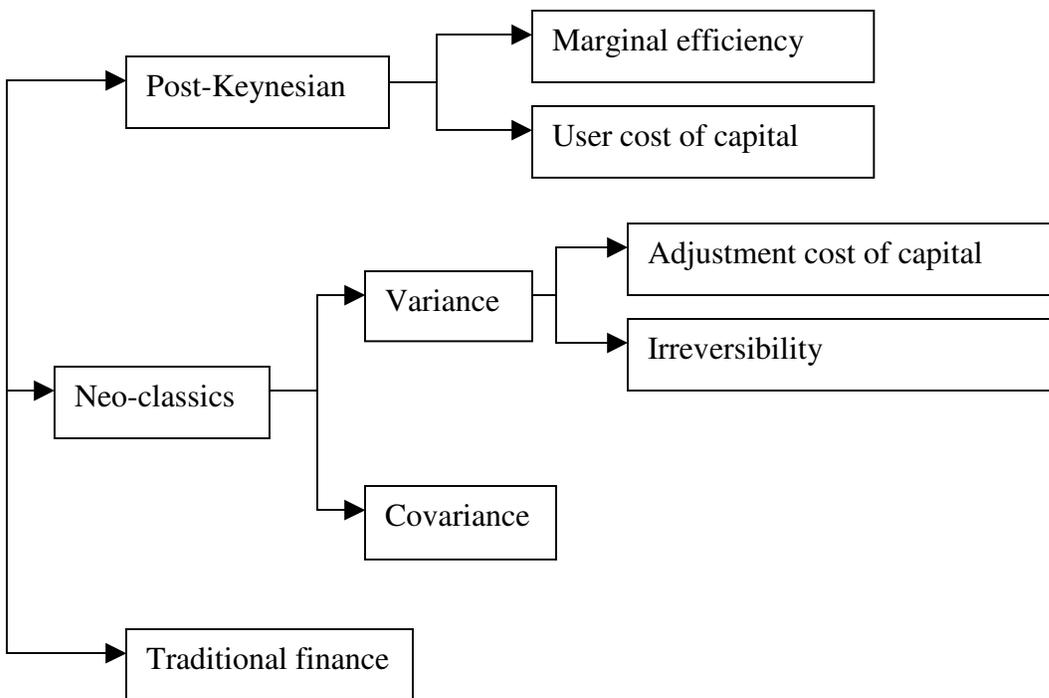


Chart 1.1- Classification of the methods in dealing with uncertainty in investment theory.

The first one, which is denoted by *Variance*, considers a firm by itself divorced from the existence of other projects and emphasizes the variation of some component of environment of a project (e.g. demand, costs, etc.) as uncertainty. The second, which is represented by *covariance*, emphasizes on the relationship between one firm and other firms in the market and relates the uncertainty to the pair wise covariance of their returns. Neo-classical methods, which emphasize on the variance as a proxy of uncertainty, diverge in two separate channels again. According to Abel and Eberly (1994):

*The firm's investment decision becomes an interesting dynamic problem, in which anticipations about the future economic environment affect current investment, when frictions prevent instantaneous and costless adjustment of the capital stock. Literatures focused on two types of frictions: adjustment costs and irreversibility.*

Adjustment cost literature is based on the study of Eisner and Strotz (1963). It assumes that firms face extra costs of adjusting their capital stock and these costs are a convex function of the rate of change of the capital stock of the firm. This implies that it is costly for a firm to increase or decrease its capital stock, and that the marginal adjustment cost is increasing in the size of the adjustment. The irreversibility literature is traced back to Arrow (1968). He argues that:

*There will be many situations in which the sale of capital goods cannot be accomplished at the same price as their purchase...For simplicity, we will make the extreme assumption that resale of capital good is impossible, so that gross investment is constrained to be non- negative.*

Contrary to the costs-adjustment method, irreversibility predicts a concave marginal revenue product of capital. According to Leahy and Whited (1996) it makes returns to investment asymmetric:

*If the future returns out to be worse than expected, the marginal revenue product of capital falls and the investor is stuck with lower returns. If prospects improve, the incentive is to invest more, thereby limiting the rise in the marginal revenue product of capital. This asymmetry implies that the marginal revenue product of capital is a concave function of wages and prices.*

In the following pages these approaches are explained further.

### **1.2.1- Traditional Finance**

Hahn (1947) argues that uncertainty represents disutility to the majority of people and will therefore only be incorporated in the price of capital. Thus, *risk premium* must be added to the market rate of interest or as *risk discount* must be subtracted from the expected yield. Modigliani and Miller (1958) define a class *k* of firms that have *equivalent return* such that “*the return on the shares of any firm in any given class is proportional to (and perfectly correlated with) the return on the shares issued by any other firm in the same class*”. Thus, all shares in a class have the same probability distribution of the ratio of the return to their expected return. In equilibrium in a perfect capital market the rate of price to monetary return must be same for all shares in class *k*. If this proportionality presents by  $(1/\rho)$ , we must have

$$p_j = \frac{1}{\rho_k} x_j$$

$$\text{or} \quad \frac{\bar{x}_j}{p_j} = \rho_k$$

where  $p_j$  denotes the price of a share,  $\bar{x}_j$  is the expected return per share of  $j$ th firm in class  $k$ .  $\rho_k$  is a constant of proportionality for all firms in class  $k$  and is interpreted as expected rate of return of any share in class  $k$  and by analogy with terminology for perpetual bonds,  $\rho_k$  can be considered as the market rate of capitalization for the expected value of uncertain streams for firms in class  $k$ .  $(1/\rho_k)$  is the price which an investor has to pay for one monetary unit of expected return in the class  $k$ . With the assumption that firms cannot issue bonds and finance their activities with debts, the study shows that the expected rate of return,  $i$ , is

$$i_j = \rho_k + (\rho_k - r) \frac{D_j}{S_j}$$

where  $r$  is the rate of interest,  $D_j$  denotes the market value of the debts of the company and  $S_j$  is the market value of its common shares. This equation implies that the expected yield of a share is equal to the appropriate capitalization rate  $\rho_k$  for a pure equity stream in the class plus a premium related to financial risk measured by the debt to equity ratio multiplied by the difference between  $\rho_k$  and the rate of interest.

This analysis has two difficulties: first as it has been mentioned earlier it does not consider dividend and so is a pure capital market analysis. Second, though the analysis is based on firm and industry level specifications the effect of uncertainty on the aggregate level of investment is unclear.

## 1.2.2- Adjustment – Cost Approach

Hartman (1972,1973) emphasizes a positive relationship between uncertainty and investment under convexity of marginal adjustment cost and discrete-time specification of the price of output. The following assumptions are made: The firm is a price taker in the output and labor market but prices in each period are unknown until the beginning of that period. The firm is confronted with randomly varying, increasing marginal costs of investment in each period. This model of adjustment cost is appealing because it allows for the relative fixity of capital. The firm has a finite planning horizon,  $T$ . In any period  $t$  within the horizon, the firm produces output  $Q_t$ , using capital  $K_t$ , and labor  $L_t$ , with the production function

$$Q_t = F(K_t, L_t)$$

where this function is concave in capital and labor. The labor input is completely variable within each period. The investment in each period  $t$  does not affect the capital stock until period  $t+1$ . Depreciation is proportional to the capital stock and capital accumulation is generated by

$$K_{t+1} = (1 - \delta)K_t + I_t$$

The adjustment cost of the investment is given by  $C(I_t, q_t)$  where  $q_t$  is a random variable or vector that allows the function to shift between periods. It is assumed that this function is increasing and strictly convex in  $I$  and  $q$ . Hence, whenever  $I$  is positive, there are increasing marginal costs to acquiring capital. Whenever  $I$  is negative  $C(I_t, q_t)$  is negative and its absolute value gives revenues obtained from selling capital goods. In this case the strict convexity reflects the difficulties of selling large quantities of capital

rapidly. The firm's objective is to maximize the expected value of the sum of discounted cash flows:

$$E \sum_{t=0}^T R^t [P_t Q_t - W_t L_t - C(I_t, q_t)]$$

where  $R$  is a discount rate and the initial capital stock is fixed at  $K_0$ . Under these circumstances, the study proves that the optimal investment does not decrease with increasing wage uncertainty.

Pindyck (1982) recalculates this relationship under different situations. Unlike other studies in which demand and cost are simply unknown at the time of decision-making their current extents are known and it is only their future amount which is uncertain. It is assumed that the market demand function shifts randomly but continuously over time according to a stochastic process. A dynamic model of the firm is assumed in which some factor inputs can be adjusted freely in response to stochastic demand changes, but other factors are quasi fixed in that adjustment costs are incurred when they are changed. The analysis is one of partial equilibrium and not general equilibrium. The study concludes that when demand shifts stochastically and continuously over time the level of desired capital and output will depend upon the curvature characteristics of the marginal adjustment costs. Uncertainty will increase the desired capital stock and output of a risk averse firm if its marginal adjustment costs are rising at an increasing or constant rate. Otherwise with a concave marginal adjustment costs, the effect of uncertainty on investment will be decreasing. The study concludes that uncertainty over costs has the same effect as demand fluctuations. These results hold irrespective of whether the firm is in a competitive or monopolistic market and whether or not the firm holds inventories.

Abel (1983) re-examines the uncertainty-investment relationship under Pindyck's continuous stochastic specification in which the current prices are known. The author demonstrates that Hartman's result continues to hold under Pindyck's assumptions. In this study it is assumed that the firm is risk neutral and operates in a competitive market and has a convex cost of adjustment function. The firm uses labor  $L_t$  and capital  $K_t$  to produce output through a Cobb-Douglas production function. The wage rate is  $w$  and  $I_t$  denotes the gross investment made by incurring an increasing convex cost of adjustment  $C(I_t)$ . Firm cash flow at time  $t$  is:

$$p_t L_t^\alpha K_t^{1-\alpha} - wL_t - \mathcal{M}_t^\beta$$

where  $p_t$  is price of output. The value of the firm will be calculated through the maximization of the summation of the present values of all future cash flows. The process of the maximization will yield a marginal cost of capital  $q$  which is inversely related to the variance. A summary of the study and related formulae has been presented in appendix A. Thus, for a given level of the current price of output  $p_t$ , an increase in uncertainty, as captured by an increase in  $\sigma^2$ , will increase  $I_t$ . Furthermore, the study shows that in the same way an increased uncertainty of real wage will increase investment and these results are independent of time.

### 1.2.3- Irreversibility Approach

Pindyck (1991) analyzes the uncertainty-investment relationship under the assumption of irreversibility. He demonstrates that under this assumption that increasing uncertainty will decrease the investment. Irreversibility of expenditures means that costs are mostly sunk costs and cannot be recovered. Another assumption is that the investment

can be delayed. This gives the firm a reason to wait for new information about costs, prices and other market conditions before it commits resources. An irreversible investment opportunity is much like a financial call option. When irreversible investment expenditure is incurred, the firm exercises or “kills” its option to invest. It eliminates the possibility of waiting for new information to arrive that might affect the desirability or timing of the expenditure. The loss of this option value is an opportunity cost that must be included in the total costs of investment. The value of the project must exceed the purchase and installation cost by an amount equal to the value of keeping the investment option alive. If  $V$  denotes the value of project,  $V$  changes due to a geometric Brownian motion<sup>1</sup>:

$$dV = \alpha V dt + \sigma V dz \quad (4)$$

where  $dz$  is the increment of a Wiener process such that:

$$dz = \varepsilon(t)(dt)^{\frac{1}{2}}$$

where  $\varepsilon(t)$  is a serially uncorrelated and normally distributed random variable. We refer to  $\alpha$  as the expected percentage rate of change of  $V$  with respect to time.  $\sigma^2$  is variance and  $\alpha$  and  $\sigma$  are constants<sup>2</sup>. With respect to the properties of the geometric Brownian motion model, equation (4) implies that current value of the project is known but future values are log-normally distributed with a variance that grows linearly with the time horizon. It is assumed that markets are sufficiently complete so that the individual decisions do not affect the opportunities available for other investors. Let  $x$  be the price of an asset or dynamic portfolio of assets perfectly correlated with  $V$ , and the correlation of

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<sup>1</sup> - For more information Ross (1999) might be studied.

<sup>2</sup> - For more information appendix of Pindyck (1991) might be studied.

$V$  with the market portfolio be denoted by  $\rho V_m$ . Then  $x$  evolves according to  $dx = \mu x dt + \sigma x dz$  and by the capital asset pricing model (CAPM) its expected return is  $\mu = r + \phi \rho V_m \sigma$  where  $r$  is risk free rate of return and  $\phi$  denotes the market price of risk. We assume that  $\delta$  denotes the difference between  $\mu$  and  $\alpha$  and it is interpreted as dividend by analogy with financial markets. Let  $F = F(V)$  be the value of the option to invest for a firm. The total return from holding the portfolio over a short time interval  $dt$  is  $dF - F_V dV - \delta V F_V dt$ . To avoid arbitrage possibilities it must be equal to  $r(F - F_V V) dt$ . Then using Ito's lemma we can calculate an expression for  $dF$ .

Now we want a rule that maximizes the value of our investment opportunity  $F(V)$ . Thus, we impose some assumptions and make some substitutions for simplicity (more details and further descriptions of the solving procedures have been presented in appendix A). Assuming that  $P$  is the price of output we find the value of the project  $V(P)$  which determines our valuation of the firm's option to invest. This in turn determines the optimal investment rule. The optimal investment rule boils down to finding a critical  $P^*$ , such that the firm invests only if  $P \geq P^*$ . The study finds out that for any given price  $P$ , an increase in  $\sigma$  causes the opportunity cost of investing in  $F(P)$  to increase more than the value of the project  $V(P)$ . Thus, the critical price  $P^*$  must increase with an increase in  $\sigma$ . Therefore, when uncertainty increases, firm will wait for a higher level of output price if  $P \leq P^*$ . The project is a set of call options on future production.

Thus greater the volatility of prices, the greater is the value of these options. Variability of output increases the critical price for investing, and reduces the net benefit of investment at every price. This means that greater uncertainty will increase the value

of waiting (that acts as an opportunity cost for investment). Therefore, a higher price is needed to persuade the firm to invest.

In a similar way Pindyck (1992) extends his study over the effect of input cost uncertainty on investment in projects that take some time to build under irreversibility. This kind of uncertainty arises when the prices of labor, land and materials needed to build a project fluctuate unpredictably or when unpredictable changes in government regulations changes the required quantities of construction inputs. This study allows for the possibility of abandoning the project midstream, and maximizes the value of the firm in a competitive capital market. So, the decision rule is: *Invest as long as the expected cost to complete the project is below a critical number*. The investment opportunity under this condition can be considered as a put option in financial markets. The holder can sell an asset worth an uncertain amount for a fixed “*exercise price*”. As its value is increased by an increase in the variance of the price of the underlying asset (like options in capital markets), therefore uncertainty will increase the value of an investment opportunity. On the other hand, input cost uncertainty reduces the critical expected cost. It means that when costs of inputs become more uncertain, it results in a value of waiting for new information before committing resources. Hence, the increasing uncertainty will lead to an increase in the value of waiting. This, leads to a reduction in investment.

Bar-Ilan and Strange (1996) study the effect of investment lags in a model of uncertain and costly reversible investment. When the construction of a project lasts for some periods then it is possible that the set off price under uncertainty may be lower than the set off price under certainty<sup>1</sup>. According to their argument the intuition of the model

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<sup>1</sup> - Set off price in defined as a level of price that encourages and persuades investors to invest.

of Pindyck (1991) is that a firm postpones its project in order to avoid facing low prices immediately after it has made an irreversible decision to enter. The opportunity cost of waiting is the certain income from the project that depends on the price during the delay. Since a firm can enter immediately, a short delay facilitates the avoidance of low returns which might be less than the opportunity cost of invested capital. The contrary result of the study of Bar-Ilan and Strange arises because authors suppose that between the decision to invest and the receipt of the first revenue of the project there exists a time lag. This assumption fundamentally changes the investment decision. Now a firm that waits cannot enter the market immediately after making a decision to invest. Thus, the opportunity cost of waiting does not depend on the price during the delay. Alternatively, it depends on the price in the future. Thus, the higher uncertainty about output price in the future will increase the opportunity cost of waiting as longer time lags increase the likelihood of higher prices. Therefore, with some lags in the investment project, the firm may hurry in order to catch the possible high prices that it might not be able to take advantage of if it is not in the market.

Abel and Eberly (1995) have studied the impact of uncertainty on long-run investment. They argue that results obtained by Pindyck apply to a firm that starts with zero capital. But consequences for an ongoing firm could be different. When investment is irreversible, the optimal investment rule is to purchase capital to prevent the marginal revenue product of capital from rising above a hurdle. This hurdle, which is the user cost of capital appropriately defined to take account of irreversibility and uncertainty, is higher than Jorgenson's user cost of capital which is computed under certainty and reversibility. This causes a newly starting firm to invest less under irreversibility as

compare to reversibility. This result is called the "*user-cost*" effect. The consequence is that an increase in the variance of the shocks tends to increase the user-cost under irreversibility without affecting the user-cost in the standard reversible case. This increase in the user-cost due to increased uncertainty tends to further reduce the optimal capital stock under irreversibility. On the other hand, for an ongoing firm, it will arrive at any future date with a capital stock representing the accumulation of capital prior to that date. If demand for firm's output is unusually low at each time, the firm would like to sell some of its capital at a positive price. But under irreversibility it cannot do so and it would be constrained by its own past investment behavior which reflects the firm's optimal response to favorable conditions in the past. This phenomenon is referred to as the "*hangover*" effect to indicate the dependence of the current capital stock on past behavior. The hangover effect can lead to a higher capital stock under irreversibility. The user-cost and hangover effect might have opposing implications for the current expectation of long-run capital stock. The two effects react in opposing directions regarding the effect of increasing uncertainty on long-run investment. User-cost effect tends to reduce the capital stock under increasing uncertainty while hangover effect tends to keep the capital stock high under increasing uncertainty with irreversibility. The study points out that the effect of uncertainty on long-run investment for an ongoing firm is even more ambiguous than for a newly started firm. In the long-run there are cases in which the user-cost dominates and cases in which the hangover effect dominates. It is confirmed in this study that in the long-run increased uncertainty can increase investment under irreversibility, but it might increase investment even more under reversibility.

Thus, whether the increase in the investment is higher under reversibility or irreversibility depends on the values and choice of parameters.

Abel and Eberly (1996) deduce the effect of uncertainty on investment when capital is costly reversible. It is assumed that the firm can purchase capital at a constant price  $b_U > 0$ , and sell it at a constant price  $b_L \leq b_U$ . This difference could be because of firm specific nature of capital or transaction costs. On basis of these two prices and by maximization of the expected present value of cash flows two separate user costs of capital can be calculated. User cost  $c_U$  is calculated for  $b_U$  and user cost  $c_L$  is calculated for  $b_L$ . Then authors define a rule for investment: “*keep the marginal revenue product of capital from leaving the closed interval  $[c_L, c_U]$ ”*. When marginal revenue of product becomes higher than  $c_U$ , firm starts to invest to bring it below the upper level of user cost. And when the marginal revenue of product falls below the  $c_L$ , firm start to disinvest to bring it above the lower level of user cost. With respect to the related calculations by authors, it is clear that increasing uncertainty widens the interval between  $c_L$  and  $c_U$ . Therefore, increasing uncertainty decreases investment.

#### **1.2.4- Covariance Approach**

Craine (1989) tries to examine the effect of risk on the allocation of capital in a simple general equilibrium model. There is a contradiction between the theories of the firm and conventional finance under uncertainty. Hartman and Abel as mentioned above argue that a mean preserving spread in the distribution of output price will increase demand for capital. But conventional financial asset pricing models suggest that an increase in the risk of an asset reduces the demand for that asset. The theory of the firm

and the theory of the finance are partial equilibrium analyses that make complementary assumptions about the relationship about the asset pay-offs and discount factor.

In general equilibrium, the discount factor and pay-off to assets are independent endogenous variables. The uncertainties, which affect firm's technologies and household preference, are exogenous. A mean preserving spread in the distribution of the exogenous states of nature makes the economy riskier. Through the maximization of lifetime utility, the technology's risk is calculated as the covariance between the riskless discount factor and the technology's return factor<sup>1</sup>. And the expected return to capital in technology  $i$  is equal to the risk free rate adjusted for capital risk. This means that riskier technologies require a higher level of expected return in order to be commercially viable.

Resources such as capital and labor, are the wealth of society. In each period aggregate capital is predetermined and aggregate labor is constant. Allocation of capital is based on the factor productivity of technology. Since capital is allocated before realization of the shocks. Output in each technology is calculated as a convex function of the productivity shock to that sector. Thus, expected output is an increasing function of the exogenous risk. But as aggregate output cannot be distributed independently of shocks to technology, the equilibrium allocation will depend on risk and expected returns as financial asset pricing models indicate.

. The article concludes that a mean preserving spread in the distribution of the state of nature that affects firm's technologies or household's preferences has no effect on aggregate investment, but it alters the allocation of capital and labor among technologies. Therefore, the share of capital devoted to less risky technologies increases.

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<sup>1</sup> - Because it shows the relative susceptibility of the technology to volatility in the discount factor which is defined as the adverse ratio of the risk free rate.

### 1.2.5- Adjustment-Cost or Irreversibility?

There are some studies that try to assess and justify the contradictions between results of adjustment-cost and irreversibility approaches. Caballero (1991) argues that the difference between two methods could be because of difference in assumptions about the possibility and cost of disinvestment.

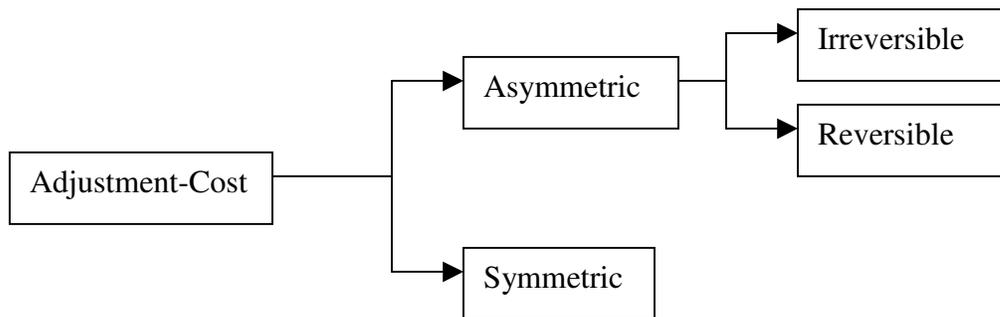


Chart 1.2- Classification of adjustment-cost theories.

But asymmetric adjustment cost is not sufficient to explain why the results are different. More important is that Hartman and Abel assume perfect competition and constant returns to scale, whereas Pindyck assumes either imperfect competition or decreasing returns to scale (or both). This paper highlights the role of the decreasing marginal returns to capital assumption (due to imperfect competition or decreasing returns to scale or both) in determining the effect of adjustment cost asymmetries on the sign of the response of investment to changes in uncertainty under the assumption of risk neutrality of investor. One of the findings is the lack of robustness of the negative relationship between investment and uncertainty under asymmetric adjustment costs to changes in the degree of competition. Asymmetric adjustment cost means that it is more expensive to

adjust downward than upward. In the case of irreversible cost, adjustment costs are infinite for downward adjustment. As a matter of fact when firms are in a nearly competitive market the conclusion of Abel and Hartman holds no matter what the assumption about asymmetry is. Conclusive consequences about the sign of investment-uncertainty relationship should not be expected from the adjustment cost literature alone. The result confirms that Hartman and Abel conclusion is shown to be robust to asymmetries in the adjustment cost function, including the irreversible investment case. Hence investment and uncertainty are positively correlated even in the extreme circumstance of irreversible investment, as long as the firm confronts a very elastic demand curve (and returns to scale are non-decreasing).

Abel and Eberly (1994) combine the two assumptions of irreversibility and existence of adjustment costs by assuming that the adjustment-cost function is strictly convex and has a value of zero at zero investment and it is infinite at any negative rate of investment. This means that they allow for cases in which the optimal rate of investment by the firm is never negative. The study introduces an augmented adjustment-cost function that considers traditional convex adjustment costs. Furthermore, it assumes the presence of fixed costs and allows for the possibility that the resale price of capital goods is below their purchase price and may even become zero. Through the maximization of the present value of the operating profits minus total investment costs, firm can calculate optimal investment. In this framework investment is a non-decreasing function of the shadow price  $q$ , which is always positive and is a non-decreasing function of variance. Thus, increase in uncertainty increases investment.

### 1.2.6- Empirical Studies

Relative to theoretical studies, there is a more general consensus among empirical investigations about the negative relationship between uncertainty and private investment. Leahy and Whited (1996) ascertain the uncertainty-investment relationship through a panel of U.S. companies. They utilize a measure of uncertainty from the variance of asset returns. The study performs various sample splits in order to test comparative implications of the three mainstream theories (i.e. adjustment-cost, irreversibility and covariance base models). The main result is that uncertainty exerts a strong negative impact on investment through its effect on  $q$  so that this impact has little relationship to risk as conventionally measured by the capital asset pricing model (CAPM). The comparison results are in favor of theories in which uncertainty directly affects investment rather than through covariance, and it is in favor of models in which the marginal revenue product of capital is concave. This leaves irreversibility models as the most likely explanation of the relationship between investment and uncertainty. However, Bo (1999) indicates that this negative effect could exist through channels other than  $q$ . Koetse *et al.* (2006) argue that  $q$  models produce more negatively significant estimates than other models do through a Meta analysis.

Nevertheless, Fuss and Vermeulen (2004) report that there is no evidence of an effect of price uncertainty on investment. Byrne and Davis (2005) find that the negative effect of uncertainty on investment is transitory in EU countries. Furthermore, Dehn (2000) indicates that positive ex-post commodity price shocks have strong positive effects on private investment in low developing countries. Darby *et al.* (1999) find a negative relation between exchange rate volatility and investment but “*there are*

*situations where that will happen, and situations where it will not*". The empirical studies are mostly confined to a few factors of uncertainty (e.g. Oshikoya, 1994; Serven , 1998; Rodrik, 1998; Stasavage, 2000; Feng, 2001; or Edmiston, 2004), single-country studies (e.g. Federer, 1993; Cecchetti, 1993;Zalewski, 1994; Reinikka, 1999; Darku, 2000; Gelb, 2001; Temple *et al.*, 2001; or Carlsson, 2004; Gaskari and Ganbari and Eghbali, 2004), and also include some cross-country papers which do not deduct private investment from aggregate investment (e.g. Brunetti and Weder, 1998; Jeong,2002; or Asteriou and Price,2005). Focusing on private investment rather than overall investment is preferable when considering the effect of uncertainty, because Aizenman and Marion (1996) have shown that in cases where high uncertainty leads to a decline in private investment, public investment often increases in compensation.

Although the majority of studies do find a negative relationship between uncertainty and investment, on the whole, both approaches are not conclusive in their assessment of the impact of uncertainty on private investment. Typically, policy-makers would want to know which sources of uncertainty are more significant for private investment. The current literature does not address this question adequately. This research provides an exhaustive empirical examination of the link between uncertainty and aggregate private investment using a large set of cross-country time-series macroeconomic and institutions data for developing countries. The study makes an attempt at clearing the significance of all aspects of uncertainty as much as possible.