Financial Factors in the Determination of Private Fixed Capital Accumulation: Theory and Evidence from the Turkish Economy

by

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This Thesis Submitted to The University of Nottingham for the Degree of Doctor of Philosophy

May 1996

To my parents

Acknowledgement

This Ph.D. thesis is the outcome of nearly four years of study in the University of Nottingham between 1992 and 1996. While working on this study, I have benefited greatly from discussion with and comments from many people both informally and at various seminars. My greatest debt of gratitude is to Andrew McKay and Michael Bleaney who have guided this work from the beginning to the end with endless patience and cheerful encouragement. Their constructive advice at various occasions has helped me to shape the contents of this study.

I am particularly grateful to those whose have kindly read and provided extremely useful comments on various chapters of this study. In this regard, I would like to thank Oliver Morrissey, Paul Mizen, John Bates and Paul Newbold. The participants of departmental seminars and of the Midland Research Student Workshop in Economics at the University of Keele provided highly constructive comments. I would also like to thank the Royal Economic Society and the University of Nottingham for financially supporting me to present two papers from this thesis at the European Economic Association Annual Meeting 1996 and the Econometric Society European Meeting 1996.

I would also like to acknowledge scholarship granted by Istanbul Technical University for my five-year postgraduate study in the U.K.. I am particularly grateful to Hayri Maraslioglu and Ahmet Tiktik of the State Planning Organisation for allowing me to use *semi-official* data about investment and prices of capital goods both at the aggregate and sectoral levels. I would like to take this opportunity also to thank Marina Mathew, Geeta Rajam, and Ali Buyukuslu whose friendship were invaluable.

During my undergraduate study in Istanbul Technical University, a number of people deserve special credit for kindling my interest in macroeconomics and econometrics, influencing the way I have come to think about an academic carrier in economics. My deepest gratitude goes to Ümit Senesen, an *excellent* teacher, who first introduced me to mathematical thinking in economics. His presence in Nottingham in the summer of 1994 and encouragement and his inspiration have been invaluable. A special acknowledgement goes to Yucel Candemir, Ertugrul Tokdemir and Gulay-Gunluk Senesen, my former teachers in economics. To them, and to many other teachers and colleagues whose names do not appear here, I owe more than I can ever repay.

Abstract

This is an analysis of the investment behaviour of Turkish firms at the aggregate and sectoral levels. Despite the growing literature of empirical private investment studies, a theory-based approach to modelling investment is rare both for developing countries in general and for Turkey in particular. One of the most commonly used modelling strategies is to adapt the main elements of the neoclassical accelerator model subject to additional structural modifications for a developing country. However, many of these studies are eclectic in the sense that they are not based on any specification of the microeconomic optimisation problem of firms. The central purpose of the thesis is to develop econometrically estimateable investment functions based on a sound microeconomic framework.

This study theoretically examines both the investment behaviour of firms and the role of financial decisions in investment behaviour in earlier chapters. Subsequent empirical chapters are built upon the main findings of the theoretical chapters, and accommodate three empirical models, all of which originate from an explicit optimisation problem of a representative firm. The first empirical model is derived from the cost minimisation of the firm subject to a given level of demand in the output market and two alternative production technology assumptions (namely putty-putty and putty-clay assumptions). The second model recognises the presence of adjustment costs of the capital stock, and develops an error-correction representation of an investment model from an quadratic cost function minimisation. These first two models analyse the roles of the neoclassical determinants of investment (the accelerator and the relative cost of capital) and credit constraints resulting from imperfections in capital markets in Turkey. However, the inclusion of the financial variable is less sound in these two models. The significance of capital market imperfections in the forms of a rising cost schedule of borrowing and quantitative constraints is the subjects of the third model. A dynamic model is developed through a maximisation of the intertemporal discounted cash flow of a representative firm subject to capital market imperfections, borrowing constraints and capital adjustment costs. An Euler equation for the rate of capital accumulation is derived by re-arranging the first-order condition for capital, which is influenced by the binding borrowing constraint through an unobservable shadow price.

These three models are applied to annual aggregate and sectoral data from Turkey. The empirical findings of this thesis suggest that fiscal and monetary policies influence investment behaviour both via the relative cost of capital and via credit availability to the private sector in Turkey. In particular, the empirical results imply that a high interest rate policy in an imperfect capital market imposing extra cost on the market rate through the risk premium may have discouraging effects on investment decisions either through its impact on the user cost of capital or through the risk premium component of cost of borrowing as in the third model. However, high interest rate policies may also affect credit availability as postulated in the McKinnon-Shaw hypothesis.

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Chapter 1

Introduction

1. The Importance of Studies on Investment

Two components of aggregate demand, consumption and investment, are of great importance in economic theory. This thesis studies the investment component of aggregate demand in a developing country, namely Turkey. Studying the determinants of investment (particularly its private component) is, in general, important for two reasons. First, from a long-run consideration, empirical studies in the recent literature of economic growth have consistently found evidence of a strong positive relationship between investment and economic growth. De Long and Summers (1993), for example, reported higher growth rates for countries investing more in equipment. Their findings become even stronger after excluding industrial countries from the sample. Khan and Reinhart (1990), on the other hand, distinguished the quantitative effects of private and public investment in developing countries, and noted that the marginal productivities of private and public investment differ in favour of the private component of aggregate investment.

Second, investment comprises a large and highly volatile component of aggregate demand. Investment, in particular private investment, is highly sensitive to external economic and technological shocks, and various government policies. Given the positive causal relationship between investment and economic growth, governments wish to stimulate investment by various fiscal and monetary measures (such as investment grants, investment credit, depreciation allowance, interest rates, and changes in demand conditions). Therefore, how responsive investment is to these different factors is important for implementing new economic policies.

Current macroeconomic studies have also revealed new evidence relating to the old controversy on the effectiveness of monetary policies on economic decisions in the real sector [e.g. see Kohn and Tsiang (1988)]. The possible link between monetary policies and real decisions may be provided through the impacts of these policies on financial factors that influence investment decisions. To investigate the effectiveness of monetary policies on real decisions (such as private investment decisions), this causal link between financial variables and private investment decisions must be studied first.

The effects of financial factors on investment is even more important in developing countries than in developed countries. Imperfections in capital markets in these countries restrict the financing of private investment to the use of internally generated financial funds and bank credit. Because the corporate sector in LDCs is highly dependent on borrowing from banks, the flow of bank credit to the private sector may be more important than retained earnings and profits. The literature on modelling private investment argues that various direct and indirect credit restrictions, which reduce the supply of credit available for investment expenditure, have a direct positive real effect on investment and thus on production [e.g. see McKinnon (1991), and Fry (1988)]. Therefore, credit constraints become one of the potential determinants of private investment particularly in developing countries.

2. A Brief Theoretical Background

Few aspects of economics have been more controversial than the theory of investment [see Chirinko (1994) for a survey]. Different theories put special emphasis on different determinants of investment spending, and postulate various microeconomic foundations to justify the importance of these variables in investment decisions. No theory, however, would be sufficient in explaining the behaviour of aggregate investment alone. So far, the current literature of investment theory has revealed three main determinants, namely output or sales (as an accelerator variable), the cost of capital, and profits (i.e. internally generated funds). Controversies started with the accelerator type of models, some of which considered only the effects of the accelerator variable, and ignored relative prices. These models have been criticised largely due to the lack of a comprehensive microeconomic foundation for investment decisions. Jorgenson's well-known neoclassical investment model, which has been dominant and an inspiration of various theoretical debates for many years, provided the first microeconomic foundation for investment decisions. In this model, factor prices play a key role. Although the model is formulated as an intertemporal problem, it turns out to be essentially static. In Jorgenson's framework, the firm is able to make instantaneous and costless adjustment in the capital stock in response to changes in its determinants.

But Jorgenson's maximisation of the intertemporal cash flow does not provide a well-defined investment function [Takayama (1991) and Haavelmo (1960)]. The main advantage of this framework is a novel definition of the cost of capital. Jorgenson's theory of investment (more accurately his capital demand theory) consists of two stages. In the first stage, a representative firm determines the optimal level of the capital stock (as well as other inputs) from the first-order condition of an intertemporal cash flow optimisation, and derives the optimal demand for capital as a function of output, the price of output, and the cost of capital. However, because of the instantaneous adjustment assumption in the derivation of the optimal capital stock, Jorgenson could not derive a stable, continuous investment demand function. He derived the empirical investment function in the second stage, using an *ad hoc* partial capital adjustment mechanism which may arise from costs of adjusting the capital stock to its optimal level. He then justified the partial adjustment with the presence of delivery lags, gestation period of already installed capital, and the cost of adjustment.

The ad hoc partial adjustment mechanism of Jorgenson's model was endogenised by Eisner and Strotz (1963), Lucas (1967), Gould (1968), Treadway (1969), assuming that capital adjustment is costly. This assumption finally provides a theoretical justification for the derivation of a dynamic investment function in Jorgenson's framework. In a conventional version of the adjustment cost literature, an investment demand schedule is derived by assuming a rising supply price of capital goods [see Mussa (1977)]. This rising supply price curve is mainly formulated with a strictly convex adjustment cost function in the cash optimisation problem.

In his seminal survey of the literature, Jorgenson suggested the neoclassical determinants of investment as being superior to financial variables [Jorgenson (1971)]. In his theoretical and empirical papers, he excluded financial variables chiefly because of the Modigliani and Miller theorem that has been widely discussed in the finance literature [Modigliani and Miller (1958), (1963), Stiglitz (1969), Sargent (1987)]. According to Modigliani and Miller, firms' real and financial decisions are, in fact, determined independently of each other, so that the financial policy of firms is exogenous and investment policy is not affected by their financial decisions. Alternatively, at the same time as the seminal works of Jorgenson [Jorgenson (1963), (1967)], the profit and the market value approach to investment took into account the interdependence of financial and investment decisions [Kalecki (1954), Grundfeld (1960), Kuh (1963)], and gained increasing momentum with the pioneering works of Tobin which introduced the market value approach [Tobin (1969), (1978), and Tobin and Brainard (1977)].

The central hypothesis of the market value approach is that investment is an increasing function of a measure of the marginal market value of the firm, namely marginal-q (the ratio of the market value of a unit of capital installed to its replacement cost). The q-theory has been an important competitive theory of investment to Jorgenson's neoclassical specification [see Hall (1977)]. In many empirical studies, the unobservable marginal-q is replaced by the observable average-q. The main advantage of the q approach is that the investment decision becomes forward-looking with the inclusion of the cost of capital adjustment. The empirical performance of the q approach however has been disappointing. Even though the q variable has been highly significant, the estimated equations have shown autocorrelation indicating misspecification of the functional form (partly because of exclusion of the accelerator and the relative prices, and partly because average-q is not a perfect substitute for marginal-q). The attempts to improve the empirical performance of the q models cover a large range of theoretical effort including the allowance for the presence of multi-capital product, the inclusion both of financing options and taxation, and of imperfect competitions.

More recent contributions to the literature of empirical investment modelling have put special emphasis both on financial factors (such as imperfect information and agency problems) and financial constraints (such as borrowing constraints), and alternative formulation of investment demand functions. According to the financial theory of investment, investment and financial decisions can be interdependent mainly because of two reasons. One possibility is the dependence on the firm's financial structure of the cost of borrowing from imperfect financial capital markets. With respect to this explanation, the cost of borrowing is a rising function of the firm's debt-equaty ratio (an indicator of the riskiness of the firm). The other reason is that the firm may face a binding finance constraint on the use of external finance options, so that both investment and financial decisions become interdependent.

Despite the fact that the empirical application of liquidity constraints in consumption decisions is now quite frequent [Zeldes (1989)], investment decisions with a binding liquidity constraint and imperfect financial capital market have started receiving attention only very recently [see Hubbard and Kashyap (1992), Whited (1992), and Bond and Meghir (1994)]. The recent financial theory of investment has borrowed a well-known modelling approach from the consumer theory (mostly known as the Euler equation approach). It has attempted to derive investment equations directly from the optimisation of the intertemporal cash flows with a linear quadratic capital adjustment cost function, and to estimate the resulting Euler equation directly without requiring the q variable.

3. The Importance of Modelling Investment in Developing Countries in General and Turkey in Particular

The different economic structure of developing countries and the high sensitivity of the economies of these countries to changes in internal and external economic conditions necessitate a new look both at the determinants of private investment, and at the interactions between these determinants and economic policies. These structural differences, in connection with the lack of data on some essential variables (which are required to test the conventional theories) such as the cost of capital, have already led many researchers to modify the neoclassical flexible accelerator model, mostly in an *eclectic* way [see Sundurarajan and Thakur (1980), and Blejer and Khan (1982)]. The literature, however, severely lacks a suitable micro-based theoretical approach to modelling private investment behaviour in developing countries, considering some essential problems of developing countries such as the strong relationship between financial factors and private investment decisions.

Research on private investment in developing countries has gained momentum following a significant slowdown in investment ratios, and an accompaning decline in economic growth, in the 1980s. Table 1.1 reports investment performance of a selected group of developing countries. By regional breakdown, Sub-Saharan African countries witnessed a drastic decline in total investment-GDP ratio from 22.9 percent in the 1974-81 period to 15.8 percent in 1982-90. These countries were followed by Latin American countries which suffered badly from the 1982 debt-crisis, and adjusted their external imbalances mainly by cutting expenditures and public investment (see Section 3 in Chapter 5). By income groups, the investment ratio of low-income African countries fell from 21.9 percent in the 1974-81 period to 14.6 percent in 1982-90. Highly indebted countries in Latin America, on the other hand, show great similarity with a declining pattern of the ratio of total investment to GDP. Three countries from East Asia (namely South Korea, Malaysia, and Thailand), however, achieved an increase in investment by pursuing high growth rates. Compared with other countries, Turkey's investment share in GDP almost remained stable. Considering the fact that Turkey was one of the most indebted counties before 1982 and suffered a lot from external imbalances, this relatively stable (and not declining) pattern of investment in Turkey has been considered as a success of the growth-oriented structural adjustment programme undertaken in the eighties [van Wijnbergen *et. al.* (1992)]. However, there is also growing concern about changes in the composition of private investment.

Many factors have been taken into account as causes of investment slumps in developing countries, and each has been the subject to a number of theoretical and empirical research [see Chapter 4, and Serven and Solimano (1993), Chhibber *et al.* (1992)]. Among others, some factors, that have been received considerable attention, are deteriorations in terms of trade [see Bleaney and Greeneway (1993), and Faini and de Melo (1990)], the decline in the availability of external borrowing and the high cost of external borrowing following the 1982 debt crisis [see Serven and Solimano (1992), Warner (1992), and Borensztein (1990)], structural adjustment to external imbalances [see Serven and Solimano (1993)], the impact of structural adjustment lending (SALs) [see Bleaney and Fielding (1995) and Fielding (1995)], and finally the volatility of the economic and political environment [see Pindyck and Solimano (1993)].

Adverse conditions in the world economy, causing a shortage of external finance, led many developing countries to adjust themselves to these new emerging conditions largely by cutting public expenditures and relying on market-based incentives. The elimination of distortions in the price system, deregulating commodity and financial markets, and fiscal adjustment have been the main elements of these so-called structural adjustment policies, with a belief that private investment (and so growth) would respond strongly to new market-oriented incentives (as the McKinnon-Shaw hypothesis, for example, predicts for financially repressed economies).

Investment in Turkey has shown great volatility in response to external shocks and changes in economic policies. Starting from the first oil-price shock, the share of investment in GDP in Turkey increased steadily until 1978. In general, expansionist and public-led economic policies in the 1970s, despite the severe world economic crisis, aimed to achieve a high growth rate around 7 percent over the period 1973-77 [see SPO (1993)]. The finance of these high growth and investment rates was met mostly by external sources, rather than by mobilising domestic sources to investment, in an era when the world economy was booming and the access to external credit market was easy. Especially in the Turkish case, the inflow of a large amount of workers' remittances from Europe played an important role in pursuing expansionary policies. However, the governments of the time were very slow to respond to external shocks following the first oil-price shock, mostly because of the unstable political situation. The delayed adjustment and ambitious public investment rates led the economy to depend very much on short-run external borrowing, most of which was used to finance public sector deficits. Besides, increased dependence on imported investment goods and external imbalances leading to a binding foreign exchange constraint has become a cause of the slowdown in investment, and in turn in growth rates in the late 1970s.

Table 1.1 The Ratio of Investment to GDP and Growth Rates in a Selected Group of Developing Countries

	Investment/GDP			Growth Rate		
	1974-81	1982-90	Δ	1974-81	1982-90	Δ
Regions						
Latin America	24.2	19.3	-4.9	4.5	1.3	-3.2
East Asia	29.4	32.8	3.4	6.3	7.8	1.5
South Asia	20.1	21.5	1.4	4.4	5.3	0.9
Sub-Saharan Africa	22.9	15.8	-7.4	3.2	2.2	-3.0
Middle East & N. Africa	26.7	23.4	-3.3	2.2	2.4	0.2
World	23.8	21.9	-1.9	2.7	3.1	0.4
Income Groups						
Low-Income Africa	21.9	14.6	-7.3	2.5	2.0	-0.5
Other Low Income	21.9	24.5	2.6	6.7	4.9	-1.8
Middle Income	26.3	23.1	-3.2	4.2	2.1	-2.1
High Income	23.1	21.2	-1.9	2.4	3.0	0.6
Highly Indebted Countries						
Argentina	23.4	11.7	-11.7	1.3	-0.5	-1.8
Bolivia	23.3	10.4	-12.9	3.2	0.1	-3.1
Brazil	23.7	20.4	-3.3	5.4	2.3	-3.1
Chile	17.6	15.3	-2.3	3.9	2.8	-1.1
Mexico	23.5	20.6	-2.9	6.7	0.9	-5.8
Uruguay	21.2	13.2	-8.0	4.2	-0.2	-4.4
Three Stable Countries						
Korea	29.9	30.8	0.9	7.9	9.6	1.7
Malaysia	28.3	30.3	2.0	7.4	5.9	-1.5
Thailand	26.5	26.7	0.2	6.8	8.0	1.2
TURKEY	22.0	22.3	0.3	4.6	5.5	0.9

Note: Δ indicates differences between two periods.
Source: Author's calculation from Guy *et al.* (1992).

Turkey launched a combination of a stabilisation and structural adjustment programme in 1980, under the supervision of the IMF and the World Bank. As a part of the stabilisation policies, public expenditures were cut, but public investment kept its historical level of 11 percent of GDP in the early 1980s. The direction of public investment, however, shifted from productive activities to infrastructure investment. The elimination of distortions in the price system and liberalisation in commodity and financial markets partly caused the cost of borrowing and production factors (except labour) to increase, and had an adverse effect on private investment. The most prominent change in the investment pattern was that, although the country attained the historical share of private investment in GDP after 1986, its composition has drastically changed from the manufacturing sector to services sector, in which housing investment represents the major part.

The performance of private investment generally in developing countries and particularly in Turkey has been the subject of numerous policy debates [e.g. Chhibber *et al.* (1992), and Serven and Salimano (1993)], and stimulated research on what determines private investment in developing countries. There is already a fast growing literature in this regard. However, theory-oriented approaches to modelling private investment have been extremely rare.

4. Aims of the Study

Our theoretical aim is, first, to examine the investment decision of a single representative firm in the presence of two main imperfections. They are the adjustment cost of capital that may arise from a rising supply price of capital goods, and the presence of upper liquidity constraints on investment expenditure. The second theoretical aim is to analyse how the determinants of investment behaviour may differ in developing countries from industrialised countries.

One of the most commonly used modelling strategies is to adapt the main elements of the neoclassical accelerator model, subject to additional structural modifications for a developing country. However, most of these studies are usually eclectic in the sense that they are mainly on a macroeconomic level without strong reference to specific formal microeconomic theory. The first empirical aim of this study is to develop empirical investment models for a developing country with a satisfactory microeconomic basis. The second is to see the importance of credit availability in investment decisions in Turkey. The motivations of each of the empirical chapters can be summarised as follows.

There has been no attempt to study the significance of different production technology assumptions such as putty-putty and putty-clay technology assumptions. To estimate an investment model, and to test the importance of neoclassical determinants with different technology assumptions, are our first motivations in Chapter 6. In doing so, a relatively larger sample size than previous studies is used, and the same model is also applied to sectoral data.

A new econometric methodology stresses the difficulties associated with the use of traditional model building (such as the one used in Chapter 6), and suggests the use of the error-correction mechanism and cointegration analysis to cope with them. Chhibber and Shafik (1992) and Fielding (1993) have applied this new methodology in the context of investment modelling in developing countries. Both also attempted to provide a microeconomic framework for this rather eclectic and data-oriented approach. In this regard, particularly, Chhibber and Shafik (1992) used the minimisation of a quadratic cost function arising from being away from the optimal level of the relevant control variable (investment in this case); however the objective function of their model is *wrongly* specified, and does not yield the error-correction mechanism of investment. Fielding (1993), on the other hand, fails to derive the cost of capital adjustment (which is the essential part of this new econometric methodology), and fails to derive the optimal investment demand from Jorgenson's cash flow optimisation. Our motivation in Chapter 7 is then to provide a theoretical model that leads to the error-correction representation of investment model with a strong microeconomic foundation.

In Chapter 6 and 7, financial factors (namely availability of credit to the private sector) are included in the model in a rather eclectic way. In Chapter 8 our motivation is to provide a theoretical model that endogenises financial decisions, and to solve the optimisation problem with the presence of a binding borrowing constraint. Therefore, testing the role of capital market imperfections in investment behaviour is the aim of this chapter.

5. Outline of the Study

The thesis starts with, firstly, examining the neoclassical determinants of investment (the accelerator, and the relative cost of capital), and their responses to exogenous shocks under different technology assumptions in Chapter 2. The chapter initially concentrates on Jorgenson's neoclassical model and on the myopic nature of his derivation of the optimality condition from a critical perspective. Two crucial assumptions of Jorgenson's model (instantaneous and costless assumptions) are also examined closely in this chapter. In subsequent sections, the instantaneous adjustment assumption is relaxed by imposing a constant exogenous upper and lower constraint on investment which the firm can undertake for each t. This particular form of the adjustment mechanism of the capital stock to its optimal level is then generalised by introducing the cost of adjustment. The chapter ends by endogenising the ad hoc partial adjustment mechanism using the cost of capital adjustment.

The main concern of Chapter 3 is with the relevance of financial decisions for the determination of investment behaviour. The influence of borrowing and liquidity constraints arising from imperfections in financial capital markets on the optimal accumulation rule and investment of a rising cost schedule is the primary subject of the chapter. Having presented the main elements of Keynesian investment theory, an important extension of this theory, namely the so-called Tobin's q theory of investment, is then explained.

Chapter 4 is devoted to a literature review of the determinants of private investment in developing counties, and to modelling issues. In addition to neoclassical determinants (the accelerator, and the relative cost of capital), some other factors such as financial factors, public investment, trade and exchange rate policies, credibility and instability, also play a key role in private investment decisions in developing countries. Of these, financial factors represents the main theme of the chapter in conjunction with Chapter 3. This chapter also considers the modelling issue by spelling out the eclectic nature of most investment studies in the literature. Data availability on some crucial variables to test the theory turns out to be a crucial factor that leads to such an approach to modelling. Chapter 4 also groups the existing models into two classes according to the data they use, namely micro and macro studies. Micro studies that are based on firm or sector level data appear to be more theory-oriented studies than those using macroeconomic time series.

Chapter 5 briefly presents an overview of the development experience of the Turkish economy. General trends in aggregate as well as private investment, in conjunction with international and sectoral comparisons, are also analysed in this chapter. Chapter 5 reviews previous studies on private investment in Turkey, and presents the main differences of the models presented in this thesis from them. Lastly, the underlying data used in the empirical estimations are also inroduced in Chapter 5.

Chapter 6 is the first empirical chapter of this study, and investigates the importance of the neoclassical determinants of investment (the accelerator, and the relative cost of capital) under two assumptions on the production technology (namely the putty-putty and putty-clay technology), with aggregate macroeconomic data as well as with disaggregate data for five main sectors (manufacturing, agriculture, services, mining, and energy). In contrast to many empirical models in the literature for developing countries, the model in this chapter is an attempt to implement a theory-based model for Turkey. This theoretical model is the *flexible-accelerator-relative-cost model*, basing on the cost minimisation of a representative firm subject to a demand constraint in the output market. Given the fact that the reliance on debt finance has been quite substantial in Turkey, the importance of credit constraints is also recognised by including credits available to the private sector in the empirical model in this chapter. The credit constraint is included in an eclectic way to test the importance of borrowing constraints in investment decisions in Turkey.

Chapter 7 continues to investigate the importance of the accelerator, the relative cost of capital, and credit constraints in investment decisions, but this time applying a different econometric methodology to Turkish data at the aggregate and sectoral levels. This chapter focuses on the data-oriented time series analyses. The main motive of writing this chapter is the fact that many macroeconomic time series are, in fact, not stationary (indicating time dependent mean and variance), and using non-stationary variables in a regression results in so-called spurious correlation [Granger and Newbold (1974)]. Keeping this defect of the conventional econometric methodology in mind (such as the one used in Chapter 6), Chapter 7 searches for further empirical evidence of the importance of the neoclassical determinants, taking explicit account of the non-stationarity of macroeconomic variables. The limited length of the data series, however, restricts the use of extensive time series analyses. The results in this chapter basically confirm the findings of Chapter 6, but the conclusion on which methodology is superior remains unanswered because of the limited use of the time series analyses and of the non-availability of a sufficiently long time series. However, the novelty of the chapter is the introduction of an error-correction representation of investment decisions. Despite the recent use of the error-correction and cointegration analyses in modelling investment demand, the literature lacks a theoretical framework integrating the innovative time series methodology into investment modelling. Chapter 7, in this respect, aims to fill an important gap in the literature by suggesting a theoretical model. The inclusion of the credit constraint into the empirical model still remains eclectic in this chapter.

Chapter 8 is the last empirical chapter and is, in particular, devoted to investigating the interaction between financial factors and investment. This chapter also reviews imperfections in financial markets in industrial and developing countries. In particular, financial liberalisation and its impacts on corporate sectors and financial capital markets are presented. Chapter 8 relaxes the perfect capital market assumptions of Jorgenson's model, and recognises the importance of asymmetric information and agency problems in a representative firm's financial decisions, and its interaction with real decisions. In contrast to the other two empirical chapters, financial variables are endogenised for the first time in this chapter. Chapter 8 develops a new dynamic investment model by a maximisation of the intertemporal discounted cash flow of a representative firm subject to capital market imperfections, borrowing constraints, and capital adjustment cost. This final model is applied to aggregate as well as sectoral data from Turkey. Lastly, Chapter 9 is devoted to some conclusions from this thesis.

Part 1

Theoretical Discussions on the Determinants of Fixed Capital Investment

The Neoclassical Theory of Investment

1. Introduction

Investment expenditures have been an important topic on the agenda of economic research for some time. Economists differ considerably on the relative importance of the factors affecting investment spending. At the heart of the differences, there are three main questions: They are i.) what the determinants of investment spending are, ii.) how quickly investment spending responds to shocks associated with these determinants, and iii.) what technology assumption about the specification of the production should be appropriate in reality. While investment and the relationship between investment and economic development still poses significant challenges for academic economists and policy makers in developing countries, the debates on the determinants of business investment expenditure in general have started gaining new initiative very recently. Some economists assign a key role to the relative prices and output, others to financial factors such as profit, borrowing *etc.*. Starting with the Jorgenson representation of the investment behaviour of a firm in a theoretical framework, all academic debates have reached a general conclusion about the key determinants of investment expenditure in the 1960s and 1970s. Relatively poor empirical evidence from a number of studies raises concern about the possibility of there being some other determinants of investment apart from prices and output. The direction of the new research agenda, on the other hand, pays attention to the role of financial factors in the determination of corporate fixed capital investment.

In earlier studies, economic analysts diverge from each other as to whether investment responds more quickly to changes in the relative prices than in output. The central issue, in this regard, involves the choice of right specification about the production function that a priori determines the elasticities of the relative prices and output. And finally, the last question addresses the issue of whether the rate of substitution between capital and labour is variable ex post and ex ante. The choice of technology also influences the relative roles of prices and output in the determination of investment expenditures.

In this chapter, a general review of the neoclassical theory of investment, which has been a starting point of many current studies, is presented. For this purpose, the chapter is divided into seven sections. Following this introduction, Section 2 gives a detailed account of the accelerator type of investment models. In Section 3, the microeconomic foundations of the neoclassical model are presented by using Jorgenson's formulations. Having addressed the novelty and weakness of this approach, the effects of exogenous constraints on investment are discussed in Section 4. As a consequence of unexpected and permanent changes in interest rates and output price, comparative dynamics of the neoclassical model are analysed with and without any constraint in section 5. Section 6 is devoted to the discussion on adjustment costs and its effects on Jorgenson's results. Conclusions drawn from the chapter are summarised, as usual, in section 7.

2. Accelerator Models

This section summarises the earlier theoretical and empirical models of investment before the Jorgenson's innovative representation of the theory. The first models to explain the causes of the volatility of investment expenditures were accelerator models. They are basically concerned with the roles of two variables, namely output (or demand) and relative prices, as determinants of investment expenditures. Despite the *direct* accelerator effects of output, relative prices (such as input prices and interest rates) either do not play any explicit role or appear to have very restrictive influence on capital demand in accelerator models. Depending on different production technology assumptions, accelerator models and the role of relative prices differ significantly. In what follows, I first present a naive accelerator model, and then a flexible accelerator model, which have been mostly used to derive the dynamic representation of the neoclassical investment demand function.

2.1. The Naive Accelerator Model:

The earliest example of the accelerator theory was put forward by Clark (1917), and has been regarded as the 'naive' accelerator model. This model states that investment expenditures occur as a constant proportion of any change in output, and relative prices (interest rates, wages, input prices), and profitability have no effects whatsoever. This robust result of the naive model can be explained by the technology assumption underlying the theory. If the production technology of a representative firm is assumed to be a fixed-coefficient Leontief technology with constant returns to scale, then the cost minimising proportion of capital and labour, determined by a given output level, will be constant *ex post* and *ex ante* [see Varian (1992)]. The ex post and ex ante rigidity of the rate of capital-labour substitution is also known as a clay-clay technology assumption. Accordingly, if the firm's technology is the Leontief fixed-coefficient technology, there is no factor substitution either ex post or ex ante.

Bearing in mind these crucial features of the naive accelerator model, assume at time period t that Q_t and K_t represent real output, and the capital stock respectively. According to the naive accelerator model, net investment, I_t^n, is given by

$$I_t^n = \Delta K_t = \alpha(Q_t - Q_{t-1}) \tag{1}$$

where α is the fixed capital-labour ratio; Δ stands for the change in K between one period and the next. Equation (1) simply indicates that a constant proportion of the change in output is used for investment. By many empirical applications of the naive model, instantaneous adjustment of capital stock and irresponsiveness to changes in relative prices have emerged as a main weakness of the model. Wynn and Holden (1974) also emphasised some other weaknesses of the naive model. First, if there is excess capacity then output can increase without requiring net investment. Second, the symmetry of the accelerator ensures that a one percent increase in output and a one percent decrease in output will correspond exactly to the same amount of capital being bought and sold. Third, there is no consideration of other variables such as profitability, expectations, liquidity, interest rate etc.; for example, lack of finance may prevent desired capital stock being achieved. And lastly, the constant capital-output ratio may only be an approximation. If the firm's production technology exhibits non-constant return to scale then the capital-output ratio also changes.

2.2. Flexible Accelerator Model:

In this slightly more complex form of accelerator models, investment is still determined mainly by output [see Chenery (1952)], but to a certain extent, relative prices may be allowed to affect capital spending. The adjustment of capital to its optimum level is no longer assumed to be instantaneous, but is assumed to be a constant proportion of the gap between actual and the desired levels of investment: that is

$$\Delta K_t = \theta\left(K_t^* - K_{t-1}\right) \tag{2}$$

where θ is the adjustment coefficient indicating the speed of adjustment of capital towards its desired level. If θ is assumed to be equal to unity, then the flexible accelerator model is reduced to the naive one, so that actual capital is equal to desired capital, thereby the adjustment becomes instantaneous.

The desired level of capital is determined by long-run considerations. Changes in desired capital stock are transformed into actual investment by a geometric distributed lag function. Note that equation (2) can alternatively be written as a first-order difference equation as follows.

$$\left[1-(1-\theta)L\right]K_t = \theta K_t^* \tag{3}$$

Solving (3) gives the actual level of investment as a weighted average of all past levels of desired capital,

$$K_t = \theta\sum_{i=0}^{\infty}(1-\theta)^i K_{t-i}^* \tag{4}$$

or

$$\Delta K_t = \theta\sum_{i=0}^{\infty}(1-\theta)^i \Delta K_{t-i}^* \tag{4'}$$

Given the fact that capital is, in fact, quasi-fixed equations (4) and (4') may state the gradual adjustment of the capital stock, rather than the instantaneous.

In equation (4), the desired capital stock is not observable, but can be specified in terms of other observable variables. The specification of desired capital stock has been the subject of a long historical debate, and a main distinctive feature of alternative versions of the basic flexible accelerator model. According to the literature, five alternative approaches to the specification of the desired capital stock can be defined, namely accelerator approach, liquidity approach, expected profit approach, and neoclassical approach [see Jorgenson and Siebert (1968) for a survey]. In the Accelerator approach of investment, desired capital is assumed to be proportional to output; i.e. $K_t^* = \alpha_1 Q_t$. Substituting K_t^* in (4') then yields

$$\Delta K_t = \alpha_1\theta\sum_{i=0}^{\infty}(1-\theta)^i \Delta Q_{t-i} \tag{5a}$$

Unlike the naive accelerator model, equation (5a) indicates that net investment is no longer determined only by the constant proportion of the change in current output, but by a weighted average of all past changes in output with geometrically declining weights.

In the Liquidity approach of investment, desired capital stock is assumed to be proportional to liquidity; $K_t^* = \alpha_2 F_t$ where F_t is a measure of liquidity; α_2 the desired ratio of capital to the flow of internal funds available for investment. With this approach, liquidity can be measured by profits after tax plus depreciation less dividends paid. Substituting desired capital stock in (4'), this time, yields

$$\Delta K_t = \alpha_2 \theta \sum_{i=0}^{\infty} (1-\theta)^i \Delta F_{t-i} \tag{5b}$$

In the expected profit model of investment, desired capital stock is related to the market valuation of the firm which can be measured as the market value of stocks outstanding plus the book value of debt including short term liabilities at the beginning of the period; $K_t^* = \alpha_3 V_t$ where V_t is the market value of the firm as an approximation of discounted value of expected future cash flow net of future investment expenditure; α_3 is the ratio of capital to market value of the firm. Then the resulting flexible accelerator model can be written as

$$\Delta K_t = \alpha_3 \theta \sum_{i=0}^{\infty} (1-\theta)^i V_{t-i} \tag{5c}$$

The neoclassical approach differs from others according to the determination of desired capital stock and to the explicit inclusion of the effects of relative prices. In equations (5a)-(5c), a single variable - either output, profits or liquidity - enters the flexible accelerator model. Restrictive assumptions embodied in accelerator models are the fixity of the capital-output ratio, α_i (i =1, 2, 3), and the absence of the substitution between capital and labour. As explained in Section 3, the neoclassical investment model defines the desired capital stock from the first-order condition of the discounted value of expected future net cash flow. The marginal product of capital $(\partial Q_t / \partial K_t)$ and the first order condition of capital from the optimisation $(\partial Q_t / \partial K_t) = (c/p)_t$ together give the optimal capital stock, $K_t^* = \alpha_4 (pQ/c)_t$ where p_t is the price of output, c_t is a variable measuring the cost of capital. Amending equation (4') in line of the neoclassical criticism, the following can be written

$$\Delta K_t = \alpha_4 \theta \sum_{i=0}^{\infty} (1-\theta)^i \left(\frac{\partial Q}{\partial K} \frac{p}{c} \right)_{t-i} \tag{6}$$

The neoclassical theory emphasises the effects of relative prices in the determination of investment spending. From the empirical point of view, choosing the correct specification of the production function is crucial in estimating the relative impacts on investment spending of the cost of capital and output variables. This is because the partial elasticities of the relative price and output variable are determined by the production function. Jorgenson assumed a Cobb-Douglas specification with decreasing returns to scale [see e.g. Jorgenson and Stephenson (1967), and Jorgenson and Siebert (1968)]. This specification is, however, not a integral feature of the neoclassical theory, but it is only essential for econometric analysis.

This Cobb-Douglas specification of the production function has been disputed by other economists [Eisner and Nadiri (1968), (1970), Bischoff (1969), (1971), and Klein (1974)]. They have argued that the use of the Cobb-Douglas specification overemphasises the role of relative prices because of the equal and unit elasticities of the desired capital stock with respect to output and relative prices. Alternatively, the constant elasticity of substitution (CES) form of the production function has been suggested by some [such as Rowley (1970), Eisner and Nadiri (1968), Eisner (1974)]. Based on the empirical results of his application of the neoclassical model to the U.K., Rowley, for example, suggested that the most suitable specification for the production function be the CES with constant return to scale, and that the Cobb-Douglas function leads directly to an exaggerated importance of relative prices.

Another criticism is that the relative price term and the output variable enter the function together as a result of the specification of desired capital stock, and it is impossible to distinguish the influence of both variables. In this sense, however, for a test of Jorgenson's results on the importance of the price variable affecting investment, Eisner and Nadiri (1968) reported some results on the double-log version of Jorgenson's model and separated out the relative effects of price and output [see also Chirinko (1986)].

2. 3. Ex ante and Ex post Substitutability of Capital and Labour:

Different investment theories have been trying to answer two central questions: What are the determinants of investment, and how responsive are the different components of investment to these determinants? We have already seen that there are two key variables put forward by these theories, namely relative prices and output or demand. The main controversy occurs when the answer to the second question is considered. The main reason for this controversy lies in the production technology assumption that distinguishes different theories.

The production technology here means the assumption on the *ex post* and *ex ante* elasticities of substitution of capital for labour, and on the malleability of capital. In the mostly used terminology of the investment literature, flexible substitutability of capital for labour is, in general, called "putty" while zero substitutability is known as "clay". In the fixed-coefficient technology of the naive accelerator model, the zero substitutability of capital for labour *ex post* and *ex ante* is, in general, named as "clay-clay". Given this, relative prices have no explicit direct role on investment.

The neoclassical approach discussed above assumes a putty-putty production technology, and allows that the factor substitution is non-zero and equal, both *ex post* and *ex ante*. By this technology assumption it is never optimal to produce with having idle capital because the firm always has a chance to replace idle capital with labour in response to changes in relative prices. In a more realistic case, the production technology can be defined as putty-clay, and this technology differs from others in the sense that the *ex ante* and *ex post* elasticity of substitution are no longer equal. In the putty-clay technology, once capital is installed in place, the capital-labour ratio is far less flexible *ex post*. The putty-clay assumption also allows the firm to have idle capital in the optimum, and implies that the capital stock responds more quickly to an increase in output or demand than to a decrease in the cost of capital services. This is because the change in factor proportion must wait either until the latest vintage capital is retired or until total capacity is increased in response to growth in desired output.

Considering this distinction between production technologies, Bischoff (1971) suggested a putty-clay version of the neoclassical approach to investment modelling as a more plausible case in reality, and allowed different responses of investment expenditure to changes in output and relative prices. An important implication of Bischoff's putty-clay framework is then that the response of investment to an increase in output should be shorter and more rapid than the response to a decrease in the user cost of capital. His well-known formulation of putty-clay investment demand function can be written as follows,

$$\Delta K_t = \alpha \sum_{i=0}^{n-1} \phi_i \left(\frac{p}{c}\right)_{t-i} Q_{t-i} + \alpha \sum_{i=0}^{n-1} \varphi_i \left(\frac{p}{c}\right)_{t-i} Q_{t-i-1} \tag{7}$$

where

$$\sum_{i=0}^{n-1} \phi_i = 1,, \quad \sum_{i=0}^{n-1} \varphi_i = 1$$

Note that different lag structures of output and relative price variables allow different responses of these variables arising from the putty-clay technology assumption of the production function. To capture the effect of replacement investment, δK_{t-1} is added to both sides of equation (7). In his empirical research, Bischoff found that price and output variables act with different lag distributions [Bischoff (1971)].

3. Jorgenson's Neoclassical Theory of Investment:

Unlike previous studies, Jorgenson's neoclassical theory provided the first rigorous theoretical framework to investigate the effectiveness of interest rate and tax policies in stimulating investment. The literature on the earlier neoclassical theory of investment is extensively dominated by Jorgenson's own studies and those with his various collaborators [e.g. see Jorgenson (1963), (1967), (1971), Jorgenson and Stephenson (1967a) and (1967b), Jorgenson and Siebert (1968), Hall and Jorgenson (1971)]. Two essential components of Jorgenson's approach underline the entire neoclassical theory of investment;

i.) *the determination of the demand for optimal (or desired) capital stock,*

ii.) *an adjustment process over time whereby investment moves the existing capital stock towards its desired level.*

The demand for capital is derived from standard economic principles, and is determined by the equality between expected marginal benefits and marginal costs from an additional unit of capital, which can be obtained from a simple cash flow maximisation of a representative firm. If price or output shocks disturb this equality, then the firm will continue to invest until the equality is re-established. In Jorgenson's neoclassical model, this equilibrium between the expected marginal benefits and the expected marginal cost always holds. Given this equality, the optimal demand for capital is obtained as a function of price variables and quantity variables such as output or demand; i.e. $K_t^* = f(p_t, c_t, Q_t)$ where K_t^* is the optimal capital stock, p_t and c_t are the price of output and the user cost of capital respectively.

Regarding the effectiveness of tax policies, the key concept in Jorgenson's model is the definition of the cost of capital services. In many investment studies, the cost of capital services has been based on a measure derived by Jorgenson [Jorgenson(1965), Hall and Jorgenson (1967), Eisner and Nadiri (1968), Bischoff (1969), Artus *et. al.* (1981), Artus and Muet (1990), Auerbach (1990), and Dailami (1992) etc.]. This measure is sometimes referred to as the "user cost of capital", and sometimes as the "implicit rental price of capital services". The correct definition of the user cost of capital is the central issue in accurate estimation and for accurate policy implications. Unlike labour input, capital is a quasi-fixed input of production, which is neither completely fixed nor definitely variable, but rather is adjustable at some adjustment costs. If capital goods could be bought and sold in a perfect market without any delay and without any transaction and adjustment costs, then only the current cost of capital goods would be relevant, and the firm would be indifferent between buying and renting capital goods. But because of delays, adjustment costs and the absence of a perfect capital goods market, the user cost of capital services diverges from the current market price, and becomes a combination of various cost factors and market conditions, which are likely to affect the cost of owning capital goods over the physical lifetime of the capital goods.

Four main components of the user cost variable can particularly be emphasised. One is the term representing the opportunity cost of the financial capital committed to capital goods, which is proxied by the short-run interest rates. The second one is the depreciation rate at which the physical capital goods in place decays by use, deterioration etc.. The third component is capital gains or losses due to changes in the market price of capital goods. And finally, the fourth one is the effect of various tax variables. Ignoring any component based on expected capital gains for the time being, this measure can be defined as follows

$$c = q'(r+\delta)\frac{(1-k)(1-uz)}{(1-u)} \tag{8}$$

[see Hall and Jorgenson (1967)], where c : the user cost of capital; q': the price of capital goods; u : the tax rate; k : a tax credit rate allowed on investment expenditure; z : the present value of the depreciation deduction on one pound investment; r : the discount rate; δ : the depreciation rate. The effects of tax parameters and interest rates that can be altered by policy makers, enter Jorgenson's investment model through the user cost of capital. The relatively significant effects of relative price variables in an empirical investment demand equation, in comparison with the output effect, therefore, can be interpreted as highlighting the importance of fiscal and interest rates policies in inducing investment. However, the effectiveness of various taxes on investment spending requires an implicit assumption that firms are unable to shift taxes forward to consumers. Different formulations from those of Jorgenson and associates are also possible. This so would lead to different estimates of the partial effects of tax rates, interest rates etc.. For example if one wants to see the effects of indirect taxes, tariffs, dual exchange rates, imperfect competition, and quantity controls then the cost of capital should be defined to embody these variables as in Auerbach (1990).

Investment is essentially a dynamic process, and dependent upon past as well as future economic and technological conditions. Jorgenson, however, dealt with this problem in an ad hoc fashion. The dynamic element of the model does not follow explicitly from the firm's optimisation problem. The specification of dynamics in Jorgenson's version of neoclassical model can be attributed to so-called maintained assumptions about delivery lags, adjustment costs and technology (i.e. vintage effects such as putty-putty and putty-clay production technology). Having derived the optimal capital stock at which the marginal benefits equal the marginal costs, gross investment is taken as the sum of net change in the current capital stock and replacement investment; $I_t = I_t^n + I_t^r$, where I_t^r and I_t^n stand for replacement investment and investment for expansion respectively. For simplicity, in many studies replacement investment is assumed to be a constant proportion of the capital stock; $I_t^r = \delta K_{t-1}$ where δ is the constant depreciation rate. Net investment, on the other hand, is given by an implicit stock adjustment mechanism. The flexible accelerator model is the one suggested in many earlier neoclassical models by Jorgenson and his collaborators. Although his theory was based on instantaneous adjustment in the determination of the optimal capital stock, Jorgenson specified a gradual adjustment mechanism to derive net investment, such as in equation (4') in which the actual capital stock moves towards its desired level gradually,

$$I_t^n = \sum_{i=0}^{\infty} \phi_i \Delta K_{t-i}^* \tag{9}$$

where ϕ_i represents the proportion of all orders that takes i period to be delivered. Assuming instantaneous adjustment in the derivation of the optimal capital stock, Jorgenson and his associates consistently assumed gradual adjustment in the derivation of equation (9). This can be considered as an important inconsistency of Jorgenson's derivation of net investment. One justification for this put forward by Jorgenson is that the firm, in fact, wishes to adjust the capital stock instantaneously, but is unable to do so because of some *unexpected* delays in delivery of capital goods. Adding replacement investment to this yields the Jorgenson's neoclassical investment model,

$$I_t = \sum_{i=0}^{\infty} \phi_i \Delta K_{t-i}^* + \delta K_{t-1} \tag{10}$$

To implement this equation econometrically, we must make an assumption on the function specification of the production technology. Following Jorgenson and Stephenson (1967) for example, a simple Cobb-Douglas production function with decreasing returns to scale can be assumed, so that

$$I_t = \alpha \sum_{i=0}^{\infty} \phi_i \Delta \left(\frac{pQ}{c} \right)_{t-i} + \delta K_{t-1} \tag{11}$$

where α is the share of capital in the production process; Q is the given level of output. This implicit dynamics, and rather ad hoc adjustment mechanism has been the main subject of many criticisms on the theoretical consistency of the neoclassical theory for many years [e.g. see Bischoff (1969) Takayama (1991), Chirinko (1993)]. One issue was the choice of the production function. As noted earlier, Jorgenson's model differs from the flexible accelerator models with the explicit assumption about the aggregate production function. With this respect, choosing the correct specification is important because the partial effects of output and the cost of capital variables are a product of this specification. Jorgenson's choice of Cobb-Douglas technology has been debated by others because of the fact that an investment function built on such an assumption may have major implications for monetary and fiscal policies. For example, the unit elasticity assumption that leads to relatively modest changes in interest rates or certain tax parameters may have substantial effects on investment. As argued earlier, instead of the Cobb-Douglas unit elasticity production function, some have used the Constant Elasticity of Substitution (CES) form of the production function, and derived an investment function which was similar to

$$I_t = a_1 \sum_{i=0}^{\infty} \phi_i \Delta \ln Q_{t-i} + a_2 \sum_{i=0}^{\infty} \varphi_i \Delta \ln(c/p)_{t-i} + \delta K_{t-1} \tag{12}$$

These two equations (11) and (12) highlight the dependence of investment on a quantity variable and a set of price variables.

In addition to the choice of the right specification of the production function, there are two more criticisms of the neoclassical investment model such as in (12). First, although investment is essentially forward-looking, and dependent on both the current situation and expectations of future conditions, the treatment of unobservable expectations in the neoclassical model, particularly in Jorgenson's, poses a serious problem. The unobservability of expectations is solved by assuming that firms form their expectations based on an extrapolation from historical data for a particular variable. This rather backward-looking expectation is represented as a distributed lag of past values of variables.

Second, Thurow (1969) considered the neoclassical model as an equilibrium theory, and alternatively suggested a more appropriate model for the disequilibrium situation where the equality between the actual cost of capital and the marginal product of capital does not hold. He argued that the presence of a delayed response of capital stock to any kind of shock creates this disequilibrium. Although Jorgenson derived the optimal capital stock in equilibrium, the derivation of investment flow utilised the disequilibrium between the cost of capital and its marginal product. Profit maximising firms eliminate this disequilibrium by investing (or disinvesting). For this, Thurow (1969) defined the desired net investment as a function that is dependent on the elasticity of output with respect to capital, marginal product of capital, the cost of capital, and the existing size of the capital stock,

$$\Delta K^{*} = \frac{1}{(\varepsilon_K - 1)}\left(\frac{F_K - c}{F_K}\right)K$$

where F_K : the marginal product of capital, ε_K : elasticity of output with respect to capital. This specification of net investment is different from that of the flexible accelerator model (see equation (2)). According to this specification, a firm will invest until the marginal product of capital equals the cost of capital. As a result of such a specification under the Cobb-Douglas Production technology assumption, Thurow obtained estimates of elasticity of substitution less than unity. Besides, "When the cost of capital variable was held constant at its median-value, turning the model into a simple accelerator model, then the model worked slightly better." [Thurow (1969): 432].

Two features of the neoclassical theory of investment should be further emphasised. First, it is the first theory rigorously derived from a firm's optimisation problem. Second, the first-order condition for the optimal capital stock is myopic. Despite the intertemporal set-up of the firm's optimisation problem, the first-order condition describing the optimal behaviour of the capital stock includes only the current variables. This is because of the instantaneous and costless adjustment assumption. Any information about the future level of output and input prices is, therefore, irrelevant for the determination of the current optimal decision. In what follows, the main assumptions on which Jorgenson's microeconomic foundation of the derivation of the desired capital stock and the myopic result are based, are presented.

3.1. Main Assumptions:

As occasionally noted in the literature, Jorgenson's theory is actually a theory of optimal demand for capital stock. Jorgenson himself stimulated this debate by noting that a firm invests in fixed capital stock to provide capital services; therefore the firm's investment decisions are clearly related to its demand for capital services. The neoclassical theory became one of the most controversial theories due to the initial assumptions on which the theory is based. Here in this section, some critical assumptions connected with Jorgenson's type of neoclassical model are first stated and then the derivation of the optimal capital stock is discussed, together with their relevance and importance for Jorgenson's results.

Assumption 1: *The firm employs only two production factors (labour and capital), and uses them to produce a single output; the firm's production technology is described a twice differentiable neoclassical production function with strictly diminishing returns to scale.*

Assumption 2: *The capital input decays at a constant geometric declining rate δ.*

Assumption 3: *There are no taxes and investment allowances.*

Assumption 4: *All markets in which the firm operates are clear.*

Assumption 5: *There is no adjustment cost involved either in purchasing or in selling capital goods.*

Assumption 6: *The firm operates in a perfect certainty world concerning the future.*

Among these assumptions, the last three deserve special attention because of their important role in the derivation of Jorgenson's result. Assumption (4) involves three markets to which the firm's decisions are related, namely output market, input markets, and financial capital markets. Regarding the output market, the perfect competition means that the firm acts as a price-taker in that market. The extension of assumption (4) to the capital goods market allows the firm to sell or purchase capital goods easily at the same price (without any depreciation in the first-hand price). As a consequence of this assumption, the first and second hand capital goods markets become identical. Other implications of this assumption in Jorgenson's derivation of the neoclassical optimal capital decision are the eliminations both of the opportunity cost of already committed funds on fixed capital investment, and of the irreversible nature of fixed capital expenditures. As far as the firm is concerned, there is, therefore, no difference between different investment opportunities.

In connection with financial capital markets, Jorgenson isolated the interaction between financial decisions and real capital investment decisions by introducing the perfect financial capital market assumption. By this extension of the assumption, the different sources of investment financing (such as equity, borrowing and retained earnings) are perfect substitutes, and the firm is indifferent between these financing options [see Modigliani and Miller, (1958)].

Assumption 6, the *instantaneous* and *costless adjustment* assumption, ensures that there are no costs of adjustment involved either in the sale or in the purchase of capital goods, and that delivery lags which cause a gradual adjustment do not exist. This assumption is also a natural extension of the perfect market assumption in output and input markets. Changes in the optimal capital stock are assumed to be instantaneous in response to various price and quantity shocks.

Assumption 5 implies stationary expectations concerning the values of all exogenous variables. In other words, the firm holds the same certain expectations about the future. One implication of this assumption together with assumption 5 is the so-called myopic capital decision rule, in which present capital demand decision is taken independently of all past and future decisions.

3.2. The Derivation of The Optimal Capital Stock and Myopic Rule :

The demand for the optimal capital stock is derived by maximising the discounted net present value of cash inflows of a representative firm over a time interval $[0,t]$. The firm is assumed to employ only two factors of production, capital and labour, and to produce a single output. Fiscal variables such as taxes and capital allowances, that take important place in Jorgenson's own analysis, are excluded for simplicity and tractability of the model. In this simple version of Jorgenson's model, let V(t) stand for net cash flows over time, and define it as follows [see Jorgenson (1963), (1967)],

$$V(t) = p(t)Q(t) - w(t)L(t) - q'(t)I(t) \tag{13}$$

where p(t) : the price of output; w(t) : wage; $q'(t)$: the price of capital goods; Q(t) : output; L(t) : labour; I(t) : investment expenditures. Since prices are assumed to be constant over time, the time indices of price variables can be ignored from now on. A general discount factor may be written as an average of all future short term interest rate, r(t), over the discount period [0, t], and can be represented by

$$R(t) = \exp\left\{-\int_0^t r(\tau)d\tau\right\} \tag{14}$$

where R(t) : the discount factor. It is also easy to derive r(t) in terms of R(t) by differentiating equation (14) with respect to time,

$$r(t) = -\frac{\dot{R}(t)}{R(t)} \tag{15}$$

where $\dot{R}(t)$ is the rate of change in the value of the discount factor $R(t)$ over time; i.e. $\dot{R}(t) = (dR/R)/dt$. To provide consistency with the Jorgenson's derivation, I keep the static expectation assumption on interest rate as well. Then, using the short-term interest rate as a constant discount factor, the net worth of the firm can be written in the following form,

$$W = \int_0^\infty \exp(-rt)V(t)dt \tag{16}$$

where $R(t) = \exp(-rt)$. The firm basically maximises W, the discounted present value of future cash flows, subject to two fundamental constraints. The first one is a simple concave neoclassical production function[1],

$$\begin{gathered} Q(t) = F[K(t), L(t)] \\ F_K, F_L > 0,\ F_{KK}, F_{LL} < 0 \end{gathered} \tag{17}$$

Given that the problem is a profit maximisation, its second-order condition is satisfied with the decreasing returns to scale assumption in order to define the optimal capital stock,

$$F_{LL}F_{KK} - F_{KL}^2 > 0 \tag{18}$$

which ensures the strict concavity of F(.) around some relevant neighbourhood of (K_t, L_t). The second constraint is the capital accumulation constraint, indicating that the rate of net changes in the capital stock is the sum of gross investment minus depreciation,

$$\dot{K}(t) = I(t) - \delta K(t) \tag{19}$$

where δ is the constant depreciation rate; $\dot{K}(t)$is the rate of change in the capital stock; in other words, net investment. It is supposed that the firm chooses the optimal paths of Q(t), L(t), K(t) and I(t) so as to maximise the present value of all future cash flows, subject to these two constraints (17) and (19). The mathematical technique used here is a continuous time dynamic programming, which is also known as the *Pontryagin's Maximum Principle.* An explanation about the technique in detail is

[1] The decreasing return to scale assumption is the necessary and sufficient condition of the profit maximisation. In general, the positivity of the determinant of the Hessian matrix of second-order derivatives of the production function with respect to capital and labour ensures the optimum for a profit maximising firm; that is

$$Det|H| = \begin{vmatrix} F_{LL} & F_{LK} \\ F_{KL} & F_{KK} \end{vmatrix} > 0$$

implying $F_{LL}F_{KK} - F_{KL}^2 > 0$. In the case of constant returns to scale, there is no unique solution of the production function [see Brechling (1975), Chirinko (1993)].

provided in the appendix. According to this technique, the following current value Hamiltonian of the above problem can be written

$$H = V(t) + \mu(t)[I(t) - \delta K(t)] \tag{20}$$

where $\mu(t)$ is called a co-state variable which is adjoined to the state variable $K(t)$. $\mu(t)$ can be explained in such a way that a marginal increase in the capital stock is expected to contribute to the total benefit of the firm by $\mu(t)$. This is also known as the shadow or demand price of capital.[2] The control variable here is $I(t)$ of the present problem. The following conditions are necessary for an optimum.

Labour:

$$pF_L = w \tag{21}$$

where $F_L = \partial F/\partial L$. Assuming an interior solution, labour is employed according to its marginal productivity. The firm is also assumed to be a price-taker in the labour market, and never faces any shortage of labour [equation (21) holds at every point of time over indefinite future]; to be more precise, $L(t) > 0$. The optimal investment rule and the dynamics of the neoclassical model are given by the following first-order conditions of the *Pontryagin's Maximum Principle*,

$$0 = \partial H/\partial I \quad \Rightarrow \quad \mu(t) = q^I \tag{22}$$

$$\dot{K}(t) = I(t) - \delta K(t) \tag{23}$$

$$\dot{\mu}(t) = (r + \delta)\mu(t) - pF_K \tag{24}$$

According to the first condition (22), the optimality requires that the expected benefit from a unit addition to the capital stock must equal its supply price. Equation (23), giving the dynamics of the capital accumulation, is the same accounting identity as equation (19). The third condition (24) represents the motion of the value of the shadow price of capital over time, which depends on the marginal productivity of capital and the sum of the discount rate and depreciation rate. The sufficiency

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[2] $\mu(t)$ is a critical variable influencing the willingness of the firm to sacrifice current revenue for capital accumulation. This is the value that the firm assigns to an increment of capital. $\mu(t)$ is thereby defined as "the expected present discounted value of the stream of returns which the firm believes that an additional unit of capital would enable it to earn" [Mussa (1977: 167]. This can formally be written as

$$\mu(t) = \int_0^{\infty} \exp[-r(s-t)]pF_K ds$$

where F_K is the marginal productivity of capital. The RHS of the equation indicates the expected discounted benefit from one unit investment over the time interval [0, t].

condition here is given by the following transversality condition [see Arrow and Kurz (1970)]

$$\lim_{t\to\infty} \exp(-rt)\mu(t)K(t) = 0 \tag{25}$$

These are the main optimality conditions to derive the desired capital stock. Using the equality of the demand for and supply price of capital goods (22), one may re-write the dynamic equation of the shadow price of capital (24), and obtain

$$\dot{q}'(t) = (r+\delta)q'(t) - pF_K \tag{24a}$$

Rearrangement of (24a) yields the well-known neoclassical marginal capital demand condition,

$$pF_K = q'\left[(r+\delta) - \hat{q}'\right] \tag{26}$$

Let

$$q'\left[(r+\delta) - \hat{q}'\right] = c \tag{26a}$$

where $\hat{q}' = \dot{q}'/q'$, which is also called capital gain (or loss) when the price of capital goods increases (or decreases). In the steady-state equilibrium of the system, $\hat{q}'$ becomes equal to zero. The right-hand side of the equality is known as the *instantaneous* rental cost of capital stock, and it is denoted by c(t). The left-hand side is the marginal *instantaneous* profitability of capital, denoted by $\Pi_K(t)$, which depends on the given current price of output, and the current production technology. The term instantaneous profitability was used to highlight the main characteristic of the neoclassical optimal capital stock rule, namely its independence of the future. The firm's operating profit at any moment of time t is to be a function of current prices and costs, such as labour, and is not influenced by technological progress and the changes in the prices of output and inputs. This is a very simple marginal productivity condition of capital which is not affected by future expectations. This is commonly known as the *myopic decision rule* of the optimal capital stock [see Arrow (1964)]. Therefore the first neoclassical proposition of Jorgenson's model can be stated as follows.

Proposition-1: *If the investor is certain about the future economic conditions, and the adjustment of the capital stock in response to any exogenous shock is instantaneous; i.e. $-\infty \le I(t) \le +\infty$, then the optimal capital stock is determined by the well-known myopic rule, in which $\Pi_K(t) = c(t)$, where $c = q'\left[(r+\delta) - \hat{q}'\right]$.*

where $-\infty \leq I(t) \leq +\infty$ represents the assumption of boundless and instantaneous adjustment. Arrow (1964) made three remarks on this result. The first one is that in the myopic decision the future profit, as a function of all future values of prices and technological progress, does not play any role in the determination of today's optimal capital stock, and current investment. The rule requires equating the instantaneous marginal profitability to the instantaneous cost. The second one is that the rate of interest is the instantaneous or short-run rate, but not the long-run rate[3], which may be considered as an average of short-run rates. The last one is the failure to allow for any upper and/or lower bound on the quantity of investment that the firm can make. These constraints can be imposed on the firm by two means. First, an upper constraint, for example, may be given exogenously by some market conditions such as imperfections in financial capital markets and binding borrowing constraints. Second, the maximum amount of investment that the firm can undertake can be determined endogeneously subject to some adjustment costs of capital. Particularly in the second one, the upper constraint is set in such a way that a rapid adjustment to the new desired level of capital is more expansive. Every cases and its effects on Jorgenson's optimality condition (26) is investigated respectively in the following sections. But first, some formal criticisms of Jorgenson's result are presented in the following section.

3.3. Takayama's Criticism:

The controversies around Jorgenson's neoclassical theory of investment arise from two critical assumptions, namely those of instantaneous and costless adjustment, and of static expectations. Takayama (1991) and (1994) particularly emphasised the instantaneous and costless adjustment assumption which implies that investment is boundless; i.e. $-\infty \leq I(t) \leq +\infty$. With static expectations, the capital stock stays constant at its steady state level over time, and varies once-for-all only in response to changes in the price of inputs and output, if, and only if, prices are allowed to change. Otherwise, the only investment expenditures will be depreciation and maintenance investment. Net investment (or disinvestment) will then take place instantaneously only when any change in prices occurs. Supporting the view of Haavelmo (1960), Takayama shows the implication of the boundless investment assumption by re-writing the current value Hamiltonian function of the earlier section [equation (20)] as follows

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[3] e.g. see the definition of R(t) in (14). Writing the discount factor R(t) as an average of all future short-run interest rates yields an optimal capital decision rule, where the rental cost of capital becomes a function of all future short-tern interest rates. In such a case, the decision rule will not be myopic.

$$H = pQ(t) - wL(t) - \delta\mu(t)K(t) + \left[\mu(t) - q'\right]I(t) \tag{27}$$

The optimality conditions of H with respect to K and μ remain the same as in equations (23) and (24) respectively. However, the implication of the boundless investment assumption becomes evident when the optimality condition of H with respect to investment is re-written as a Kuhn-Tucker condition associated with the boundlessness of investment in Jorgenson's model as follows

$$\mu(t)(\partial H/\partial I) = 0, \qquad I(t)\left[\mu(t) - q'\right] = 0 \tag{28}$$

(28) implies that Jorgenson's results (derived in the earlier section) can be obtained only when $\mu(t) = q'$, then $-\infty < I(t) < +\infty$. But (28) also implies two alternative cases that Jorgenson has ignored. They are

(i) $$I(t) \to +\infty, \quad \text{if } \mu(t) > q' \tag{29a}$$

(ii) $$I(t) \to -\infty, \quad \text{if } \mu(t) < q' \tag{29b}$$

Given the boundless investment assumption, the firm is able to purchase (sell) infinitely, when the expected benefit from an additional capital good is higher (lower) than its supply price (or cost). There will not be any finite amount of investment. Without costs of adjustment or any bound upon investment expenditure in the model, the optimal investment level will be indeterminate.

3.4. The Neoclassical Investment Demand Schedule:

Given the assumption of Jorgenson's model, we found that the capital stock is adjusted instantaneously and kept constant over time. The important disagreement on the earlier neoclassical theory was whether or not the theory yields an investment demand schedule as a function of interest rates and other prices [see Haavelmo (1960)Jorgenson (1967), and Sandmo (1971)]. Haavelmo, in this sense, argues that

> "*If the producer is able to find the accurate K_0 at t_0 and if all prices and the interest rate are going to stay constant, he will obviously not want to acquire any finite amount of additional capital after t_0 (except, of course, necessary replacement to keep K constant). Therefore, for all practical purposes, the conditions above determine a zero rate of net investment for this procedure.*" (Haavelmo, 1960: 164).

In the neoclassical theory, investment can be represented as a rather passive decision. Given instantaneous and static expectations assumptions, the capital adjustment in response to any change in the interest rate and prices takes place as a once-for-all increase in the capital stock. This response, on the other hand, is temporary, and vanishes when the adjustment of the capital stock to its new level is over. Jorgenson

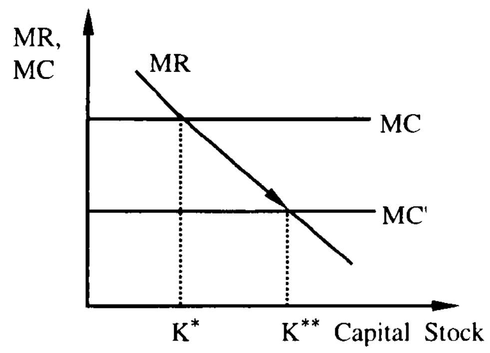


Figure 2.1

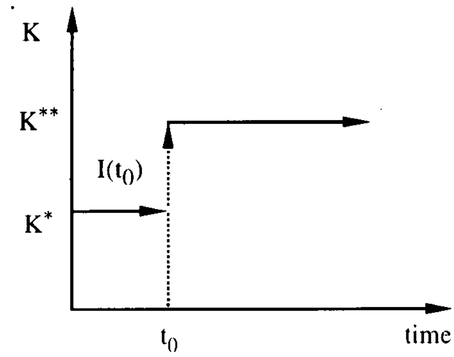


Figure 2.2

himself -who was disappointed with Haavelmo's criticism- however advocated his model by simply allowing the price of capital goods to change, then derived an investment demand schedule despite the stationary expectation assumption in his model [Jorgenson, (1967)]. Assume that the capital stock, K(t), is continuous at any time over a time period (see Figure 2.2). Consider again that the static price expectation assumption holds, and that at time t_0 the price of capital goods falls, moving the marginal cost of capital from MC to MC' (see Figure 2.1). The marginal cost curves are horizontal because of the static expectation assumption. The marginal revenue curve of capital, on the other hand, is a downward sloping function of the capital stock due to the concavity assumption of the production function ($F_K > 0, F_{KK} < 0$.) Given the new marginal cost of capital MC', the firm must add (K^{**}-K^*) to its initial capital stock at a rate which is equal to the net investment, over some time interval. But the instantaneous and costless adjustment assumption, however, allows the firm to reach the new optimal level by investing (K^{**}-K^*) at once. This temporary change in the price of capital goods causes a jump in the capital stock at time t_0 (see Figure 2.2). Given the new level of prices, the firm will reach the new optimal capital stock, K^{**}, by investing by $I(t_0)$ once, and then remains at this new level of capital stock. Despite Jorgenson's attempts, as long as one keeps the stationary expectation assumption and therefore assumes horizontal marginal adjustment cost function (which is unresponsive to the rate of investment), the derivation of a continuous investment demand schedule is not possible in Jorgenson's capital demand model.

In this and earlier sections, I have reproduced Jorgenson's results, and have summarised the main criticism arising from the assumptions of the model. In particular, for the benefit of the argument of investment demand behaviour under a binding constraint to be developed in Chapter 3 and Chapter 8, I have given special attention to the boundless investment assumption. In what follows Jorgenson's model is improved in two possible ways to derive a stable investment demand schedule for which such a schedule is to be the subject of an empirical testing for a developing country later in this thesis. These modifications namely are i.) imposing exogenous upper and lower constraints on the rate of investment, ii.) assuming that capital adjustment is subject to some costs.

4. Investment Behaviour Under Exogenous Constraints

In addition to the boundlessness of investment as a consequence of instantaneous and costless capital adjustment assumption of Jorgenson's model, the perfect capital goods market assumption can also be questioned. The immediate implication of this assumption is that at the microeconomic level, there is a fixed price of capital at which the firm is able to purchase and sell capital goods in any quantity. But in reality, the prices at which capital goods are purchased differ from the prices at which the firm sells capital goods. Besides, there may be some additional costs arising from installing capital goods that cannot be recovered from their sell. Therefore capital goods markets in reality are not perfect, and Jorgenson's model requires another modification. Arrow (1968), in this regard, suggests an extreme case, a zero lower bound on investment, indicating that there exists no secondary capital goods market. In other words, he assumes that the firm is unable to sell capital goods which are already being used in the production. This characteristic of investment is known as *irreversibility*. The implication of imposing the irreversibility constraint is analysed in Chapter 3.

Consider now that the firm is unable to invest at an infinite rate due to the presence of installation costs that are sunk in nature. Because of these costs and maybe because of delivery lags, the marginal cost of capital may be an increasing function of investment, and the firm can accomplish the capital adjustment not instantaneously, but rather gradually, and can invest only by a certain amount for each t over the overall adjustment period. This gradual, or intertemporal, adjustment to the optimal capital stock may impose an upper bound on the investment expenditure, and result in the derivation of a finite level of investment.

Nevertheless, the capital stock adjustment costs are not the only way of justification of an upper bound on investment. Financial constraints, such as limited access to financial resources, various imperfections and direct borrowing constraints in credit markets, where the firm borrows to finance a fraction of its investment expenditure, are other well-known sources of an upper constraint on investment expenditures.

In what follows, I shall analyse the effects of such upper and lower bounds on investment, and present a gradual pattern of the adjustment process, arising from the fact that the firm cannot adjust itself *instantaneously*. For this I shall hold rather *ad hoc*, but general, exogenous investment constraints [see Takayama (1994) for example] such as

$$I_t^{\min} \leq I(t) \leq I_t^{\max} \tag{30}$$

The upper and lower limits on investment are assumed to be constant. This is known as a "bang-bang" solution.[4] Accordingly, the firm is assumed to invest (or disinvest) by a constant amount until it reaches its steady-state equilibrium. In this chapter, only the effects on the myopic rule of such constraints are considered. In Chapter 3, the economic justification for the presence of an upper and a lower constraint arising from imperfections in financial capital market are provided. The solution to the neoclassical cash flow maximisation subject to those described earlier and this additional constraint is quite straightforward. The following Lagrange function, including the previous Hamiltonian function (20) and the above constraint (30), can be written as follows

$$L = H + \lambda_1\left(I_t^{\max} - I_t\right) + \lambda_2\left(I_t - I_t^{\min}\right) \tag{31}$$

where λ_1 and λ_2 are two Lagrange multipliers associated with the upper and lower bounds of investment. While the first-order conditions with respect to K and μ remain exactly the same as in (23) and (24) respectively, only the optimality conditions of investment changes subject to the new constraint (30), and is obtained as follows

$$\frac{\partial L}{\partial I_t} = \frac{\partial H}{\partial I_t} - \lambda_1 + \lambda_2 = 0 \tag{32}$$

or

$$\mu(t) - q' - \lambda_1 + \lambda_2 = 0 \tag{32'}$$

Note that if $I_t = I_t^{\min}$ then $\lambda_2 > 0$; in other words, the lower bound is binding, but the upper one is not ($\lambda_1 = 0$). Therefore, the optimality condition (32') can be re-written as

---

[4] In the optimum control literature, the solution of any control problem requires that the state, co-state and control variables as well as the Hamiltonian function itself be piecewise continuous functions of time. Any discontinuity in these variables involves a finite jump. For example, discontinuity in investment here leads to corners in the state variable K. Therefore, if $(\partial H/\partial I)$ cannot be sustained over an interval of time then the control problem is called "bang-bang". The state variable, the multiplier function, and the Hamiltonian must still be continuous, regardless of discontinuity in investment [see Leonard and Long (1992), Kamien and Schwartz (1991)].

$$\mu(t) - q^{I} + \lambda_2 = 0 \tag{33}$$

Since $\lambda_2 > 0$, the following inequality is also true

$$\mu(t) - q^{I} < 0 \tag{33a}$$

where the marginal benefit from a unit addition to the capital stock is expected to be less than the supply price of capital goods. The firm then starts to invest (or disinvest) at the constant minimum rate, because otherwise it would not be profitable. By investing at the lowest level (or disinvesting), the firm would wait for the excess capital stock to depreciate to the new lower optimum level. If the secondary capital goods were allowed in the model, the firm would sell the excess capital stock it holds. But this would not be possible in the case of the zero lower constraint on disinvestment.

If one assumes that $I_t = I_t^{\max}$, therefore $\lambda_1 > 0$ and $\lambda_2 = 0$, then the optimality condition (32') implies that

$$\mu(t) - q^{I} > 0 \tag{34}$$

Where the expected marginal benefit from each additional fixed capital investment is higher than its supply price, and the firm is expected to invest at the higher rate to exploit this profit opportunity.

In the case where neither constraint is binding ($\lambda_1 = 0$ and $\lambda_2 = 0$), the optimality condition for investment is the same as that of Jorgenson

$$\mu(t) - q^{I} = 0 \tag{35}$$

and the optimal investment level will be at a level between the upper and lower investment levels, and is bounded by neither of them. These optimality conditions altogether can hence be summarised, with an additional assumption that the capital goods market is imperfect (in the sense that the purchasing and selling price of capital goods are not the same, as follows

<u>Proposition-2</u>: *If the firm operates in perfect input and output markets with stationary expectations about the future, and the actual investment that it can undertake is restricted by the condition that $I_t^{\min} \leq I_t \leq I_t^{\max}$, then the optimal investment is determined by the following rules:*

$$\begin{array}{ll} I_t = I_t^{\max} & \text{if } \mu(t) > q^{I} \\ I_t = I_t^{\min} & \text{if } \mu(t) < q^{I} \\ I_t \in \left(I_t^{\min}, I_t^{\max}\right) & \text{if } \mu(t) = q^{I}. \end{array}$$

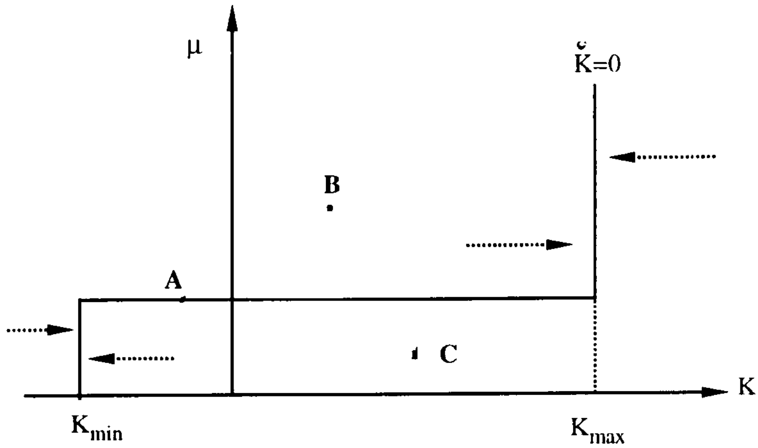


Figure 2.3

According to the first two results above, the Myopic decision rule of Jorgenson's model no longer holds on the time interval where either $\mu(t)<q$ or $\mu(t)>q$. The capital stock adjustment to the optimal level is not instantaneous, but gradual due to the existence of the upper and lower constraints on investment. Using (19), the net contributions to the existing capital stock each time during the adjustment to the new optimal capital stock (that is constant in the first two cases) in three cases in proposition 2 are given by

$$\dot{K}_t = I_t^{\min} - \delta K_t \tag{19a}$$
$$\dot{K}_t = I_t^{\max} - \delta K_t \tag{19b}$$
$$\dot{K}_t = I_t - \delta K_t \tag{19c}$$

Before going further, I draw a phase diagram describing the overall dynamic equilibrium of the neoclassical model in a (μ-K) co-ordinate system, where the myopic feature of Jorgenson's model disappears for some intervals where $\mu_t \neq q'$. Using this phase diagram, one can then analyse the dynamic properties of the model. The dynamics of the system are given by a pair of differential equations, namely equation (23) and equation (24). These two differential equations must both be satisfied to give steady-state equilibrium of the model in the long run. Each differential equation associated with either the state or the co-state variable corresponds to a locus along which changes in the value of that state or co-state variable are zero; i.e. $\dot{K}=0$ and $\dot{\mu}=0$. The long-run equilibrium can then be defined as a situation where both differential equations of the state and the co-state variable are constant, and then at the intersection of the $\dot{\mu}=0$ and $\dot{K}=0$ loci [see Begg (1982) for detail].

Using (23) and (24), we can draw a phase diagram describing the optimal path of μ and K along which both differential equations are satisfied. The locus applying to the capital stock is derived from the capital accumulation equations (19). Three loci corresponding to the same assumption that $\dot{K} = 0$ can be derived from (19), that are

$$K_t^{\min} = I_t^{\min}/\delta = \text{constant}, \quad (36a)$$

$$K_t^{\max} = I_t^{\max}/\delta = \text{constant}, \quad (36b)$$

$$K_t = I_t/\delta \ , \quad 36c)$$

The locus of $\dot{K}$ is indeed a combination of these three equations. Since $I_t^{\min}$ and $I_t^{\max}$ are exogenously given, the capital stocks, to which they correspond, are also constant (remember that there are no net changes in the existing capital stock in steady state), and the loci of $\dot{K}$ [given by (36a) and (36b)] are drawn as vertical lines. The slope of (35c) is, however, infinite with respect to μ, and can be drawn as a horizontal line as in Figure 2.3.

How does K move at any point of time in the figure? Along the bold line in Figure 2.3, the net changes in capital stock are assumed to be zero; $\dot{K} = 0$. Anywhere on the locus $\dot{K}$, at point A for example, the optimality condition of investment holds ($\mu(t) = q^I$), in the sense that the shadow (or demand) price of capital is equal to its supply price (this is the standard myopic rule). The amount of investment being required by the firm at point A (this is only replacement investment) may not exceed $I_t^{\max}$, but may also be less than $I_t^{\max}$. At any point above the horizontal and the left of the vertical locus (such as at point B), the equality of the demand price of capital goods with its supply price does not hold, the firm's expected demand price of capital exceeds its supply price (i.e. $\mu(t) > q$), and a higher shadow price above the point A induces the firm to increase its *ex ante* demand for capital. However, the presence of an upper constraint on the amount of investment that the firm can undertake at once, prevents it from increasing the capital stock instantaneously to attain the new steady-state equilibrium, but rather allows for a gradual adjustment, *investing each time by* $I_t^{\max}$. This movement of the capital stock is given by the arror pointing right in Figure 2.3. Similarly, at any point towards the right of the vertical locus and the below the horizontal one (such as at point C), the firm expects a lower shadow price (i.e $\mu(t) < q$) decreases its *ex ante* demand for capital. However, the firm is not able to adjust itself to this new equilibrium instantaneously because of the presence of an

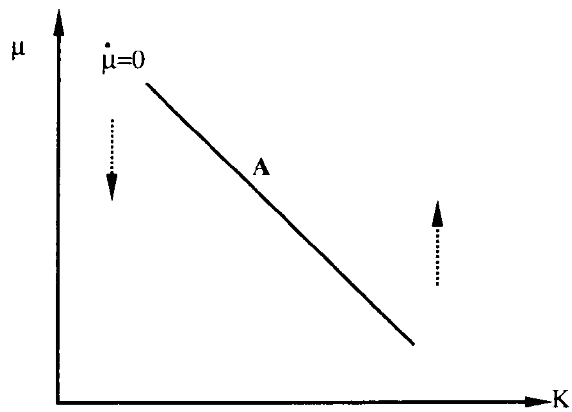


Figure 2.4

imperfect secondary capital goods market (therefore the lower bound on investment $\dot{I}_t^{min}$). This movement of the capital stock is represented by the arrow pointing left in Figure 2.3. The firm is then allowed for a gradual adjustment through investing or disinvesting by the amount of $\dot{I}_t^{max}$ or $\dot{I}_t^{min}$ each time.

The locus associated with the dynamic equation of μ can also be derived in a similar way. Assume that $\dot{\mu} = 0$ in (24), and write the following relationship between K and μ.

$$\dot{\mu}(t) = \frac{pF_K}{(r+\delta)} \tag{37}$$

The slope of the locus is given by $(\partial\mu/\partial K)$, which equals $[pF_{KK}/(r+\delta)]$. Since $F_{KK} < 0$ due to the concavity of the production function, $(\partial\mu/\partial K)$ will be negative, indicating a downward sloping locus of μ as in Figure 2.4.

Starting at a point A on the locus of $\dot{\mu} = 0$, consider an increase in capital stock towards the right in Figure 2.4. Since $\partial F_K/\partial K$ is negative, $\dot{\mu} = (r+\delta)\mu - pF_K$ will be positive; an increase in capital stock will then push the value of $\dot{\mu}$ upwards. Therefore, at any point above the locus of $\dot{\mu} = 0$, the direction of the movement of μ is upwards, whereas by a similar argument, it is downwards at any point below the locus.

We can combine these two separate figures so as to show how μ and K move together (see Figure 2.5). In Figure 2.5, *A* is the only unique point of equilibrium that $\dot{\mu} = \dot{K} = 0$ hold together. Note that the model has a saddlepoint solution which means that there is only one stable convergence path that leads the system to the steady-state equilibrium point A. SS in Figure 2.5 represents this stable convergence path that is

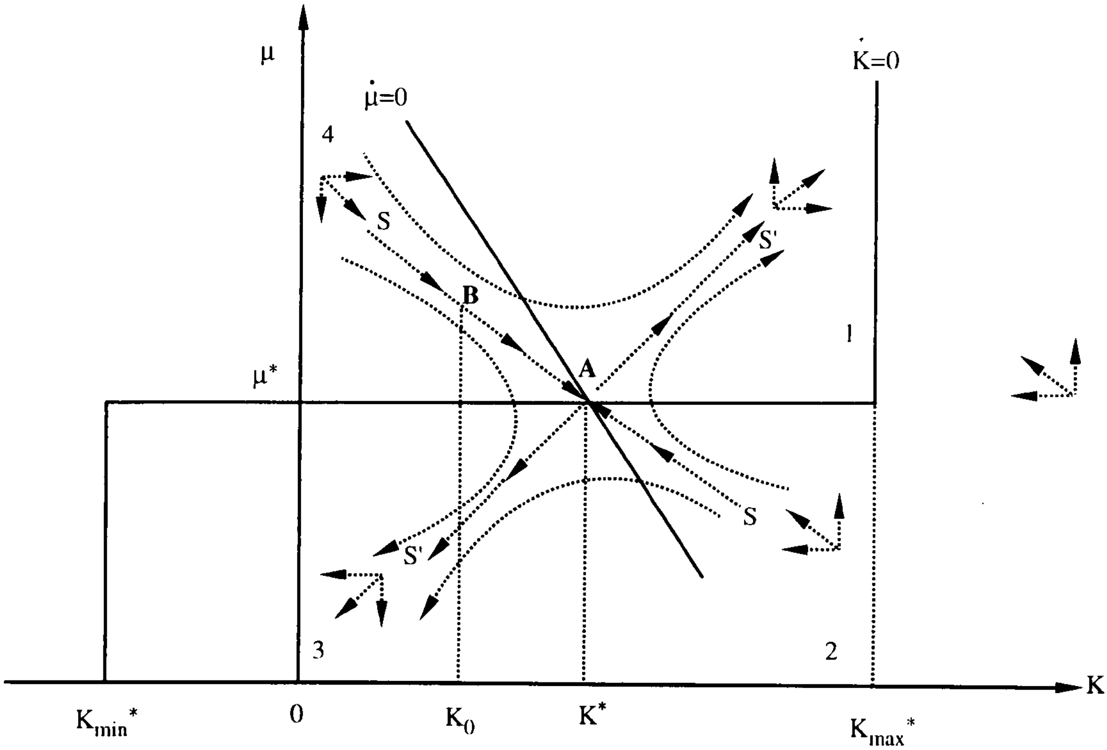
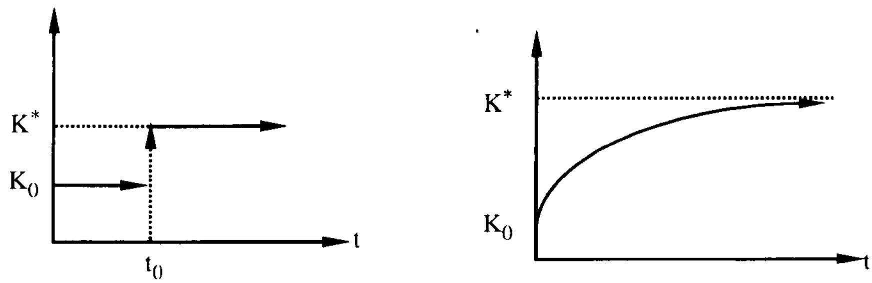


Figure 2.5

unique in a saddlepoint solution. Any path, like S'S' passing through quadrants (1) and (3), is unstable, because the direction of a movement on S'S' is away from the steady state. At any point on the stable path SS the firm moves towards the steady state equilibrium A. Consider point B on the left-hand side of A, for example. The actual amount of capital stock that the firm has (K_0), is less than its optimal level (K^*). As a result, the shadow price of capital will be expected to be higher than its optimal level, $\mu^*(t)$. Therefore, the firm experiences capital deficiency according to this new situation, and is induced to demand more capital goods ex ante, and fills the gap between *actual* and *desired* level of capital stock gradually by investing I^{max} for each t, but not instantaneously. At any point on the right hand side of A, the adjustment takes place by selling the excess capital stock (by the amount of I^{min}), and by moving towards the point A.

This adjustment, according to the neoclassical theory of investment, would be instantaneous in the absence of any constraint on the amount of investment being requested by the firm. Since there exist upper and lower bounds on the rate of investment which the firm can undertake, the adjustment becomes rather gradual. The path of this adjustment can be depicted as in Figure 2.6b.



Unboundless adjustment of the optimal capital stock

(a)

A bounded capital adjustment

(b)

Figure 2.6

In Figure 2.6, two different cases (namely the boundless capital adjustment and the adjustment with an upper bound) are depicted. The initial assumption is that the actual level of capital is less than its new optimal level. Assume that K_0 is the optimal capital stock of an initial steady-state equilibrium (that is not shown in Figure 2.5), but is the *actual* level of the capital stock in the new situation that moves the level of the optimal capital stock to K^*. Note that the capital deficiency of the firm is (K^*-K_0). This describes point *B* in Figure 2.5. However, the adjustment of the capital stock to this new optimal level would not be instantaneous as in the boundless adjustment in panel (a) of Figure 2.6. Due to the existence of an upper constraint on investment, the firm adjusts its actual capital stock to K^* gradually by investing only c constant amount I^{max} for each t as illustrated in panel (b).

5. Comparative Statics:

In this section the effects of changes in some exogenous variables on the steady-state equilibrium and the optimal convergence path of the model described in the previous section are analysed by using the phase diagram. For the present purpose, two possible different cases must be distinguished, namely the case where the steady-state equilibrium is established on the horizontal part of the locus $\dot{K}$, and the case where the same equilibrium is established on the vertical part of $\dot{K}$. I start with the first case, and then analyse the effects of an *unexpected exogenous* shock arising from changes either in interest rates or in the price of output on the capital adjustment path. The firm perceives the shock as permanent in the sense that the new equilibrium is established at a higher level of the steady-state capital stock, and never returns to its old level unless a contrary shock occurs.

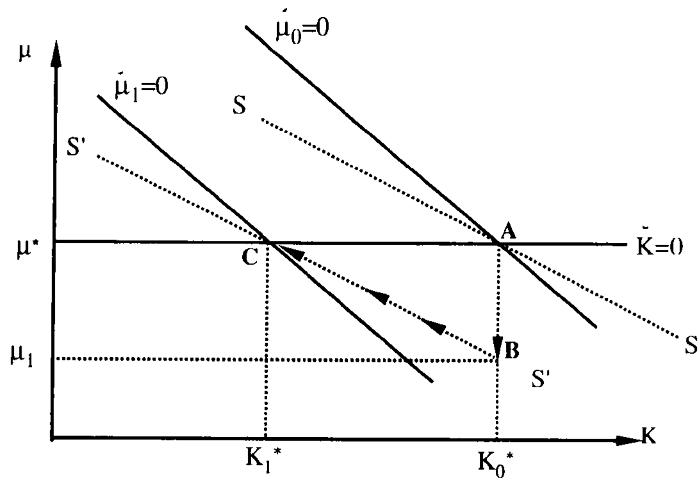


Figure 2.7

In the steady-state equilibrium, the firm is assumed to invest only to maintain the existing level of the desired capital stock. The presence of the upper and lower bound on investment imposes an upper and a lower constraint on the optimal capital stock that the firm is able to maintain. According to Section 4, the upper and the lower bound on the capital stock are $K^{max} = I^{max}/\delta$ and $K^{min} = I^{min}/\delta$ respectively. In this respect, two cases are analysed depending on whether or not either the upper or the lower bound on investment is binding in the new steady-state equilibrium. The first one is called an unconstrained case in the sense that having reached the new steady state equilibrium, investment for replacement purpose is more than the lower bound (or less than the upper bound) on investment (i.e. the optimal capital stock is less (more) than its lower (upper) bound on the capital stock). The second case is a constrained one in the sense that the firm in the new steady-state equilibrium wishes to extend the desired level of the capital stock to a new level by investing a constant amount for each t over the adjustment period, but constrained by either the upper or the lower bound on the capital stock. Therefore, the new steady-state equilibrium is established at a constrained level of the optimal capital stock.

5.1. The Unconstrained Case:

Assume that the firm's disinvestment (or investment) requirement emerges as a result of a rise (or decline) in the short-run interest rates. This disinvestment requirement may be more than the lower constraint, but the presence of this constraint forces the firm to disinvest only I^{min} for each t over the adjustment period. This case of the model involves the horizontal part of the locus $\dot{K}=0$ and the locus $\dot{\mu}=0$ in Figure 2.5. As seen in the previous section, the locus $\dot{K}=0$ is independent of interest rate, and is not affected by a change in the interest rate. But the locus $\dot{\mu}=0$ is a function of

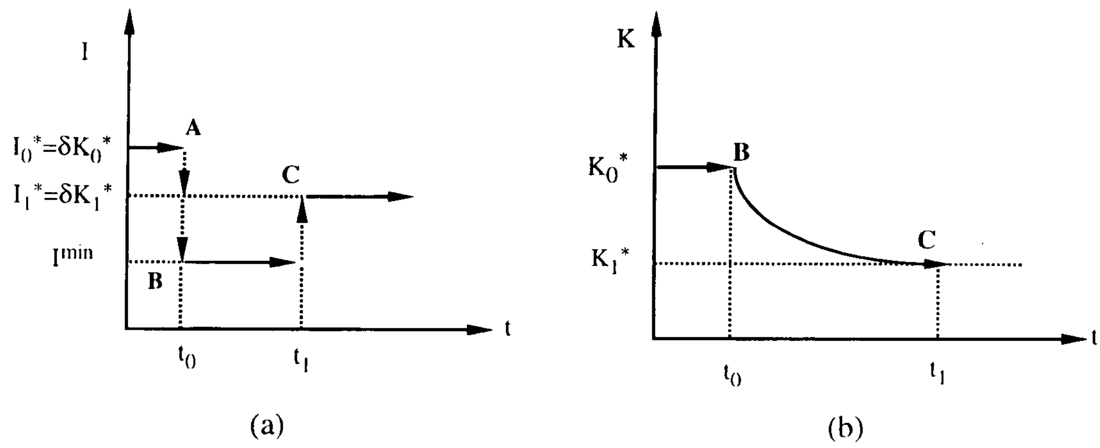


Figure 2.8

the interest rate, the depreciation rate, the output price, and the marginal productivity of capital. To see this functional relationship recall equation (37) from the previous section

$$\mu(t) = \frac{pF_K}{(r+\delta)} \tag{37}$$

Note that an increase in interest rates will reduce the locus given by (37). To see the impact of this change on the adjustment path of the system to the new equilibrium, assume that the firm is initially in the steady state equilibrium point A (see Figure 2.7). Following the increase in *r ceteris paribus*, the locus of $\dot{\mu}=0$ shifts from $\dot{\mu}_0$ evaluated at the old interest rate to $\dot{\mu}_1$ evaluated at the new interest rate. The stable convergence path SS also moves to the new level S'S' that is parallel to SS. At this new level of interest rates, the firm instantaneously realises that it holds excess capital stock $(K_1^* - K_0^*)$ where K_0^* and K_1^* are the levels of the optimal capital stock before and after the interest rate shock respectively. Since the firm perceives that this change in the interest rate is permanent, the marginal benefits of holding an additional capital stock drops to μ_1 at point B, and the firm wishes to disinvest the excess capital stock. Remember from proposition 2, that the adjustment of the capital stock for the region where $\mu(t) < q^l$ (i.e. below the locus $\dot{K}$ in Figure 2.7) is given by equation (19a), that is

$$\dot{K}_t = I^{min} - \delta K_t$$

Therefore, as the firm disinvests (or invests) by I^{min} for each t and gradually adjusts its capital stock to the new level, the marginal benefits from a unit capital stock increase and reach their steady state equilibrium level at point C [see Figure 2.7].

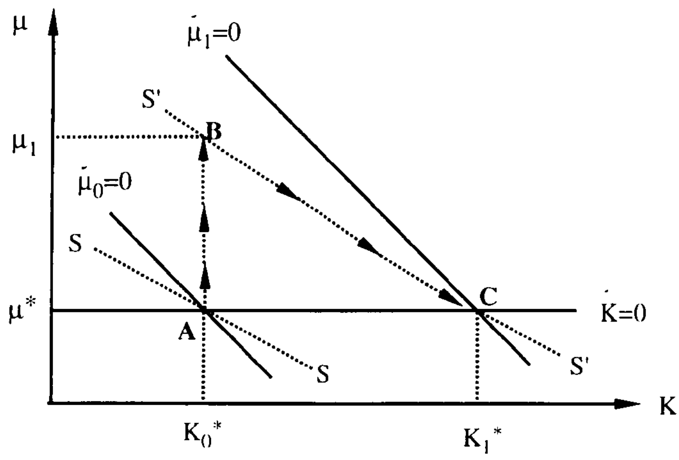


Figure 2.9

The time paths of investment and the actual capital stock can be drawn as in Figure 2.8. In panel (a), the time path of investment is presented. Initially, the firm undertakes only the replacement investment ($I_0^* = \delta K_0^*$) in the old steady state equilibrium point A. Following the interest rate shock, the firm instantaneously starts disinvesting (or decreases the level of investment to the minimum level), and the level of disinvestment jumps to I^{min}. By investing (or disinvesting) a constant minimum amount, the firm then returns to its new optimal level at point C with a new optimal level of investment (which is equal to $I_1^* = \delta K_1^*$ where $I^{min} < I_1^* < I^{max}$). Panel (b), on the other hand, illustrates the gradual adjustment of the actual capital stock to its new optimal level in the new steady-state equilibrium.

Similarly, the impact of an increase in the price of output can also be shown with the help of the phase diagram. According to equation (37), the increase in the output price raises the marginal expected benefit from an additional capital stock, and thereby shifts the locus $\dot\mu$ upwards from $\dot\mu_0$ to $\dot\mu_1$. The firm (that has initially been at point A) instantaneously jumps to point B on the new convergence path S'S' [see Figure 2.9]. At B, the new value of the shadow price of capital is higher than its previous level ($\mu^* < \mu_1$), and the adjustment process of capital is given by (19b) for all values of $\mu(t)$ greater than the purchasing price of capital goods q', (i.e. above the locus $\dot K = 0$), that is

$$\dot K_t = I^{max} - \delta K_t$$

Following the initial jump in μ, its value falls thereafter at a diminishing rate ($F_K < 0$) as the firm increases the capital stock by investing a constant rate I^{max}. And finally the new steady-state equilibrium is established at C where $\dot\mu = \dot K = 0$.

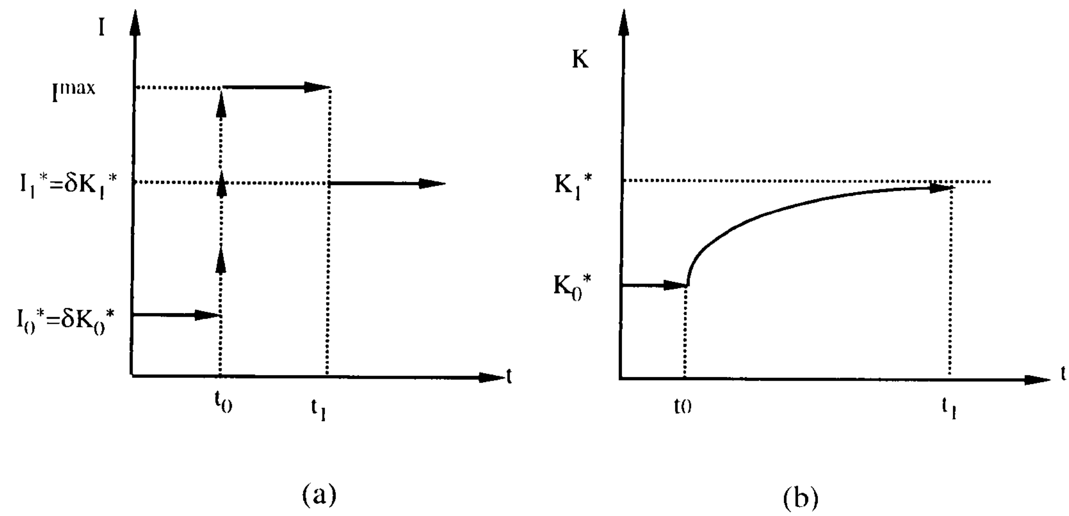


Figure 2.10

Panel (a) in Figure 2.10 illustrates the time path of investment. In response to the increase in the output prices, the firm jumps to the investment level I^{max}, and remains at this investment level until the firm reaches the new optimal stock where $\mu(t)=q^{I}$ at t_1. Having attained the new desired level of capital stock, the rate of investment then jumps again to I_1^*, the new level in the new steady-state equilibrium C. At point C, the firm invests only for replacement purpose (i.e. $I_1^* = \delta K_1^*$ where $I^{min} < I_1^* < I^{max}$). The time path of actual capital stock is also given in panel (b).

5.2. The Constrained Case:

In this section the upper bound on investment is binding in the new steady-state equilibrium, and determines the maximum level of the capital stock that the firm is able to maintain in a new steady state (i.e. $K^{max} = I^{max}/\delta$). Again, I assume an unexpected and permanent exogenous increase in the price of output. The same argument is also applicable to a case with a binding lower constraint on investment.

* *Moving from a steady-state equilibrium on the horizontal part of the locus $\dot{K}=0$ to a new steady-state equilibrium on the vertical part of the locus $\dot{K}=0$.*

Now consider a case in which the steady-state equilibrium of the firm is initially at point A on the horizontal part of the locus $\dot{K}=0$ in Figure 2.11. The firm in the stead-state equilibrium is assumed to invest only to maintain the existing capital stock. The implication of being on this line is that replacement (as well as the optimal level of the capital stock) is not bounded by the upper bound. Following an increase in the price of output, assume that the locus $\dot{\mu}$ shifts to μ_1 parallel to μ_0. The new steady-state convergence path also moves parallel to S'S'. In response to the new

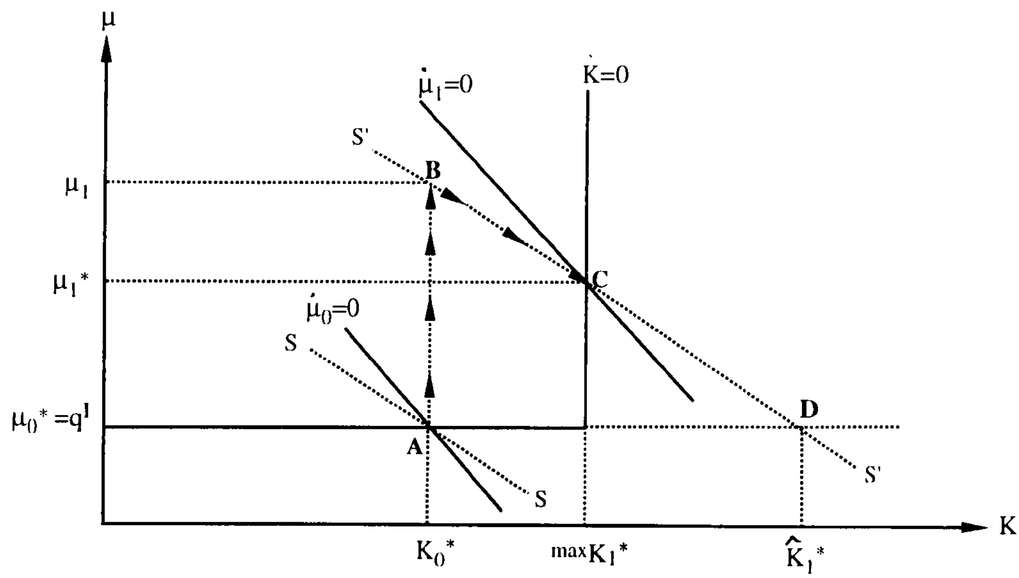


Figure 2.11

level of output price, the firm wishes to adjust to the new desired level of the capital stock at D, $\hat{K}_1^*$. However, the feature of this new convergence path is that because the firm is able to invest only I^{max} for each t over the adjustment period and because the upper bound on investment establishes an upper constraint on the optimal capital stock ${}^{max}K_1^*$, the firm is unable to extend its capital stock further than that limit, and cannot reach the *unconstrained* level of the capital stock $\hat{K}_1^*$ at D.

The overall adjustment process takes place as follows. The firm, first, jumps from A to B in response to the increase in the output price shock. Then it follows the path S'S'. Since in the region above the locus $\dot{K}=0$, the capital stock adjustment is given by (19b) for all values of $\mu(t)$ greater than the purchasing price of capital goods q^I, the firm is able to invest only I^{max} for each t over the adjustment period. As the capital stock increases gradually, the value of $\mu(t)$ falls. However, as soon as the firm attains ${}^{max}K_1^*$, the amount of investment that the firm can undertake (I^{max}) becomes insufficient to extend the capital stock further, and remains at the level by investing only for replacement that $I^{max} = I_1^* = \delta\,{}^{max}K_1^*$. And the new steady-state equilibrium is set at point C, instead of point D. Note that the new steady-state equilibrium at C is established in the region where $\mu(t) = \mu_1^*(t) > q^I$. Unless the exogenous upper constraint is relaxed to allow the firm to expand its capital stock to its unconstrained level, the Jorgenson's myopic rule (26) does not hold.

In Figure 2.12, the time path of investment is illustrated. In the figure, two different adjustments of an constrained and unconstrained firms are shown. By assumption, the unconstrained firm differs from its constrained counterpart because

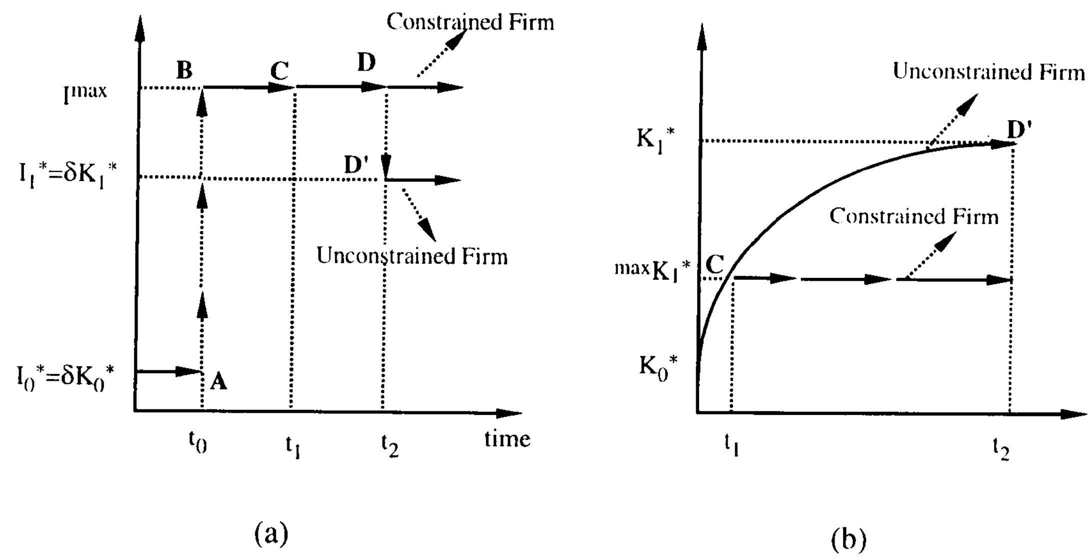


Figure 2.12

the maximum level of the capital stock of the former is higher than that of the latter. Both firms are assumed to follow the same optimal investment path $I_0^* = \delta K_0^*$ until t_0 when the output price shock occurs, and both jump to a maximum available investment path I^{max}. They then continue to adjust their capital stock according to (19b) by investing I^{max} for each t. At point C (at time t_1) the constrained firm stops extending its capital stock because of the upper bound on the capital stock, I^{max}/δ. Since the maximum level of investment I^{max} allows this firm to maintain the existence level of capital stock, the constrained firm thereafter continues to stay on the path CDE. Having jumped to B, the unconstrained firm, on the other hand, follows the path BCD' until t_2 when it completes the adjustment of its capital stock to the new optimal level. Because by assumption, the level of the new optimal capital stock of the unconstrained firm is less than its upper bound on the capital stock, it jumps to a lower optimal investment path, I_1^* (at D') than I^{max}, and stays at this level thereafter.

Panel (b) of Figure 2.12 shows the optimal capital adjustment paths of both the constrained and unconstrained firms. From the figure, having reached point C, both firms start following different adjustment paths. While the constrained one remains at the level $^{max}K_1^*$, the unconstrained firm continues to expand its capital stock until it reaches $\hat{K}_1^*$ in t_2.

6. Adjustment Costs:

As presented in Section 3, Jorgenson's theory of investment was based on the instantaneous and costless capital adjustment assumption. The particular results of this assumption were that the firm was able to invest any amount in response to instantaneous changes in the demand for the optimal capital stock without affecting the price of capital goods. A further consequence was that the firm could not have a stable investment demand schedule showing a relationship between the rate of and the cost of investment. Keeping the costless capital assumption in Section 4, the instantaneous adjustment assumption was relaxed by imposing exogenous constant upper and lower constraints on the rate of investment for each t over time. As a consequence of these constraints, the adjustment process of the actual capital stock became gradual. But an unappealing nature of this modification was the imposition of exogenous constraints in an *ad hoc* fashion without depending on the firm's investment requirement for each t. By removing the costless capital adjustment assumption in this section, a more general case of the derivation of the rate of investment is analysed. By the cost of adjustment assumption, the cost of investment becomes related to the rate of investment, and the upper (or lower) limit on the rate of investment that the firm can undertake for each t over time is determined endogenously by the adjustment cost function.

The literature, in general, assumes an increasing (convex) cost function of capital adjustment. Accordingly, the costs of capital rise at an increasing rate as investment (or disinvestment) increases. Therefore, it is rational for the firm to make the adjustment gradually, but not instantaneously because of high cost. Also expectations play a direct role in this gradual adjustment. Due to the high acquiring cost of investment, firms start adjusting capital stocks in advance of, for example, any expected changes in output that might actually happen in the future. Hence, anticipating future changes, firms expect to reduce total adjustment cost by spreading capital adjustment over time [see Söderström (1976), and Abel (1980)].

The idea of adjustment costs was first introduced by Eisner and Strotz (1963), and later developed by Lucas (1967a), (1967b), Gould (1968), and Treadway (1969), to make Jorgenson's analysis fully dynamic. As explained in earlier sections, Jorgenson's neoclassical theory is, in fact, a theory of optimum demand for capital, but not an investment theory. The rate of investment is rather derived using an *ad hoc* capital adjustment mechanism under the delivery lags assumption. Despite the intertemporal nature of investment, expectations were not dealt with by Jorgenson (explicitly assuming static expectations) in the derivation of the optimal capital stock;

but they are implicitly included in the derivation of the rate of investment through the distributed lags.

The crucial feature of the adjustment cost literature is that the rate of investment can directly be derived from the firm's optimisation problem, and does not require any given stock adjustment mechanism in the derivation. Instead, the capital adjustment mechanism is endogenised by deriving the speed of adjustment dependent on some variables such as interest rates, cash flows, and on the parameters characterising the firm's technology [see Lucas (1967b), Coen (1971), Nickell (1978), and Galeotti (1990)].

The cost of adjustment has become the important component of today's most popular investment models. Abel (1979) and (1980) incorporated an adjustment cost function into Tobin's q theory of investment. More recently, the Euler Equation approach has also been based on an adjustment cost technology [e.g. see Bond and Meghir (1994), and Galeotti, Schiantarelli and Jaramillo (1994)]. The difference between these alternative theories arises from the different treatments of expectations. A more detailed survey of these issues and the applications of a quadratic adjustment cost function in the derivation of an estimateable investment function to investigate the determinants of Turkish private investment expenditure are also presented in subsequent chapters.

Types of Adjustment Cost Functions

Adjustment costs are divided into two main groups according to their sources, namely external and internal costs of adjustment. External adjustment costs mean that the cost of adjustment does not affect the firm's production activities, and is independent of output and input prices. Perhaps the most popular explanation of external adjustment cost introduced in the literature is the monopsonistic capital goods market, so that the supply price of capital goods is an increasing function of quantity demanded by the firm; i.e. $q'(I)$, and $dq'/dI > 0$.

Most of the studies in the adjustment cost literature have focused on internal adjustment costs [Abel (1980), El-Hodiri and Takayama (1981), Abel and Blanchard (1983), Blanchard (1983), and Chirinko (1993)]. Internal costs, which represent output foregone in the process of adjustment, mean that the resources devoted to adjustment are firm-specific, and that there is a direct relationship between production and adjustment. The production function is represented as a function of capital and

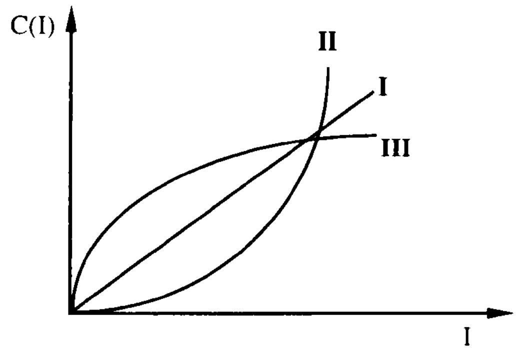


Figure 2.13

labour, as well as services of adjustment. The more general case incorporates adjustment services within the non-separable production function [see Lucas (1967a)]

$$Q = Q(K_t, L_t, I_t) \tag{38}$$

where $Q_I < 0$. Given that the production function is linearly homogenous in capital and labour, non-separability indicates that the marginal productivities of capital and labour are both affected by the extent of adjustment; i.e. a higher rate of investment changes the capital-labour ratio in current production and affects the marginal productivities of capital and labour. As a special case of (39), if the marginal productivity is independent of adjustment services (i.e. $Q_{KI} = Q_{LI} = 0$), then the production function becomes additively separable [see Treadway (1969) and (1970)],

$$Q = Q(K_t, L_t) + C(I_t) \tag{39}$$

As explained in the following sections, this specification of internal adjustment costs has been more commonly used in the q-theory literature [e.g. see Summers (1981), Hayashi (1982), Hubbard and Kashyap (1992), Galeotti *et al.* (1994)].

Regarding the curvature of the adjustment cost function, there exist mainly three types of cost function as given in Figure 2.13. All three cases in Figure 2.13 are plotted for the positive marginal cost of investment, $C'(I_t) > 0$. The share of the adjustment cost curve is given by the second-order derivative of the function. In the linear adjustment cost case (case I), the first-derivative of the adjustment cost function is positive, but the second-order derivative is zero. The only component of the capital adjustment is the price of capital goods, and is not dependent on the rate of investment. In this case, corresponding to Jorgenson's costless capital adjustment assumption, adjustment is always instantaneous, because there is no gain from postponing investment until the next periods. In the case of increasing cost (case II), the second-order derivative of the function is positive. In other words, the costs rises at an increasing rate as investment increases [$C'(I_t) > 0$ and $C''(I_t) > 0$]. Case III represents a decreasing marginal cost of capital [$C'(I_t) > 0$ and $C''(I_t) < 0$], and relevant, at least for low rates of investment.

6.1. Introducing an Adjustment Cost Function into The Firm's Maximisation Problem

In this section, I introduce adjustment costs associated with the sale and purchase of capital goods over a principal price. An assumption of external adjustment costs is held in the present section for the empirical consideration of the issue in Chapter 8. Such costs can be justified by the rising supply price of capital goods in a monopsonistic capital goods market [see Mussa (1977)]. For this purpose, I remove assumption 5 in Section 3.1, and replace by the following assumption,

Assumption 5': *There are some adjustment costs associated with changing the capital stock. These costs are a function of the rate of investment, and comprise two components, namely a linear component (purchasing price of capital goods), and a convex component that indicates rising costs at a higher rate of investment;* $C(I_t) = q^I[I_t + \Psi(I_t)]$ *where* $C'(I_t) > 0$, *and* $C''(I_t) > 0$. *If the rate of investment is zero, these costs are also zero.*

The question now is how the addition of adjustment costs affects the optimality conditions (22), (23), and (24) of Jorgenson's representative firm. Here, the optimising behaviour of Jorgenson's representative firm will be modified subject to costs of adjustment. The firm's objective function becomes identical to

$$V_t = p(t)Q(t) - w(t)L(t) - C(I) \tag{13'}$$

where $C(I)$ is the convex adjustment costs function form assumption 5' with $C'(I_t) > 0$, $C''(I_t) > 0$, $C(0) = 0$. The optimisation (13') subject to (17) and (19) yields

$$p\frac{\partial F}{\partial L} = w \tag{21}$$

$$\mu(t) = C'(I) \tag{22'}$$

and

$$\dot{\mu}(t) = (r + \delta)\mu(t) - pF_K \tag{24}$$

where $C'(I) = \partial C_t / \partial I_t$. (22') simply says that the firm equates the marginal cost of an additional unit of capital stock to the expected marginal benefits from an extra unit increase in the capital stock. The marginal benefits are measured by the shadow price of capital, $\mu(t)$. Due to capital's durability, this benefit is the discounted sum of the present and future's marginal revenue product; i.e. $\mu(t)=\int_0^T \exp[(r+\delta)(s-t)]pF_K dt$. Using (24), the dynamic equation (22') can also be written as follows

$$C'(I_t)=\int_0^\infty \exp[(r+\delta)(s-t)]p\frac{\partial F}{\partial K}ds \tag{40}$$

The left-hand side of (40) is a function of the time path of capital stock from time t into infinite future, while the right-hand side is a function of the current rate of investment. (40) implies that the time path of capital stock depends on the current rate of investment, but does not give a decision rule for determining the current level of investment. However, if I assume that the production function has a constant returns to scale property, then (40) reduces a particular special case in which the marginal products of both labour and capital become a function of both the capital-labour ratio. This ratio is then determined in terms of constant exogenous prices by condition (21) above. Therefore, the marginal product of capital becomes a function of current and future levels of prices along the optimal path [$\partial F(K,L)/\partial K = f'(k)$ where $k = K/L$ and $k = k(q', w, p)$ form the optimality condition for labour in (21)]. Condition (40) then determines the level of investment in terms of prices [see Treadway (1969) and Gould (1968)].

Differentiating (22') with respect to time and using the dynamic equation (24), the following can be written,

$$pF_K=(r+\delta)C'(I_t)-C''(I_t)\dot{I}_t \tag{41}$$

Equation (41) is used to solve for the optimal rate of investment with the constant returns to scale assumption. Following the discussion above, it can easily be seen that the optimal rate of investment will depend on the current and future prices and the parameters of the adjustment cost function. Now, if we assume that the firm is in the steady state equilibrium (i.e. $\dot{\mu}=0$) and all prices remain constant, then equation (41) indicates the following equality between the marginal revenue of investment and the marginal cost of investment,

$$pF_K=(r+\delta)C'(I_t) \Leftrightarrow [MR=MC] \tag{42}$$

Due to the constant returns to scale assumption, the marginal product of capital will be a function of the capital-labour ratio which is itself determined by the prices, and then is independent of the rate of investment. Therefore, the MR curve is drawn as a declining line as in Figure 2.14. On the other hand, because of the convexity

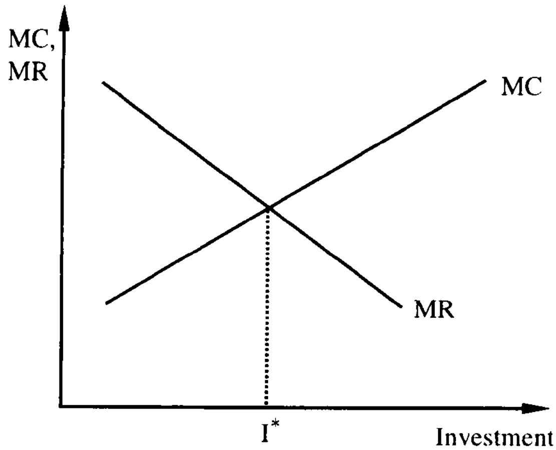


Figure 2.14

assumption of the adjustment cost function, the marginal cost curve is drawn with a rising slope with respect to the rate of investment. Unlike the Jorgenson's model, the investment demand can then be determined at the intersection of the marginal revenue of investment and the marginal cost of investment. In Figure 2.14, this condition is also illustrated under the quadratic adjustment cost assumption. The steady state investment demand is determined at I^*. The addition of the adjustment costs function into the firm's maximisation problem finally yields a well-defined investment demand function. The explicit definition of I^* is obtained by inverting (42), and writing an investment demand schedule as a function of the marginal revenue of capital. Using the convex adjustment costs assumption, we therefore derive the steady state investment demand schedule depending on interest rate, input and output prices, and the parameters of the cost of adjustment function,

$$\dot{I}_t = G(p, w, r, a) \tag{43}$$

where a is the parameter of the adjustment cost function. The signs of each variable can easily be seen from their derivatives.

$$\partial I/\partial r = (\partial I/\partial \mu)(\partial \mu/\partial r) < 0 \tag{44a}$$

$$\partial I/\partial w = (\partial I/\partial \mu)(\partial \mu/\partial w) < 0 \tag{44b}$$

$$\partial I/\partial p = (\partial I/\partial \mu)(\partial \mu/\partial p) > 0 \tag{44c}$$

where $\partial I/\partial \mu > 0$, $\partial \mu/\partial r < 0$, $\partial \mu/\partial w < 0$ and $\partial \mu/\partial p > 0$ [see also Treadway (1969)].

Now assume that the production function is decreasing returns to scale. Using (24) and the equation of the motion of the capital stock jointly with (22'), the following system of two non-linear differential equations can be written

$$\dot{K}_t = I_t - \delta K_t = C'^{-1}(\mu_t) - \delta K_t \tag{45}$$

$$\dot{\mu}_t = (r + \delta)\mu_t - pF_K \tag{24}$$

where C'(.) is assumed to have an inverse function of investment. The behaviour of this system and its difference from the *bang-bang* system in Section 4 can conveniently be analysed in the (μ_t, K_t) space. Following the explanation in Section 4, the graphical solution of the system can be derived as follows. For the locus $\dot{\mu}_t = 0$, (24) can be solved, and the following curve can be derived

$$\mu_t = \frac{pF_K}{(r + \delta)}$$

This is the same curve as (37) in Section 4. The slope of this curve is

$$\frac{d\mu_t}{dK_t} = \frac{pF_{KK}}{(r + \delta)} < 0 \tag{46}$$

since F_{KK} under the decreasing returns to scale assumption. Therefore, the slope of the locus $\dot{\mu}_t = 0$ is downwards. The locus $\dot{K}_t = 0$ can be solved from (45). This gives

$$K_t = (1/\delta)C'^{-1}(\mu_t) \tag{47}$$

The locus (47) differs from its counterpart in Section 4 where the locus $\dot{K}_t = 0$ is horizontal and independent on μ_t, for some values of investment and vertical for the upper and lower bounds on investment. The slope of (47) is given

$$\frac{dK_t}{d\mu_t} = (1/\delta)\frac{dI_t}{d\mu_t}C''^{-1}(\mu_t) \tag{48}$$

The convexity of the adjustment cost function provides that C"(.) >0. It is obvious that if the expected benefits from a unit capital instalment are positive, then the firm continues to invest. An increase in μ_t also raises the amount of capital that the firm wishes to invest; i.e. $dI_t/d\mu_t > 0$. Therefore, the slope of the locus $\dot{K}_t = 0$ is upwards. Figure 2.15 illustrates the behaviour of this system. The movement of μ_t below and above the locus remains the same as before. Anywhere below the locus, a downwards movement of the capital stock results in a decline in the capital stock (shown by a downward arrows). Similarly, an increase in the capital stock above the locus $\dot{\mu}_t = 0$ causes an increase in the value of μ_t (shown by a upward arrows). Using the same argument, the movement of the capital stock can also be determined. At any point

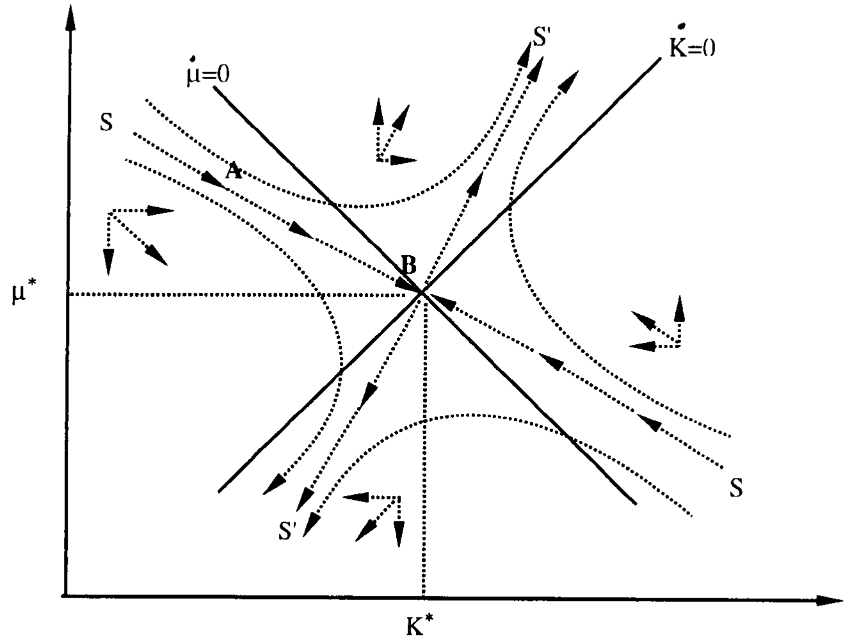


Figure 2.15

above the locus $\dot{K}_t = 0$ any upwards movement of μ_t leads to an increase in the capital stock according to (48). This is illustrated by arrows pointing right. The movement of the capital stock will be decreasing on the below the locus (shown by arrows pointing left).

The difference of the system with the cost of capital adjustment from the one with bang-bang condition (30) is as follows. In the earlier system, the rate of investment over the interval where $\mu_t > q^I$ is determined independently of the value of μ_t, and is constant I^{max}, *vice versa*. However, in the present system, the rate of investment is dependent on the value of μ_t. Accordingly, if the value of μ_t is higher than the total cost of increasing the capital stock one unit (i.e. $\mu_t > C'(I_t)$) anywhere above the locus $\dot{K}_t = 0$, the rate of investment will no longer be constant, but will change at a *decreasing rate* until μ_t becomes equal to the total cost of owning a unit capital stock. On the locus $\dot{K}_t = 0$ however, the condition that $\mu_t = C'(I_t)$ holds. Given this feature of the new system, the rate of investment above and below the locus $\dot{K}_t = 0$ takes any value, other than I^{max} and I^{min} respectively. Therefore the optimisation problem with the cost of capital adjustment no longer has a bang-bang solution, but it is more general than the bang-bang problem.

Figure 2.15 illustrates the time path of investment. Assume that the firm is at point A on the steady-state convergence path SS, and gradually adjusts towards its optimal level of the capital stock K^* at point B. Note that the optimal investment

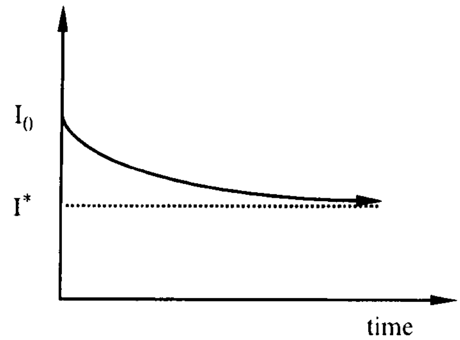


Figure 2.16

level in the steady-state equilibrium point B is replacement investment. Because of the presence of adjustment costs, the time path of investment follows a declining path rather than a constant one as in the bang-bang problem.

6.2. The Speed of Adjustment and Flexible Accelerator Model:

The standard approach to modelling dynamics of investment by Jorgenson is to determine the desired capital stock from the cash-flow optimisation, and to use it as a long-run desired capital stock in an ad hoc adjustment mechanism to determine the firm's optimal investment path. The assumption behind the adjustment mechanism is the proposition that the actual capital stock cannot adjust to the desired level instantaneously and frictionlessly, but rather gradually due to the presence of delivery lags. Such an adjustment mechanism, which was accommodated by Jorgenson and his various collaborators, can be stated with the continuous form of the geometrically declining distributed lag function (2)

$$\dot{K}_t = \theta\left(K_t^* - K_t\right) \tag{2a}$$

However, the presence of adjustment costs in the model leads us to the derivation of the flexible accelerator mechanism (2a) directly from the optimisation problem (13') above. Under static expectations and the constant returns to scale assumption of the production function, Gould (1968) derived a version of (2a) where $\theta=\delta$. To see this result, assume that (42) in steady-state equilibrium holds. In such situation, to maintain desired capital stock requires a certain level of replacement investment which satisfies

$$C'\left(\delta K^*\right) = \left(r+\delta\right)F_K \tag{45}$$

$$I(t) = \delta K \tag{45a}$$

From the capital account identity (23), the actual the rate of investment is given

$$I(t) = \dot{K}(t) + \delta K(t) \tag{23}$$

Substituting the equality $I_t = \delta K_t^*$ into (23) then yields

$$\dot{K}_t = \delta(K_t^* - K_t) \tag{2b}$$

where δ is a constant rate of depreciation. (2b) is the flexible accelerator mechanism that is derived from the optimisation problem under the cost of adjustment and constant returns to scale assumptions. Gould (1968) noted that the shortcoming of use of (2a) resulted largely in the implicit assumption that desired capital stock is determined independently of the determination of the rate of capital accumulation. He emphasised that some variables used to define desired capital stock (such as the level of output, internal funds) were, in fact, affected by the amount of investment expenditures (i.e. (2a)). Therefore, the determinants of desired capital stock and the rate of capital accumulation by (2a) are interrelated. But, the fixity of the speed of adjustment coefficient, θ, in (2a) does not allow the recognition of the impacts of some economic constraints and variables on the optimal adjustment path.

Lucas (1967a) and Treadway (1970), on the other hand, introduced time-varying adjustment paths for multiple inputs cases. Using dynamic optimisation techniques, they solved for the optimal paths of investment under the assumption of a strictly quadratic adjustment cost function. Lucas (1967a) particularly illustrated this result for a single capital input case. The similar result to Lucas (1967a) can also be derived from the solution of the dynamic system of two differential equations (45) and (24)

$$\dot{K}_t = C'^{-1}(\mu_t) - \delta K_t \tag{45}$$

$$\dot{\mu}_t = (r + \delta)\mu_t - pF_K \tag{24}$$

Linearising this differential system around its steady state yields

$$\dot{K}_t = C''^{-1}(\mu_t)(\mu_t - \mu_t^*) - \delta(K_t - K_t^*) \tag{50}$$

$$\dot{\mu}_t = (r + \delta)(\mu_t - \mu_t^*) - pF_{KK}(K_t - K_t^*) \tag{51}$$

(50) and (51) can be written in a matrix form as

$$\begin{bmatrix} \dot{K}_t \\ \dot{\mu}_t \end{bmatrix} = \begin{bmatrix} -\delta & C''^{-1}(\mu_t) \\ -pF_{KK} & (r+\delta) \end{bmatrix} \begin{bmatrix} K_t - K_t^* \\ \mu_t - \mu_t^* \end{bmatrix} \tag{52}$$

The characteristic roots of this system are real and opposite in sign, but only the negative root provides the system to approach its steady state point. Then the solution of (52) gives a saddle point as in Figure 2.15. The stable solution to (52) is asymptotically approximated by

$$K_t - K^* = \exp(\theta t)(K^* - K_0) \tag{53}$$

where θ is the negative root of the characteristic functions of (52). Differentiating (53) with respect to time, we derive the flexible accelerator model

$$\dot{K}_t = \theta(K_t - K^*) \tag{54}$$

where

$$\theta = -(1/2)\left\{r - \sqrt{(r+2\delta)^2 - 4\,pF_{KK}(K^*)/C''(I^*)}\right\} \tag{55}$$

[also see Lucas (1967a) for a multiple input case]. There are two separate important implications of the specification of θ in (55) regarding the rate of interest. First, increases in interest rates raise the user cost of capital, and then reduce the optimal capital stock. Second, increases in interest rates also reduce the optimal speed of adjustment.

In order to investigate the effects of cash flows, or some measure of internal funds available for investment, a relatively more *ad hoc* version of (2a) was defined by Coen (1971). Coen argued that due to imperfections in capital markets, lenders of firms would impose a risk premium over borrowing rates on high leverage firms, and cause a divergence between borrowing and lending rates. He assumed that firms would in general prefer an internal finance option because its cost would be less than that of external finance. However, when internal finance possibilities are exhausted and the anticipated returns to investment are higher than the cost of borrowing, firms may start using external finance. Having discussed the importance of internal finance constraint in the determination of investment expenditures, he defined the adjustment coefficient as a function of internal finance, and wrote the investment function as

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

where

$$\theta = \Phi(IF_t) \tag{56}$$

where IF_t is the level of internal finance. The similar ad hoc specification has also been used by many others to test the effects of some other constraint at a macroeconomic level in developing countries as I discuss in Chapter 4 and Chapter 6; for a more complex form of (56) see Inselbag (1973). The following chapter endogenises financial decisions as a result of imperfections in financial capital market, and derive a similar but explicit formulation of (56).

7. Conclusion

The chapter has reviewed the neoclassical theory of investment. The neoclassical theory reveals two main determinants of investment, namely the user cost of capital and output. The question of how responsive investment is to these two variables remains dependent on technology assumptions on the production function. Empirical studies have suggested that fixed capital investment is more responsive to net changes in output than changes in the relative prices with the putty-clay technology assumption.

This chapter has also reviewed Jorgenson's innovative representation of neoclassical theory of investment. In doing so, two crucial assumptions of his model, namely instantaneous and costless capital adjustment assumption and their implications in the derivation of a finite investment level have been investigated. It has also shown that Jorgenson's model as it is, is inappropriate to derive an investment demand schedule which is needed for an empirical purposes. To derive a finite level of investment, two possible modifications of his model have been considered. First, an upper and lower bound on investment that a representative can undertake for each t over the capital adjustment process. According to this modification, it has been shown that the optimal investment of the firm follows a constant time path, and that the capital adjustment becomes gradual in contrast to Jorgenson's model. Second, the adjustment of the capital stock is assumed to be subject to some cost other than the purchasing price of capital goods. Particularly, this adjustment cost has been assumed to be convex in the solution of the firm's optimisation problem, and a finite level of investment has been derived as a relatively general case rather than imposing a constraint on investment. The difference of these two modifications of Jorgenson's model is that in the second one, investment is not constant, but changes at a decreasing rate, and the firm's optimal investment level for each t over the adjustment process adjusts gradually. However, under constant returns to scale and constant prices assumptions, the adjustment cost model yields a constant amount of investment for each t which can be regarded as an upper bound on investment.

And lastly, the ad hoc partial adjustment mechanism of earlier neoclassical theory and Jorgenson's has been endogenised under the adjustment cost of capital assumption. Also, a particular emphasis has been put on the financial factors that may influence the speed of adjustment through their impacts on the coefficient of the partial adjustment.

In connection with subsequent chapters, this chapter was a theoretical introduction to the neoclassical accelerator model of investment. The importance of two main determinants of the model (the cost of capital and the accelerator) will be the aims of Chapter 6 and Chapter 7. The importance of the adjustment cost assumption will be recognised in Chapter 7 and Chapter 8, and theoretically consistent models of investment will be derived using the cost of capital adjustment. The consequences of upper financial constraint arising from imperfections in financial capital markets is analysed in the next chapter.

Appendix

Maximum Principle of Optimum Control

The Maximum Principle for optimum control, developed by Pontryagin, et. al., is the method used in this chapter. In a simple optimum control problem, two kinds of variables, namely state and control variables, exist. The movement of a state variable is given by a first-order differential equation. A typical continuous time optimum control problem can be presented as follows,

Maximise $$\int_0^{\infty} exp(-rt)\{\Pi[K(t), p(t), w(t)] - q(t)I(t)\}dt \tag{A.1}$$

subject to $$\dot{K}(t) = I(t) - \delta K(t) \tag{A.2}$$

$$K(0) = K_0 \tag{A.3}$$

(A.1) represents the discounted value of net future cash flows. (A.2) is a first-order differential equation giving the net increase in the capital stock. (A.3) is an initial condition, which is usually given. Functions (A.1) and (A.2) are assumed to be continuously differentiable functions. The control variable I(t) and the state variable K(t) are piecewise continuous functions of time. The control variable influences the maximand (A.1) both directly through its own value in the maximand and indirectly through its effect on the state variable K(t) as in (A.2). The solution of the problem yields the optimal investment path $I^*(t)$, where * indicates the optimality of investment. Having substituted $I^*(t)$ into (A.2), the solution of the optimal capital stock $K^*(t)$ can be derived, given the initial value of capital K_0.

The problem can be solved by using a simple Lagrangean approach. Let L(t) denote the Lagrange function, and define as

$$L(t)=\int_{0}^{\infty}\exp(-rt)\left\{\left\{\Pi\left[K(t),p(t),w(t)\right]-q(t)I(t)\right\}-\mu(t)\left[\dot{K}(t)-I(t)+\delta K(t)\right]\right\}dt \qquad \text{(A.4)}$$

where in the optimal control terminology, the Lagrange multiplier $\mu(t)$ is called a co-state variable. The standard Lagrange optimisation technique cannot directly be applied to (A.4) due to the term $\dot{K}(t)$. Instead, the relevant part of (A.4) can be characterised by integrating $\mu(t)\dot{K}(t)$ by parts,

$$\int_{0}^{\infty}\exp(-rt)\mu(t)\dot{K}(t)dt=\exp(-rt)\mu(t)K(t)\Big|_{0}^{\infty}-\int_{0}^{\infty}\exp(-rt)K(t)\left[\dot{\mu}(t)-r\mu(t)\right]dt$$

$$=\mu(0)K(0)-\int_{0}^{\infty}\exp(-rt)K(t)\left[\dot{\mu}(t)-r\mu(t)\right]dt$$

assuming that

$$\lim_{t\to\infty}\exp(-rt)\mu(t)K(t)=0 \qquad \text{(A.5)}$$

which is known as a transversality condition. Substituting all these into (A.4) gives

$$L(t)=\int_{0}^{\infty}\exp(-rt)\left\{\left\{\Pi\left[K(t),p(t),w(t)\right]-q(t)I(t)\right\}+\mu(t)\left[I(t)-\delta K(t)\right]\right.$$

$$\left.+\dot{\mu}(t)K(t)-r\mu(t)K(t)\right\}dt-\mu(0)K(0) \qquad \text{(A.5a)}$$

Define the terms on the first line on the right hand side by

$$H(K,I,\mu,t)=\left\{\Pi\left[K(t),p(t),w(t)\right]-q(t)I(t)\right\}+\mu(t)\left[I(t)-\delta K(t)\right] \qquad \text{(A.6)}$$

The function H is known as the Hamiltonian function. Therefore

$$L(t)=\int_{0}^{\infty}\exp(-rt)\left\{H(K,I,\mu,t)+\dot{\mu}(t)K(t)-r\mu(t)K(t)\right\}dt-\mu(0)K(0) \qquad \text{(A.4b)}$$

The optimality condition of the Lagrangean function ensure that the first derivatives of L(t) with respect to I(t), K(t) and μ(t) will be zero;

$$\partial L/\partial I=0\Leftrightarrow\partial H/\partial I=0$$
$$\partial L/\partial K=0\Leftrightarrow\partial H/\partial K+\dot{\mu}=0$$

One more condition can be derived from (A.4) by differentiating L(t) with respect to μ(t),

$$\partial L/\partial \mu = 0 \Leftrightarrow \partial H/\partial \mu - \dot{K} = 0$$

Therefore, the following first-order conditions can be written so as to give the optimal investment flow and capital stock

$$\partial H/\partial I = 0, \tag{A.7}$$

$$-\partial H/\partial K = \dot{\mu}, \tag{A.8}$$

$$\partial H/\partial \mu = \dot{K} \tag{A.9}$$

Chapter 3

The Theory of Investment and Finance

1. Introduction

In the previous chapter, the neoclassical model of the firm's investment behaviour was analysed in a framework characterised by a perfect financial capital market. This assumption implies that the firm is indifferent between different financing options (such as borrowing, issuing equity and retained earnings) of investment, since their costs to the firm are the same and given. As a result of such an assumption, the firm has free access to financial markets whenever it wishes to finance its investment expenditure through external resources. In this framework, the financial policy of the firm is exogenous, and there is no interdependence between investment and financial decisions.

As Jorgenson and his associates excluded financial factors from their empirical models, they basically relied on the Modigliani and Miller theorem. According to this theorem, financial policy is of no relevance to the value of the firm, and investment is, therefore, not affected by financial decisions.

The primary aim of this chapter is to show the interdependence of financial policies and investment plans. In this regard, I assume that financial capital markets in which the firm borrows are imperfect, and define two forms of imperfections in these markets. According to the first one, a representative firm faces a quantitative constraint on its borrowing requirement, and becomes dependent on its internal financial funds (such as profits and retained earnings). The second form of imperfection is characterised by an increasing convex cost of borrowing. Assuming that there are no binding quantitative constraints, the firm's cost schedule of borrowing is considered as an increasing function of the firm's debt-equity ratio at the margin. Also, the effects of such imperfect capital market assumption on the optimal adjustment path of the capital stock are taken into consideration in this chapter. However, for the empirical implementation of these two different forms of imperfect capital market assumptions, Chapter 8 suggests a model and tests it with Turkish data.

Regarding the specification of upper and lower constraints on investment, Chapter 2 has treated them as exogenous. One possible explanation of the presence of such a constant upper constraint on investment may be the costs of capital adjustment as noted in Chapter 2. Particularly, if we assume that the production function possesses constant returns to scale, and all prices are constant over time, then the amount of investment required for each t during the adjustment process of the capital stock becomes constant. Unlike Chapter 2, the present chapter justifies the presence of such an upper constraint on investment by assuming a specific form of imperfection in financial capital markets. In Section 3, this upper constraint takes special forms such as the level of current profits and retained earnings. Concerning the specification of the lower bound, I follow Arrow (1968), and assume that there exists no secondary capital goods market in which the firm can sell its excess capital stock instantaneously. This condition is widely known as irreversibility of capital spending.

Even long before Jorgenson's studies on investment, the interdependence between financial factors and investment decisions had been recognised by a number of studies [Keynes (1936), Kalecki (1954), Duesenberry (1958), Gruendfeld (1960), and Kuh (1963)]. Keynes in his influential book took into consideration an additional cost element over the principle level of the cost of borrowing, and defined it as the cost arising out of lender's risk [Keynes (1936): 144]. The reason of such costs has been discussed in the recent macroeconomics, and has closely been related to imperfections in financial markets, and the agency problem associated with these imperfections [e.g. Jaffee and Russell (1976) and Stiglitz and Weiss (1981)]. The modern interpretation of Keynes in this new macroeconomic framework is built upon the concept of imperfect information. The basic argument of imperfect information is that firms may have more information about the nature and the prospective yields of their investment plans than their lenders. Such imperfection in the form of "asymmetric information" is particularly important for the lenders in a situation where there is a possibility that the firm may go bankrupt. Thus asymmetric information can lead the lenders to search for more information about the real nature of the investment plans, and to spend more on monitoring the firm's activities. However, all this imposes additional costs on borrowing according to the riskness of the investment plans (such costs can be called 'risk premium' because of their nature). if the default risk of lending is high, then the risk premium to be charged will be high as well. Keynes also noted that if the borrower and lender were the same person, then such cost would not exist [see Keynes (1936): 144].

Kalecki (1954) considered gross savings out of current profits (i.e. retained earnings) and changes in profits as the main determinants of investment. In connection with imperfections in financial markets, Kalecki particularly noted that "*gross savings of firms,..., extend the boundaries set to investment plans by limited capital market and the factor of 'increasing risk'.*" [Kalecki (1954): 97]. Grundfeld (1960), on the other hand, accommodated the market value approach defined in the previous chapter, and specified the desired capital stock in terms of the outstanding securities of the firm. Kuh (1963) in this regard included internal funds available for investment (mainly in line of Kalecki (1954)), using the liquidity approach described in the previous chapter [see Section 2.2 of Chapter 2].

The importance of the role assigned to financial factor in modelling investment behaviour has also been the subject of a long historical debate starting with Jorgenson (1971) and Elliot (1973). However, on the theoretical front, the last two decades witnessed major breakthroughs in modelling capital market imperfections [e.g. see Gertler (1988) for a survey]. Steigum (1983), for example, suggested an alternative 'financial theory' of investment in which some specific capital market imperfections are considered. He criticised the use of strictly convex adjustment costs in the derivation of stable and continuous investment demand schedule. He noted that many adjustment costs (such as transaction, search, and information costs) are, in fact, concave. Instead of using a convex adjustment cost function, he suggested that some imperfections in capital markets rule out instantaneous adjustment of the capital stock to its optimal level, and demonstrated that the optimal adjustment path can be approximated by a flexible accelerator model even without using the convex adjustment cost function. The important part of his model is the assumption that the cost of borrowing comprises of two components, the risk free interest rate and a default risk premium arising from the agency problem. He postulated that the default risk premium is an increasing function of the firm's debt-equity ratio. Unlike Jorgenson's cash flow maximisation, Steigum proposed that the firm behaves as if it maximises the entrepreneur's intertemporal utility.

The most influential theoretical breakthrough in macroeconomics in the late 1970s and 1980s emphasised the direct interrelationship between financial markets and investment plans through borrowing constraints. As will be discussed later in this chapter, firms may face non-price credit rationing in financial capital markets either because of the absence of a well-developed capital market (as is the case in many developing countries) or due to imperfections in existing capital markets (such as asymmetric information). In particular, in developing countries the rate of interest on loan may be kept lower than its equilibrium level by governments for various reasons. The rate of returns on investment in these countries, on the other hand, may be quite high, leading to excess demand for bank credit. In such a situation, the price mechanism is replaced by qualitative restrictions on credit to adjust the supply of and demand for credit. However in some cases, some firms' demand for credit may be restricted by lenders even if they are willing to pay the prevailing rate of interest. The reason for this behaviour of lenders is as follows. As lenders increase the rate of interest according to the riskness of investment plans (due to the agency problem), the lenders' expected returns decrease with rising risk premium component of the interest rate. Besides, increasing interest rates cause the lenders to face fewer and fewer risk-averse firms (with increasing default risk of loan). To avoid the consequences of high monitoring cost, the lenders may also ration some firms depending on some firm specific measures (such as reputation, size) [see Chapter 8].

No matter what the reason is, such imperfections in financial capital markets impose an upper bound on the investment paths of some firms, and leave them totally dependent on their own internally generated funds. The limited access to capital markets by some small firms operating in such a capital market, particularly, is an example of the dependence of these firms' investment plans on internal financial funds, not because the lenders are not able to distinguish the riskness of such small firms, but also because of the high cost of obtaining and monitoring information about these firms.

The main concern of the chapter is the relevance of financial decisions for investment plans. In this respect, Section 2 re-generates a simple presentation of the Modigliani and Miller irrelevance theorem. This section also shows under which assumptions the Modigliani and Miller theorem is relevant. Section 3 examines the dynamic effects of irreversibility and liquidity constraints on the optimal capital accumulation and investment plans of the firm. In the same section, borrowing is included in Jorgenson's cash flow model with a rising cost schedule of borrowing, and its impact on the optimal adjustment path of the capital stock is analysed. Section 4 examines the main elements of the Keynesian theory of investment and the role of financial factors in this theory. As an extension of both Jorgenson's neoclassical and the Keynesian theory of investment, Tobin's q theory of investment is discussed in Section 5. The last section of the chapter is devoted to some conclusions.

2. Modigliani and Miller Theorem

Starting from the mid-1960s, empirical studies on the theory of neoclassical investment have excluded purely financial factors from investment decisions. Modigliani and Miller (1958) provided the formal theoretical justification for the irrelevance of financial structure and decisions of a firm for real investment. In particular, the Modigliani and Miller theorem implies that in the absence of income tax, the firm's cost of financial capital is independent of the way that the firm finances its investment expenditure (it may be through retained earnings, or through issuing bond or equity). Therefore the firm is indifferent between different financing options.

There are many versions of the Modigliani and Miller theorem. Here in this section, a simplified version of the formal model is set out, by following Fama (1978), Hoover (1992). Before presenting the model, some important assumptions of the extreme form of the theorem can be noted as follows [see Fama (1978)].

Assumption 1: *Financial capital markets are perfect; there are no transaction costs to invest or any danger of bankruptcy, and no taxes.*

Assumption 2: *Agents have equal access to financial capital markets. Then no firms enjoy any special advantage over individuals in financial markets. This means that the types of securities that can be issued by firms can also be issued by investors. Its important implications for the model here is that the prices of securities are determined by the characteristics of their payoff streams and not by whether they are issued by firms or investors.*

Assumption 3: *There is complete agreement of homogeneous expectations (or rational expectations). All information is costlessly available to all market agents, and all agents assess the implications of information for the future prospects of firms and securities to correct their error.*

Assumption 4: *Agents are concerned only about the pattern of returns of their financial assets under different states of the world, but not about a test for particular portfolio combinations independently of their effects on risk and return.*

Assumption 5: *Firms' investment decisions are made according to given strategies; i.e. they are made independently of how investment is financed, but according to calculations of the present value of firms' assets.*

The formal model re-produced here is a simple, and standard one. Assume that, for a given time period, the following arbitrage equation[1] for a representative firm in equilibrium holds,

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[1] The similar arbitrage equation in a dynamic form is also going to be accommodated in Chapter 8 by assuming that the firm does not issue equity.

$$V = p^e E + B \tag{1}$$

where V is the value of the firm's real capital stock; B is the value of its debt to banks and bondholders; E is the number of total shares outstanding; and p^e is the price of each share. Let v be the firm's rate of return on its real capital in different states of the world. The net rate of return per real capital is the difference between v and the rate of return on debt, r, that the firm promises to pay to banks and to its bondholders. Therefore total return on real capital net of borrowing cost can be

$$vV - rB = v\left(p^e E + B\right) - rB \tag{2}$$

Given (2), the return per pound invested in the firm's shares, h, can be calculated as

$$h = \frac{v\left(p^e E + B\right) - rB}{p^e E} = \left(v - r\frac{B}{p^e E + B}\right)\left(\frac{p^e E + B}{p^e E}\right) \tag{3}$$

The total cost of financial capital (comprising of debt and equity financing) to the firm, TC, is then written as the sum of the total cost of shares, $hp^e E$, and the total cost of bonds, rB; that is

$$TC = hp^e E + rB \tag{4}$$

The average cost AC is therefore

$$AC = h\left(\frac{p^e E}{p^e E + B}\right) + r\left(\frac{B}{p^e E + B}\right) \tag{5}$$

Substituting (3) in (5)

$$AC = \left(v - r\frac{B}{p^e E + B}\right)\left(\frac{p^e E + B}{p^e E}\right)\left(\frac{p^e E}{p^e E + B}\right) + r\left(\frac{B}{p^e E + B}\right) \tag{6}$$

or

$$AC = v \tag{6'}$$

This says that the average cost of financial capital (from borrowing and equity financing) to the firm is equal to the rate of return on the firm's real capital, and this cost is not affected by the firm's 'debt-capital' (or debt-equity) ratio. Therefore the firm's financial and real decisions (such as investment) are separable, and determined independently of each other, as long as v is itself is independent of the means of finance (see assumption 5). This is a simple representation of the Modigliani and Miller theorem.

The interdependence of investment and financial decisions is recognised in the present chapter. It is considered that this interdependence arises due to the imperfect nature of financial markets. In this regard, two possible approaches are taken into consideration to make financial decisions relevant for investment in this chapter. The first one is the assumption that self-financing is the marginal source of financing investment. This situation may arise for the reason that the firm is unable to borrow from capital markets by any desired level, then face a binding quantitative constraint in this imperfect financial capital market. Therefore the firm has to rely on its internal financial resources to finance its marginal investment. In such a situation, there will be an upper bound on the amount of investment that the firm can make for each t.

The second one is the assumption of a rising *convex* cost function of borrowing [see Hochman *et al.* (1973), and Steigum (1983)]. According to assumptions of Jorgenson's model in Chapter 2 (as well as of the Modigliani and Miller theorem above), a firm faces a given cost of financing capital, and it is able to borrow at this cost as much as it wishes. Our second justification of imperfect financial capital markets involves the fact that the firm cannot borrow boundlessly. Due to asymmetric information and agency problem between the firm and bondholders of the firm, the cost of financial capital may be positively related to the firm's debt-equity ratio. While showing the interdependence of financial and investment decisions, this approach also provides a theoretical back up for a mostly used modelling strategy of financial variable in empirical private investment models in developing countries [see Sundurarajan and Thakur (1980), and Blejer and Khan (1984)].[2] Many studies in developing countries have considered the importance of financial factors in the determination of private investment behaviour, and modelled the effects of these factors generally by specifying a variable adjustment coefficient in terms of financial variables. Section 6.2 in Chapter 2 briefly draws attention to this issue, but leaves the more detailed theoretical discussion to this chapter. In section 3 here, the adjustment coefficient of the partial adjustment mechanism is theoretically derived as a function of financial factor.

[2] A detailed review of this modelling strategy is presented in Chapter 4.

3. Financial Market Imperfections and Investment Behaviour

3.1. Capital Market Imperfections in the Form of Quantitative Constraints on Investment

Financial constraints here are modelled both by the level of current profits and by retained earnings. Depending on the specification of the financial constraint in the theoretical model, optimal capital accumulation rules and investment plans show some differences. A simple theoretical model is presented to investigate this role of financial constraints in the optimal capital and investment plans in this chapter. Their empirical significance for the Turkish economy is presented in Chapter 8 with the help of a simple empirical model.

In some respects, the model in this chapter shows a similarity to the one in Chapter 2. However, the model in the previous chapter assumes that an upper constraint (as well as a lower constraint) is exogenously imposed,[3] and is permanently binding over the adjustment process. The model in the present chapter, on the other hand, considers the dynamic effects of a temporary upper constraint on investment. For this purpose, it is assumed that the upper (or lower) bound is binding only over a certain time interval. Therefore, the behaviour of a rational firm with perfect foresight before and after this interval becomes the central issue to be discussed in this chapter.

Another essential part of the model here is the assumption of an imperfect secondary capital goods market. According to this assumption, the selling price of already used capital goods is lower than their purchasing price mainly because of unrecoverable sunk costs. Such costs may create a wedge between the purchasing price and the selling price of capital particularly if the adjustment of the capital stock is subject to costs. But in the following model, I make a very restrictive assumption that the secondary capital goods market does not exist, and reselling capital is not possible. This assumption is known as the *irreversibility* assumption of capital. This also corresponds to the "putty-clay" technology assumption as discussed in the previous chapter, in the sense that once capital is installed in place with a specific production technology, it cannot be sold or re-used in a different production process. Consequently, the firm that wishes to disinvest, must wait until the capital stock dies out at a constant geometric rate (by assumption). As an immediate implication of this assumption, Jorgenson's myopic investment decision rule turns out to be a forward-

[3] As discussed in the introduction, one possibility of the presence of such an upper bound on the amount of investment can be justified by the adjustment costs of capital. In particular, the constant returns to scale and constant prices assumptions may yield a constant upper bound on investment.

looking one in the sense that the firm becomes aware of the fact that holding excess capital stock may be costly if economic conditions worsen (e.g. demand for this firm's output may fall). So it tries to foresee what the economic conditions would be in the near future. If it anticipates, for example, that disinvestment would be necessary in the future as a result of, say, a fall in demand, then it calls off or reduces current investment plans to avoid having the cost of possessing excess capital stock in the future. The assumption of the absence of secondary capital market goods market is not new in the literature, and has been used in different theoretical analysis by Arrow (1968), Appelbaum and Harris (1978), Nickell (1978), Schworm (1980), and Niho and Musacchio (1983).

The model assesses the impact on the optimal capital accumulation rule of the availability of internally generated financial funds acting as an upper bound, and the irreversibility constraint acting as a lower bound on investment spending. Similar to the assumptions in Chapter 2, these constraints are also accompanied by the following simplifying additional assumption of the model

Assumption 1: *There is one capital good, K_t, which is assumed to be a "quasi-fixed" input which means it is neither completly variable nor definitely fixed. And labour, L_t, is the only variable input.*

Assumption 2: *All markets in which the firm buys production factors and sells goods are perfectly competitive.*

Assumption 3: *There are no installation (or adjustment) costs of capital.*

Assumption 4: *The firm can foresee the future perfectly; i.e. there is no uncertainty*

Assumption 5: *Capital markets are imperfect in the form of quantitative constraints on investment. As a result, the firm must rely on any kind of internally generated funds. There is no debt financing and no equity issued, therefore the only finance option is to be either current profits or retained earnings that can be transferable over time.*

Assumption 6: *The profit function is positive, non-decreasing, convex and linear homogenous in wage, and concave and increasing in the capital stock.*

Assumption 6 suggests the following

$$\tilde{\pi}\big(w(t), p(t), q'(t), K(t)\big) = \max_{Q(t)}\left\{p(t)Q(t)\big|\big(K(t), Q(t)\big) \in T\right\} \tag{7}$$

where $\tilde{\pi}(.)$: the restricted profit function, $w(.)$: wage rate, $p(.)$: the price of output, $q'(.)$: the price of capital goods, $Q(.)$: the level of output, $K(.)$: the capital stock, T: the production possibilities set.

The technological change and changes in prices are assumed to be continuous so that $\tilde{\pi}(.)$ is also continuous in time. Let $\tilde{\pi}(K_t,t)=\tilde{\pi}(w,p,q^I,K)$ suppressing all indices of prices. (7) is strictly concave, increasing, twice differentiable function of the capital stock; i.e. $\tilde{\pi}_K > 0$, $\tilde{\pi}_{KK} < 0$ (where $\tilde{\pi}_K = \partial\tilde{\pi}/\partial K_t$ and $\tilde{\pi}_{KK} = \partial^2\tilde{\pi}/\partial K_t^2$).

With respect to assumption 5, the theory suggests two different internal financial constraints, namely the current profits constraint [see Appelbaum and Harris (1978)], and the retained earning constraint [see Schworm (1980)]. The optimal capital accumulation rules and optimal investment decisions differ depending on which financial constraint is effective in the model. In this section, both constraints and their effects on the optimal policy of the firm are analysed separately. The model, which is similar to the one in the previous chapter, specifies the forms of the upper and lower constraints on investment (namely the internal financial constraint and the irreversibility constraint respectively). Unlike Arrow (1968), and Appelbaume and Harris (1978), the following model is more general in the sense that the replacement investment and the price of capital goods are also included in the solution.

The firm is assumed to maximise the sum of discounted cash flow over a time interval (0, +∞) by choosing the optimal time paths of investment *I(t)*, and labour, *L(t)*, subject to i.) the equation describing capital accumulation (i.e. capital account equation), ii.) the irreversibility constraint, iii.) an internal finance constraint on investment; that is

Maximise $$\int_0^\infty R(t)\left[\tilde{\pi}(K_t,t)-q_t^I I_t\right]dt \tag{8}$$

subject to

$$\dot{K}_t = I_t - \delta K_t \tag{9}$$

$$q_t^I I_t \geq 0 \tag{10}$$

$$q_t^I I_t \leq \bar{I}^f \tag{11}$$

$$K(0) = K_0 > 0 \tag{12}$$

$$\lim_{t\to\infty} R(T)K_T = 0 \tag{13}$$

where $\bar{I}^f$: the upper limit of investment spending which is specified by accommodating either current profits or retained earnings,

$$R(t) = \exp\left\{-\int_0^t r(\tau)d\tau\right\}, \quad r(t) = -\frac{\dot{R}(t)}{R(t)} \tag{14}$$

(10) and (11) represent the irreversibility and internal finance constraints respectively. These constraints influence decision rules for the optimal capital accumulation and investment.

To assess the dynamic effects of quantitative constraints, we take into consideration two different criteria. I call the first one "the purchasing criterion" that involves the comparison of the shadow price of capital (μ_t) with its purchasing price (q^I). This is also the rule we have discussed in the previous chapter. Accordingly, if the shadow price of capital is higher than its purchasing price, then the firm considers that purchasing capital stock leaves net profit to it. Hence the firm decides to invest until this net profit disappears as the value of the shadow price of capital declines, and vice versa. I call the second one "the renting criterion" that involves the comparison of the discounted marginal product of a unit capital investment (i.e. the shadow price of capital) with its implicit rental price. The rental cost will be defined as the discounted value of expected rental payments for a unit of capital goods over a time interval that the firm could pay if renting, instead of purchasing, was an option. Now, assume a time interval where the shadow price of capital is less than its purchasing price, but higher than its rental price. According to the purchasing criterion, purchasing capital goods over this interval is not profitable for the firm. However, if renting capital is allowed, then the firm, according to the renting criterion, prefers to rent capital goods in the beginning of the interval, and returns them at the end of the interval. In Jorgenson's model, these two decision criteria are identical, and the firm is indifferent between renting and purchasing capital goods, since there are no binding constraints on investment. The immediate effects of the presence of constraint either (4) or (5) will be to make these two decision criteria different. Needless to say, one can easily realise from the discussion above that the imposition of constraints on investment turns the problem into a forward-looking one by invoking the firm to foresee the near future.

Before starting the formulation of the model, it is necessary to note that the optimal capital accumulation and investment decisions differ according to the interval over which the firm makes decisions. Following Arrow (1968)'s and Appelbaum and Harris (1978)'s terminology, three different intervals can be mentioned. They are i.) a free interval where neither the upper constraint nor the lower constraint proposed here is effective, ii.) a blocked interval where only the irreversibility constraint is effective, and finally iii.) a bounded interval where the internal finance constraint is binding. In

Chapter 2, a case with a binding lower constraint on investment corresponds to a blocked interval, while a binding upper constraint refers to a bounded interval. Unlike the model in the present chapter, the constraints in Chapter 2 are assumed to be permanent. The model, whose solution is presented below subject to different binding constraints, considers the dynamic effects of any *temporary* constraint that are effective over a certain time interval, and takes into account expected marginal net changes in the shadow price of a capital good over that interval. Depending on these changes in the shadow price, the firm's renting and purchasing criteria differs.

3.1.1. The Irreversibility Constraint

Here I postpone imposing the internal finance restriction (11) for a while, and investigate the likely impact of the irreversibility constraint on optimal investment policies. The results to be derived shortly are no different from a re-formulation of those of Arrow (1968). Two different optimal decision rules regarding the constraint (10) can be stated through the following two propositions.

Proposition 1: *If $I_t > 0$ on an interval where the lower constraint is not binding, then the optimal capital policy is described by the well-known myopic rule. The firm chooses the capital stock, K_t, so that both decision criteria are satisfied simultaneously. In other words, the shadow price of capital becomes equal to its purchasing price ($\mu_t = q^I$) while the marginal productivity of capital equals its rental cost (that is $\tilde{\pi}_K(K_t, t) = c_t$ where $c_t = q_t^I(r_t + \delta - \hat{q}_t^I)$, and $\hat{q}_t^I = \dot{q}_t^I / q_t^I$).*

According to proposition 1, if the firm is not bounded by the irreversibility condition, then Jorgenson's myopic rule produced in the previous chapter holds, and the firm becomes indifferent between the purchasing criterion and the renting criterion over a free interval.

Proposition 2: *On a blocked interval (t_0, t_1), beginning at some $t_0 > 0$ on a free interval and ending at some $t_1 < +\infty$ on a free interval, the following decision rules holds for all t, $t_0 < t < t_1$.*

(a) $$\int_{t_0}^{t_1} e^{-\sigma t}\left[c_t - \tilde{\pi}_K(K_t, t)\right]dt = 0$$

(b) $$\int_{t_0}^{t} e^{-\sigma t}\left[c_t - \tilde{\pi}_K(K_t, t)\right]dt < 0 \quad \text{for } t_0 < t < t_1$$

(c) $$\int_{t}^{t_1} e^{-\sigma t}\left[c_t - \tilde{\pi}_K(K_t, t)\right]dt > 0 \quad \text{for } t_0 < t < t_1$$

where $\sigma = (r + \delta)$.

Simple interpretations of proposition 2 are as follows. Remember that a block interval is mainly characterised by the fact that the firm wishes to sell its excess capital stock, but it is unable to do so because of the irreversibility constraint. The reason why the firm wishes to sell capital is that the marginal benefit from a capital good is less than its purchasing price, $\mu_t < q^I$. Relations (a-c) in proposition 2 define three different renting criteria. Bearing this in mind, (a) describes a situation where the blocked interval starts at a free interval and ends at another free interval. Equation (a) says that at the margin, the discounted rental cost of capital (c_t is the instantaneous rental cost of capital) and its discounted marginal benefit are equal, and the firm becomes indifferent between renting and not renting for the entire period. (b) indicates a blocked interval starting at a free interval and ending at some time on the blocked interval. With respect to (b), the marginal expected rental cost of a capital good is less than its expected discounted marginal benefit. In such situation, renting a capital good at t_0 and returning it at t (rather than purchasing a capital good at t_0 and holding it) would be profitable for the firm if renting was an option in the model. Since the only option is purchasing, and the purchasing criterion indicates that $\mu_t < q^I$, then the firm does not wish to buy a capital good. (c) is, on the other hand, a situation starting at the blocked interval and ending at a free interval. Relation (c) assures that the expected discounted marginal cost of renting is higher than its discounted marginal benefit, and therefore, the firm would not wish to rent a capital good in such an interval.

<u>Proof</u>: The optimal strategies are given by the solution of the maximisation of cash flows over [0, $+\infty$] subject to (9), (10), (12), and (13). The optimal policy of the firm, denoted by (K_t^*, I_t^*), also means the maximisation of the following current value Hamiltonian

$$H_t = \left[\tilde{\pi}(K_t,t) - q_t^I I_t\right] + \mu_t(I_t - \delta K_t) \tag{15}$$

where μ_t: the shadow price of a unit of capital goods, a function of time (μ_t>0); q_t^I: the purchasing price of capital goods. The Lagrangean function associated with H(t) and the irreversibility constraint can be formulated as,

$$L_t = H_t + \lambda_t q_t^I I_t \tag{16}$$

where λ_t: the Lagrange multiplier for the constraint (10) ($\lambda_t \geq 0$). The optimal investment strategy, I_t^*, is however given by the following Kuhn-Tucker necessary condition,

$$\left(\frac{\partial L_t}{\partial I_t}\right) \leq 0, \qquad I_t^* \geq 0, \qquad I_t^*\left[\mu_t + q_t^I(\lambda_t - 1)\right] = 0, \tag{17}$$

There are two possible cases associated with this Kuhn-Tucker condition:

(i) if $I_t^* > 0$ $(\Rightarrow \lambda_t = 0)$, then $\mu_t = q_t^I$ (18)

(ii) if $I_t^* = 0$ $(\Rightarrow \lambda_t > 0)$, then $\mu_t < q_t^I$ (19)

(i) describes a free interval over which the optimal investment undertaken by the firm is positive. This is given by the purchasing criterion $\mu_t = q^I$. On the other hand, condition (ii) indicates the purchasing criterion on the blocked interval. Since $\mu_t < q^I$ over the blocked interval, the optimal investment strategy for the firm is to be zero investment. The dynamics of the system are given by the constraint (3) and the motion of the shadow value of a unit of capital goods[4], μ_t, that is

$$\dot{K}_t = I_t - \delta K_t \tag{20}$$

$$\dot{\mu}_t = (r+\delta)\mu_t - \tilde{\pi}_K \tag{21}$$

where $\tilde{\pi}_K$ is the marginal product of capital. For a while, assume that $I_t^* > 0$ and $\mu_t = q_t^I$, then (21) becomes identical to

$$\tilde{\pi}_K = (r+\delta)q_t^I - \dot{q}_t^I \tag{22}$$

or

$$\tilde{\pi}_K = q_t^I\left[(r+\delta) - \hat{q}_t^I\right] \tag{22a}$$

where $\hat{q}_t^I = \dot{q}_t^I / q_t^I$. From the discussion in chapter 1, the right-hand side of (22a) can be called the "implicit rental cost of capital"[5] and denoted by c_t. Hence

$$\tilde{\pi}_K = c_t \tag{23}$$

Therefore, proposition 1 holds. This rule is merely the myopic decision rule that has been discussed in Chapter 2. The optimal capital accumulation on a free interval is determined by the myopic rule which is independent of the future values of the price of capital goods, interest rate, and technology.

Consider now the optimal investment decision of the firm over a time interval (t_0, t_1). From condition (18), let $\beta_t = \mu_t - q_t^I$; i.e. the net expected marginal benefits from a unit capital investment. Provided that t_0 and t_1 are both located on a free interval, the net expected marginal benefit from a unit capital investment at t_0 and t_1 will be zero from proposition 1; that is $\beta(t_0) = \beta(t_1) = 0$.

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[4] The technical derivation of a similar problem has extensively been discussed in the previous chapter

[5] The user cost of capital and the rental cost of capital are two terms that have generally been used to describe c_t in the literature.

In relation to proposition 2, three possible cases are to be considered here; (a) the firm is assumed to be initially at t_0 and gives up some capital stock at t_1, (b) the case where the firm installs a unit capital good at t_0 and wishes to disinvest at t on a blocked interval, and finally (c) the firm which is initially at t on the blocked interval, invests and wishes to sell capital goods at t_1 on the free interval.

(a) The optimal capital accumulation rule for an interval of time (t_0, t_1), where $\beta(t_0)=\beta(t_1)=0$. According to condition (19), the optimal investment policy is that $I_t^*=0$. To see the optimal capital accumulation rule, using (21), define the following

$$\dot{\beta}_t=(r+\delta)\beta_t-\tilde{\pi}_K+q_t'(r+\delta-\hat{q}_t') \tag{24}$$

or

$$\dot{\beta}_t=(r+\delta)\beta_t+(c_t-\tilde{\pi}_K) \tag{25}$$

The change in the value of the net marginal benefit of a unit of capital goods instalment is given by the integral of (25) over the period (t_0, t_1);

$$\int_{t_0}^{t_1}\dot{\beta}_\tau d\tau=\beta(t_1)-\beta(t_0)=\int_{t_0}^{t_1}\exp[-(r+\delta)(s-\tau)](c_\tau-\tilde{\pi}_K(\tau))d\tau=0 \tag{26}$$

where $\beta(t_0)=\beta(t_1)=0$. So it is also true that

$$\int_{t_0}^{t_1}e^{-\sigma t}(c_t-\tilde{\pi}_K(t))dt=0 \tag{27}$$

where $\sigma=(r+\delta)$. Therefore proposition 2a holds over an interval (t_0, t_1).

(b) Now consider the optimal capital accumulation rule for the interval (t_0, t) beginning at t_0 on a free interval ($\beta(t_0)=0$) and ending at t on the blocked interval. Needless to say that at any point on the entire blocked interval $t_0<t<t_1$, $\beta(t)=\mu_t-q_t'<0$ according to condition (19). Using (25), the following can be defined over the interval (t_0, t),

$$\beta(t)-\beta(t_0)=\int_{t_0}^{t}\exp[-(r+\delta)(s-\tau)](c_\tau-\tilde{\pi}_K(\tau))d\tau<0 \tag{28}$$

where $\beta(t)<0$, and $\beta(t_0)=0$ due to the assumption that t_0 is on the free interval and so $\mu(t_0)=q'(t_0)$. Hence

$$\beta(t)=\int_{t_0}^{t}\exp[-\sigma(s-\tau)](c_\tau-\tilde{\pi}_K(\tau))d\tau<0 \tag{29}$$

where $\sigma=(r+\delta)$. It follows that

$$\int_{t_0}^{t} e^{-\sigma(s-\tau)} c_\tau d\tau < \int_{t_0}^{t} e^{-\sigma(s-\tau)} \tilde{\pi}_K d\tau \tag{30}$$

The left-hand side of (23) stands for the term that describes the expected present value of implicit rental cost of a unit capital good over the time interval (t_0, t). The right-hand side is the expected marginal product from this capital instalment over the same time period.

According to (30), if renting a capital good was an option together with purchasing, then the firm would prefer to rent because its discounted marginal benefit from that capital good is higher than its marginal discounted rental cost. However, since renting is, in fact, not allowed in the model, the firm must take into consideration the purchasing criterion. According to the condition in (19), the purchasing criterion over a block interval (such as the one starting at t_0 on a free interval and ending at t on the blocked interval) implies that the shadow price of a capital good is less than its purchasing price (i.e. $\mu_t < q_t^I$). For the firm whose investment (or disinvestment) is constrained by a zero lower constraint, this means not to invest over this blocked interval (i.e. $I_t^* = 0$). Therefore, proposition 2b also holds.

(c) Consider the optimal capital accumulation rule for an interval of time starting at t on the blocked interval and ending at t_1 on a free interval where $\beta(t) < 0$, $\beta(t_1) = 0$ respectively. Given the condition in (19), $\dot{\beta}(t)$ in (25) becomes identical to the following condition,

$$\beta(t_1) - \beta(t) = \int_t^{t_1} \exp[-(r+\delta)(s-\tau)](c_\tau - \tilde{\pi}_K(\tau))d\tau < 0 \tag{31}$$

then

$$\int_t^{t_1} e^{-\sigma t}(c_t - \tilde{\pi}_K(t))dt > 0 \tag{32}$$

since $\beta(t_1) = 0$ and $-\beta(t) < 0$. (32) implies that the discounted marginal rental cost of a capital good is higher than its discounted marginal benefit. Therefore the firm would not wish to rent beginning at any point in the blocked interval and ending at t_1. However, since the optimal investment strategy is given by the purchasing criterion $\mu_t < q_t^I$, the firm does not invest at all. This completes the proof of proposition 2.

In Figure 3.1, the optimal capital adjustment process is illustrated. For this purpose, assume that the capital stock changes according to a monotonically increasing function. Over a free interval on which the optimal investment is finite, and positive ($I^* > 0$), the firm is able to increase its capital stock. At point A, assume that having

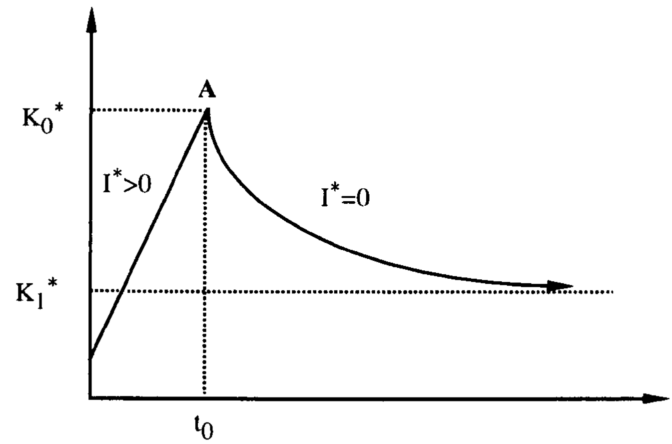

Figure 3.1

reached K_0^*, the firm wishes to disinvest for some reasons (e.g. because of an increase in the interest rate), and adjust its optimal capital stock to a new level, K_1^*. However, because of the binding irreversibility constraint becoming effective after t_0, the firm is unable to disinvest. Instead, it invests nothing, and waits until the excess capital stock depreciates by a constant rate. Therefore, after point A, the capital stock approaches to the new level by geometrically declining.

So far, the presence of any financial constraints that may bind investment expenditure of a firm above has been ignored. As mentioned earlier in this chapter, the effects of a financial constraint on the optimal capital accumulation are closely related to the choice of a specification of such a constraint. In this regard, two different specifications have been adopted here. The first one assumes that investment at any moment of time is limited by the firm's current profits [Appelbaum and Harris (1978)]. The second one introduces the stock of accumulated retained earnings as a financial constraint [Schworm (1980)].

3.1.2. Current Profits as a Financial Constraint

In this section, the optimal capital policy of the firm with an upper investment constraint is examined under the assumption that self-financing is the marginal source of finance. The upper bound is such that the amount of investment made by the firm is limited by current profits. Such constraints may arise from a number of capital market imperfections. Particularly, in the case of the absence of a capital market on which the firm can borrow, the firm must rely on its internally generated funds to finance its investment. As explained earlier in the introduction of this chapter, non-price credit rationing also leads the firm to finance its investment through internally generated funds (profits in this section by assumption) mainly due to asymmetric information and agency problem. Capital market imperfection as such are not at all unusual in practice.

Appelbaum and Harris (1978) examined capital accumulation under the assumption that investment is financed by current profits at the margin. In their model, the financial constraint is a consequence of a number of assumptions, i.) no borrowing is possible, ii.) no retained earnings are held (i.e. all cash flow must be distributed to shareholders). During bounded intervals in which the firm is constrained, the general expectation is that the firm with bounded investment plans has a lower capital stock relative to a firm which is not constrained by such a constraint. As noted in Chapter 2, this is also the case with a permanently binding upper constraint on investment. The main conclusion of their model, however, differs from this expectation. Due to the intertemporal nature of the model, the firm anticipates future profit constraints, and increases its investment over some interval in order to increase future profits. By increasing the capital stock over some intervals, the firm will then be able to generate more profits and also to decrease the demand for capital in the future. Therefore, this behaviour of the firm reduces the stringency of future financial constraints [for a similar result also see Blanchard and Sarch (1982) and Precious (1987)].

Appelbaum and Harris (1978) analysed the optimal capital policy of a constrained firm by comparing it with that of a reference firm which is not constrained, but is identical in all other respects. For this, they examined the discounted marginal present values of an additional unit of capital services of each firm over a certain time interval. They defined a time interval starting on a free interval at t_0 and ending on the bounded interval at $t>t_0$. They proved that during such a bounded interval (t_0, t), the constrained firm expects more marginal contribution from a unit capital service than the unconstrained does. Despite the fact that one might expect the constrained firm to assign more marginal value from an additional capital service, according to the counter intuitive results of Appelbaum and Harris, the constrained firm increases the capital stock to its limit, before it enters the bounded interval, in order to ensure that it is not constrained in the future. This is because more investment (and accumulating more capital) today would mean a higher profit level in the future due to the intertemporal nature of the decision. Therefore, excess capital stock today would also increase profits in the future, relaxing the stringency of the future profit constraint. In addition to Arrow (1968)'s propositions, Appelbaum and Harris (1978), then, formulate the following proposition.[6]

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[6] This proposition holds only if the constrained firm starts from a free interval, and has a change to accumulate excess capital stock. If the firm starts the optimal policy with capital deficiency, then it

Proposition 3: *Over an time interval (t_0, t_1) in which the upper constraint on investment is effective, excluding intervals beginning at t_0=0, but including intervals which may or may not end in finite time, the marginal value of a unit of capital services for use in any sub-period $[t_0,t]\subset[t_0,t_1]$ is less for the constrained firm in the imperfect capital market than for the unconstrained counterpart in the perfect capital market. Therefore, in some sub-period $[t_0,t]\subset[t_0,t_1]$, the former possesses more capital stock then the latter.*

Proof: The optimal strategy is given by the solution of the maximisation of the cash flow problem in the previous section. However, the problem can be extended by noting that investment expenditure cannot be higher than the firm's *current* level of profits, that is

$$q_t^I I_t \le \tilde{\pi}(K_t,t) \tag{33}$$

With this additional constraint, the solution can be derived from the optimisation of the following extended Lagrangean function,

$$L_t = \left[\tilde{\pi}(K_t,t) - q_t^I I_t\right] + \mu_t(I_t - \delta K_t) + \lambda_t q_t^I I_t + \eta_t\left[\tilde{\pi}(K_t,t) - q_t^I I_t\right] \tag{34}$$

where η_t: the Lagrange multiplier associated with the profit constraint (33) (η_t≥0). The Kuhn-Tucker necessary condition for the optimal investment policy can, then, be re-written as

$$\left(\frac{\partial L_t}{\partial I_t}\right) \le 0, \qquad I_t^* \ge 0, \qquad I_t^*\left[\mu_t + q_t^I(\lambda_t - 1) - \eta_t\right] = 0, \tag{35}$$

In addition to conditions (18) and (19) in the previous section, a new condition associated with the profit constraint can be written as follows[7]

(iii) if $q_t^I I_t^* = \tilde{\pi}(K_t,t)$ $(\Rightarrow \eta_t > 0 \text{ and } \lambda_t = 0)$, then $\mu_t > q_t^I$ (36)

The dynamics of the model are given by the similar equations as before

$$\dot{K}_t = I_t - \delta K_t \tag{10}$$

$$\dot{\beta}_t = (r+\delta)\beta_t + \left[c_t - \tilde{\pi}_K(K_t,t)\right] - \eta_t \tilde{\pi}_K(K_t,t) \tag{37}$$

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never accumulates excess capital stock. In the case where the optimal policy starting at t_0 requires an initial jump into the bounded interval, the result would be similar to capital deficiency.

[7] Note that the irreversibility constraint is not binding, therefore the Lagrange multiplier associated with that constraint, λ_t, will be zero.

where $\beta_t = \mu_t - q_t^I$, and $c_t = q_t^I(r + \delta - \hat{q}_t^I)$, $\hat{q}_t^I = \dot{q}_t^I / q_t^I$. Note that $\beta_t > 0$ at any moment of time t on the bounded interval from (36). Because μ_t is a continuous function of time, β_t will also be a continuous function of time for t >0.

Assume now that the firm starts to be constrained over an interval (t_0, t_1), being t_0 and t_1 on a free interval (so that $\beta(t_0) = \beta(t_1) = 0$). Over an interval $[t_0, t] \subset [t_0, t_1]$ where $\beta(t) > 0$, changes in the value of the net marginal benefits from a unit of capital services is given by the integral of (37),

$$\int_{t_0}^{t} \dot{\beta}_t d\tau = \beta(t) - \beta(t_0) = \int_{t_0}^{t} \exp[-(r+\delta)(s-\tau)]\{[c_\tau - \tilde{\pi}_K(K_\tau, \tau)] - \eta_\tau \tilde{\pi}_K(K_\tau, \tau)\} d\tau \geq 0 \qquad (38)$$

for $\forall t \in (t_0, t_1)$, with equality if $t = t_1$. Remember that $\beta(t_1) = 0$ because t_1 is on the free interval, and $\beta(t)$ is strictly positive because t is on the bounded interval. Using (36), we can also write

$$\int_{t_0}^{t} \exp[-\sigma(s-\tau)][c_\tau - \tilde{\pi}_K(K_\tau, \tau)] d\tau \geq \int_{t_0}^{t} \exp[-\sigma(s-\tau)] \eta_\tau \tilde{\pi}_K(K_\tau, \tau) d\tau \qquad (39)$$

where $(r+\delta)$. Since it is already known from the Kuhn-Tucker condition (36) that $\eta_t > 0$,the following is also true

$$\int_{t_0}^{t} \exp[-\sigma(s-\tau)][c_\tau - \tilde{\pi}_K(K_\tau, \tau)] d\tau \geq \int_{t_0}^{t} \exp[-\sigma(s-\tau)] \eta_\tau \tilde{\pi}_K(K_\tau, \tau) d\tau > 0 \quad (40)$$

for all t, $t_0 < t < t_1$.

Let $s(K_t, t) = \tilde{\pi}_K(K_t, t)$ where $s(K_t, t)$ is the efficiency price of capital services. Using proposition 1 in the previous section, we can write that $c_t = s^u(K_t^u, t)$ where $s^u(\bullet)$ is the efficiency price of a unit of capital services for the unconstrained firm. The same can also be written for the bounded case, $s^c(K_t^c, t) = \tilde{\pi}_t(K_t^c, t)$ where $s^c(\bullet)$ is the efficiency price of a unit capital service for the constrained firm Hence (40) becomes identical to

$$\int_{t_0}^{t} \exp[-\sigma(s-\tau)](s^u(\tau) - s^c(\tau)) d\tau > 0 \qquad (41)$$

for $\forall t \in (t_0, t_1)$. So

$$\int_{t_0}^{t} \exp[-\sigma(s-\tau)] s^u(\tau) d\tau > \int_{t_0}^{t} \exp[-\sigma(s-\tau)] s^c(\tau) d\tau \qquad (42)$$

The left-hand side of (42) corresponds to the marginal value of an additional unit of capital services expected by the unconstrained firm. The term on the right-hand side of

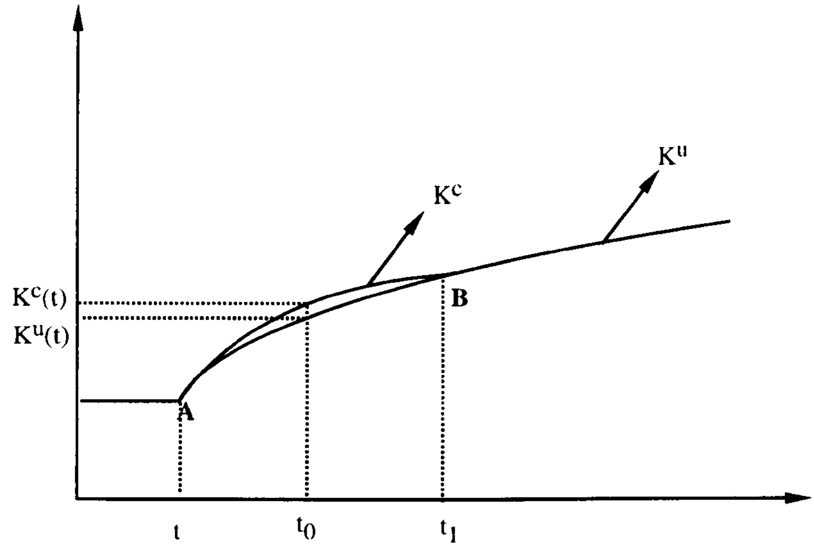

Figure 3.2

inequality (42) is the marginal value of a unit capital expected by the constrained firm. According to (42), the unconstrained firm expects more marginal benefits from a unit capital than its constrained counterpart does over some certain intervals over some time interval between (t_0, t_1). Given the diminishing marginal profitability assumption, if the constrained firm relatively expects a lower marginal value of a unit capital good than that of the unconstrained firm in the future, then it means that the constrained firm has more capital stock today, so that the instalment of a capital good in the future would add less marginal value to the firm's total value. Therefore, bounded intervals which start at $t_0>0$ (t_0 is on a free interval) are intervals characterised by "capital excess". Let K^u and K^c be the levels of capital stock of the unconstrained and constrained firm respectively, then $K^u < K^c$ over bounded intervals for at least some $t \in (t_0, t_1)$. Hence, proposition 3 holds.

Figure 3.2 illustrates the adjustment paths of both the constrained and the unconstrained firm after, say, a decline in the rate of interest. As a result, both firms wish to accumulate capital stock starting at point A. As the unconstrained firm continues to follow its unconstrained path of adjustment K^u, the constrained one foresees the upper constraint which is going to be effective on it over a time interval (t_0, t_1). Therefore it accumulates excess capital stock (compared to its unconstrained counterpart) over the period between $\hat{t}$ and t_0 in order to reduce the stringency of the future constraint, and enters the bounded interval (t_0, t_1) with excess capital stock ($K^u < K^c$ at t_0). Then at the end of the period (at point B), the constrained firm may return to its unconstrained adjustment path. In this example, the implicit assumption is that the firm is able to accumulate sufficient excess capital stock not to face any capital deficiency at any time over the bounded interval.

3.1.3. Retained Earnings as a Financial Constraint

Relaxing the assumption that all cash flows must be distributed to shareholders as made in Appelbaum and Harris (1978), Schworm (1980) assumed that firms can always retain current earnings to finance the optimal capital accumulation in the future. In his model, there are two ways of transferring current funds into the future. The firm can either purchase capital or accumulate retained earnings. The allocation of financial funds between purchasing capital and retained earnings depends on their relative rate of returns to the firm. If the rate of return on purchasing capital is higher than or equal to the rate of return on accumulating retained earnings, then the firm always purchases capital goods.

A representative firm in Schworm's model can either retain earnings or distribute them to shareholders. Investment decisions are made subject to the financial constraint imposed by the stock of accumulated retained earnings, E_t. He analysed the dynamic effects of a binding temporary financial constraint over some intervals, and added a new state variable, E_t , to Appelbaum and Harris's model. The accumulation of retained earnings was modelled by the following differential equation,

$$\dot{E}_t = r_t E_t + \left[\tilde{\pi}(K_t, t) - q_t^I I_t\right] \tag{43}$$

The addition to accumulated retained earnings at any moment of time is the current interest rate earned on the already exist stock of retained earnings plus the cash flow in the current period. By assumption, the inability of borrowing implies that the investment path is constrained by the availability of accumulated retained earnings. The upper bound on investment in Schworm's model is imposed on the firm by

$$E_t \geq 0. \tag{44}$$

This inequality constraint implies that as long as internal funds available for investment are sufficient, the firm follows the optimal investment path of a unconstrained firm. Once these funds are exhausted, the firm starts to spend all current profits to finance its investment for some bounded interval, so that $E_t = \dot{E}_t = 0$. This implies the following

$$q_t^I I_t \leq \tilde{\pi}(K_t, t), \text{ with equality if } E_t = 0 \tag{45}$$

He proved that unlike Appealbaum and Harris, the marginal value of a unit addition of capital services firm is not less for a constraint than for a unconstrained firm. This implies that the capital stock of the constrained firm is not greater than that of the unconstrained firm (i.e. the constrained firm does not have capital excess). The reason for such a counter intuitive result is that the retained earnings constraint has no anticipatory effect on capital accumulation as in Appelbaum and Harris (1978). In Schworm's model, the anticipation of a financial constraint in the future induces the firm only to accumulate retained earnings, and to reduce current investment in order to postpone the exhaustion of internal funds in the future. This argument, however, ignores the fact that current investment increases the funds available in the future by increasing future profits.

3.2. Capital Market Imperfections in the Form of Increasing Cost of Borrowing

In this section, I specify capital market imperfections by a rising convex cost function of borrowing. By such a function, it is assumed that lenders charge a default risk premium over the risk-free interest rate due to agency problems arising from asymmetric information in imperfect capital markets. I also assume that there is no quantitative constraint imposed on the firm's optimal investment path as was the case in the previous section.

Two separate modifications of Jorgenson cash flow maximisation problem are accommodated in this section. The first one is that the cost of borrowing, z, is assumed to be an increasing function of the debt-equity ratio, y, of the firm. In this respect, the proposed model below is an extension of Steigum (1983) in which the firm maximises the entrepreneur's intertemporal utility, but not the discounted future cash flows. The second modification is the inclusion of borrowing into the model by proposing an additional stock accumulation equation, together with capital stock adjustment equation (19) in Chapter 2. The specifications of this new debt-stock accumulation equation is in line with Dailami (1992), (1990) and Sundararajan (1985).

The Model

Assume a representative firm which invests in physical capital (K) without capital adjustment costs, borrows or holds financial assets. I assume that the firm is not strictly bounded by any quantitative constraint on investment, but the cost of borrowing, z, is a rising function of the debt-equity ratio, y, for all y greater than some numbers $\bar{y} \geq 0$. For $y \leq \bar{y}$, z is a positive constant, i (the riskless interest rate). More formally, the cost of borrowing function can be written as

$$z(y)=\begin{cases} i & for -1<y<\bar{y} \\ i+\Gamma(y-\bar{y})\, for & y>\bar{y} \end{cases} \tag{46}$$

where $y=B/E$, and $E=q'K-B$ [see Steigum (1983)]. Following Steigum (1983), I assume that the function $\Gamma(y-\bar{y})$ is an strictly increasing convex function; i.e. $\Gamma'(\cdot)>0$, and $\Gamma''(\cdot)>0$ [for a similar specification of the cost of borrowing function, see Hochman *et al.* (1973)]. The convexity of the function with respect to debt stock, B, provides an increasing risk premium at the margin due to agency problems. The total cost of borrowing for the value of the outstanding debt stock is $z(y)B$. The marginal cost of borrowing, $m(y)$, is then given by

$$m(y)=\frac{\partial[z(B/E)]B}{\partial B}=z(y)+yz'(y) \tag{47}$$

Its derivative for all $y\neq\bar{y}$ is then

$$m'(y)=2z'(y)+yz''(y) \tag{48}$$

and zero for $y<\bar{y}$. $z(y)$ is also a decreasing function of the capital stock; i.e. $\partial\{z[B/(q'K-B)]\}B/\partial K=-q'y^2z'(y)$.

So far, the model has closely followed Steigum (1983). I now introduce the debt stock accumulation equation borrowed from Dailami (1992), (1990) and Sundararajan (1985).

$$\dot{B}_t=b_t-\gamma B_t \tag{49}$$

where b_t is the amount of borrowing for each t, γ being the constant amortisation rate on the outstanding debt stock. The cash flow equation (13) in Chapter 2 can then be modified by allowing for borrowing as follows.

$$V_t=pQ_t-wL_t-q'I_t-z(y)B_t+\dot{B}_t \tag{50}$$

Substituting (49) into (50) yields

$$V_t=pQ_t-wL_t-q'I_t-z(y)B_t+b_t-\gamma B_t \tag{50a}$$

The aim of the firm is, as before, to maximise (50a) subject to the capital account identity and the debt stock accumulation equation (49); that is

$$\left.\begin{array}{ll} \text{Maximise} & \int_0^{\infty} \exp(-rt)V_t dt \\ \text{subject to} & \\ \text{(i)} & \dot{K}_t = I_t - \delta K_t \\ \text{(ii)} & \dot{B}_t = b_t - \gamma B_t \end{array}\right\} \quad (51)$$

K_0, B_0 are given

In (51), in addition to investment, the amount of borrowing, b_t, is also a control variable. To solve the optimisation problem (51), write the following current value Hamiltonian function

$$H_t = \left[pQ_t - wL_t - q'I_t - z(y)B_t + b_t - \gamma B_t\right] + \mu_t(I_t - \delta K_t) + \eta_t(b_t - \gamma B_t) \quad (52)$$

where μ_t and η_t are co-state variables associated with K_t and B_t respectively. The following conditions are necessary for an optimum

$$pF_L = w \quad (53)$$

$$0 = \partial H/\partial I \quad \Rightarrow \quad \mu_t = q' \quad (54)$$

$$0 = \partial H/\partial B \quad \Rightarrow \quad \eta_t = -1 \quad (55)$$

$$\dot{\mu}_t = (r+\delta)\mu_t - pF_K - q'y^2 z'(y) \quad (56)$$

$$\dot{\eta}_t = (r+\gamma)\eta_t + m(y) + \gamma \quad (57)$$

Unlike the model in Chapter 2, the present model yields two different equilibrium conditions for the firm. The first one is for the financial market from which the firm borrows. Substituting (55) in (57) gives the decision rule for borrowing for the firm, that is

$$m(y) = r \quad (58)$$

(58) implies that the firm borrows from imperfect capital markets until its marginal cost of borrowing becomes equal to the *constant* discount rate. This also indicates an instantaneous adjustment of the firm's optimal debt stock to any exogenous change in the discount rate. From the optimality condition (58), the firm is able to determine the optimal debt-equity ratio, y^*. Using the identity $q'K = B + E$, and letting k^* be the optimal debt-capital ratio, (58) also yields a constant debt-capital ratio since

$k^* = y^*/(1+y^*)$. Given these optimal levels of the debt-equity and the debt-capital ratios, the firm, then, determines the optimal capital stock corresponding to these ratios. This is given by the second equilibrium condition in capital goods market from (56), that is

$$pF_K = q'\left[(r+\delta) - y^2 z'(y)\right] \tag{59}$$

(59) is basically the similar optimality condition for the capital stock in Jorgenson's model, except the user cost of capital on the right-hand side including an additional term $y^2 z'(y)$. If the cost of borrowing is a given constant (i.e. $z'(y)=0$) as in the model in Chapter 2, the optimality condition reduces to the myopic rule of Jorgenson's model in equilibrium. According to (59), an increase in the marginal return on capital increases the demand for the capital stock. Because of the interdependence of financing decisions and investment decisions, the firm must finance this increase in the capital stock in a way that the optimal debt-equity ratio, which is determined according to the equilibrium condition in the financial capital market, remains constant (i.e. debt and equity must increase equally).

Many studies for developing countries have incorporated financial variables into private investment models. Following Coen (1971), Sundararajan and Thakur (1980), Tun Wai and Wong (1982), Blejer and Kahn (1984) and Sundararajan (1985), for example, assumed that the availability of finance for investment influences the adjustment process of the capital stock through the adjustment coefficient of the partial adjustment mechanism. To see this effect theoretically, I now accommodate assumption (5') in Section 6.1 of Chapter 2 regarding the presence of strictly convex adjustment costs. The set up of the model is the same as before, but only the optimality condition (54) differs in the following way,

$$\mu_t = C'(I_t) \tag{54'}$$

As it is usually the case in the adjustment cost model, (54') implies that investment is an increasing function of the shadow value of the capital stock, assuming that C'(.) is an invertable function. As explained in Chapter 2, μ indicates the marginal benefit from a unit of installed capital stock which declines as the rate of investment increases. Its explicit definition with the presence of a rising cost of borrowing can then be obtained from (56) as

$$\mu_t = \int_0^\infty \exp[-(r+\delta)(s-t)]\left[pF_K + q'y^2 z'(y)\right]ds \tag{60}$$

According to (60), the value of the shadow price of capital comprises two components in the presence of a rising cost of borrowing. The first one is the present value of marginal productivity of a unit capital over its life period. The increase in the capital stock also contributes to the value of μ through the cost of borrowing, the second component of (6). Given $\partial\{z[B/(q'K-B)]\}B/\partial K=-q'y^2z'(y)$, an increase in the capital stock will also decrease the marginal cost of borrowing, and increase the value of μ by $q'y^2z'(y)$.

Two different differential equations give the dynamics of the system, namely equation (51-i) and (56). The linearised form of this system can be obtained around the steady-state values of μ and K as follows

$$\dot{K}_t = C'^{-1}(\mu_t)(\mu_t-\mu_t^*)-\delta(K_t-K_t^*) \tag{61}$$

$$\dot{\mu}_t=(r+\delta)(\mu_t-\mu_t^*)-[pF_{KK}+2yy_K m'(y)](K_t-K_t^*) \tag{62}$$

In a matrix form,

$$\begin{bmatrix}\dot{K}_t\\ \dot{\mu}_t\end{bmatrix}=\begin{bmatrix}-\delta & C''^{-1}(\mu_t)\\ -[pF_{KK}+2yy_K m'(y)] & (r+\delta)\end{bmatrix}\begin{bmatrix}K_t-K_t^*\\ \mu_t-\mu_t^*\end{bmatrix} \tag{63}$$

The characteristic roots of this system are real and opposite in sign, and the solution gives a saddle point. The stability of the system is provided only by the negative root. As shown in chapter 2 , this negative root is also the adjustment coefficient of the partial adjustment mechanism that governs the movement of capital towards its desired level. The speed of adjustment can be given by this negative root from the solution of the system of two differential equations in (63); that is

$$\theta=-(1/2)\left\{r-\sqrt{(r+2\delta)^2-4[pF_{KK}+2yy_K m'(y)]/C''^{-1}(I_t^*)}\right\} \tag{64}$$

With the definition of the adjustment coefficient in (64), the speed of adjustment becomes an endogenous choice variable as indicated in Sundararajan and Thakur (1980) and Blejer and Khan (1984). Its value, however, is determined by the properties of both the production function and financial capital markets. If the production function exhibits constant returns to scale, and financial capital markets are perfect (i.e. $m'=0$), then the adjustment coefficient θ becomes equal to the constant rate of depreciation δ as in Gould (1968). The same result can be derived with both the constant returns to scale and constant debt-equity ($y_K=0$) assumption.

The general conclusion from this section is that once we include borrowing and assume that the cost of borrowing is an increasing function of the debt-equity ratio, financial and investment decisions become interrelated. In connection with a number of studies for developing countries, the nature of capital markets in these countries influences the adjustment path of the capital stock. The firm's optimal strategy needs to satisfy two equilibrium conditions simultaneously. First, the firm in the financial market attains the equilibrium at the point where the marginal cost of borrowing equals the constant discount rate. This equilibrium condition determines the firm's optimal debt-equity composition to finance investment expenditure obtained from the second equilibrium condition in the capital goods market.

4. Keynesian Theory of Investment and Financial Factors

In his influential book in which he sets forth the main elements of investment theory, Keynes differs from his neoclassical counterparts in two respects [Keynes (1936): 136-146]. First, and most importantly, Keynes emphasises the potential role of the behaviour of the capital-good-producer industry that is largely ignored in Jorgenson's version of the neoclassical theory of investment. Second, Keynes recognises the significant role of financial factors in investment decisions. Analysing the Keynesian theory of investment is also important because one of the major competitors to Jorgenson's investment theory, namely Tobin's q theory, finds its origin in the *General Theory*.

The main components of the Keynesian theory of investment are explained in Chapter 11 of the *General Theory*. In this chapter, Keynes referred to the investment function as the marginal efficiency of capital (*m.e.c.*) schedule. The *mec* is the rate of return by which all future expected benefits from a unit capital good during its economic life are discounted. Keynes suggested a negative relationship between the marginal efficiency of a particular type of capital and the investment in that capital good, and notified two reasons to justify it. First, the prospective yield from an additional capital good diminishes as the capital stock expands. Second, an increase in demand for capital goods would create excess demand pressure on the supply of such capital goods and cause its supply price to rise. In some respects, this is a relaxation of Jorgenson's perfect market assumption for the capital good market in the sense that the instantaneous adjustment of the capital good demanding firm disappears because the manufacturers of capital goods are only able to adjust their supplies to changes in demand conditions gradually, not instantaneously. To induce the capital-good-producing firms to adjust their capacity to the new demand conditions, the supply price of capital goods must rise. By supply price of capital, Keynes defined "... *not the* *market price at which an asset of the type in question can actually be purchased in the market, but the price which would just induce a manufacturer newly to produce an additional unit of such asset, i.e. what is sometimes called its replacement costs."* [Keynes (1936): 135].

The first justification of the negative relationship is closely related to the concept of the demand for the optimal capital stock in Jorgenson's model. As explained earlier in Chapter 2, the demand for an additional capital stock of a firm is determined according to the expected marginal benefits from that additional capital good discounted by the rate of interest. In the Keynesian tradition, this is called "the demand price of capital", which has been named as the shadow price of capital in the previous chapter. Following the derivation of the shadow price of capital in Chapter 2, the demand price of the same capital good can be written as follows.

$$q^d = \int_0^T \exp(-rt)\pi_K^e dt \qquad (65)$$

where q^d: the demand price of a unit capital good, T: the economic life of unit capital good, π_K^e: the expected marginal profit from a unit capital which is a function of a neoclassical production function and the price of output; i.e. $\pi_K^e = pF_K$. Since the production function is concave in K, the expected profit from an additional capital good diminishes as the capital stock increases [see Mussa (1977), Abel (1980), Precious (1987), and Chirinko (1993)]. Any fall in the rate of interest would increase the expected marginal profit from a unit capital good, and induce the firm to increase its capital stock. In Jorgenson's model, the adjustment would be instantaneous without any bound on the amount of investment. However, in the Keynesian model, the supply-side condition enters the model to determine the speed of the gradual capital adjustment because the capital-good supplying firms require an increase in the supply price of capital goods to produce more capital goods to meet each extra demand for capital goods in the market. Therefore, the capital good demanding firm adjusts its capital stock to new levels by demanding at a decreasing rate because a larger amount of demand for capital requires a higher rise in the supply price of capital goods to induce the manufacturers of those goods to supply.

The question of the capital demanding firm is at which rate it should invest for each t over the adjustment period. In the Keynesian model, this is determined by another equilibrium condition in the capital good market. From the capital good demanding firm's point of view, the total marginal present value of a capital good

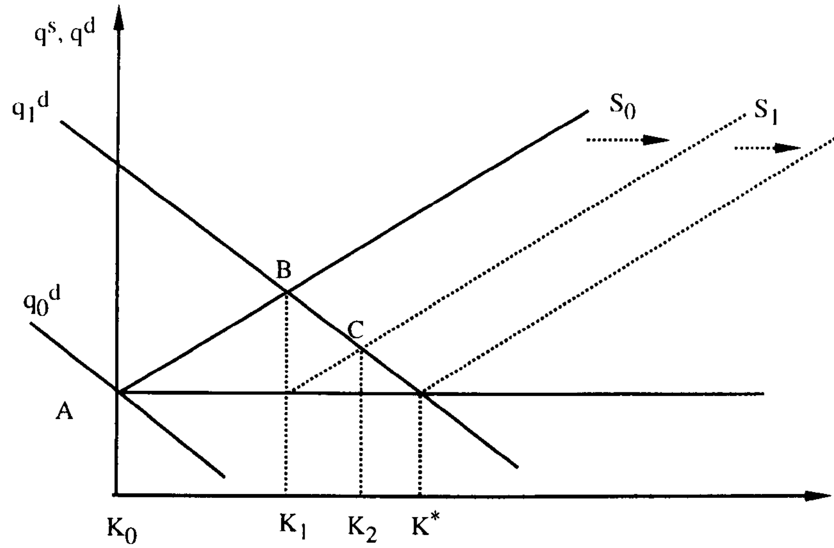

Figure 3.3

discounted by the marginal efficiency of capital must be equal to its supply price. To be more precise, let q^s be the supply price of capital. Then the second equilibrium condition is given in the Keynesian model as follows.

$$\int_0^T \exp(-mt)\pi_K^e dt = q^s \tag{66}$$

where m: the marginal efficiency of capital. The firm which wishes to expand its capital stock continues to invest until the equilibrium condition in (66) hold. Keynes indicates that "*...the actual rate of current investment will be pushed to the point where there is no longer any class of capital-asset of which the marginal efficiency exceeds the current rate of interest. In other words, the rate of investment will be pushed to the point on the investment demand-schedule where the marginal efficiency of capital in general is equal to the market rate of interest.*" [Keynes (1936): 136]. This implies that the demand and supply prices of capital goods must be equal in equilibrium,

$$q^d = q^s \qquad \Rightarrow \qquad m = r \text{ where } I = 0$$

The gradual adjustment of the capital stock in the Keynesian model can be seen in Figure 3.3 which is borrowed from Precious (1987). Now assume that a firm in equilibrium faces a fall in the rate of interest. The immediate effects of such a fall on the demand price of capital in (65) cause an increase in the marginal profits from a unit capital good discounted by the rate of interest. So the firm realises a capital deficiency in the new situation, and wishes to expand its new level of the optimal capital stock K^*. In Figure 3.3, the demand price of capital is drawn with a declining slope because of the diminishing returns to scale assumption of the production function. The supply curve of capital goods is, on the other hand, upward-sloping because a rise in the supply price of capital goods increases the supply of these goods. In Jorgenson's perfect capital goods market assumption provides this curve to be horizontal as seen in the figure. The fall in the interest rate is illustrated by an upward shift in q^d. In Jorgenson's model, such a decline induces the firm to adjust its capital stock to K^* instantaneously. With a rising supply curve, the firm first increases its capital stock to K_1 at B by investing (K_1-K_0). However, this increase in the capital stock has two different effects. First of all, it declines the marginal productivity of an additional capital good at the margin. Secondly, each addition to the capital stock also leads to a decline in the marginal efficiency of capital because of its negative relationship with the investment in that capital good. But eventually, excess demand for capital goods increases the supply price of capital goods, and induces the capital-good-producing industry to supply more, shifting the supply curve from S_0 to S_1. Then the firm reaches point C by investing (K_2-K_1). Then gradually the firm attains the new equilibrium level at a lower level of the rate of interest and the marginal efficiency of capital and at higher capital stock than the initial level.

In the light of this discussion, the marginal efficiency of capital can be regarded as a function of the rate of investment, the supply price of capital goods, and finally the expected level of demand in the output market, that is

$$m.e.c. = mec\left(I, q^s, Q^e\right) \tag{67}$$

where Q^e: the expected level of output. Q^e is the accelerator variable, and is included to take into account the effects of demand for output.

4.1. The Marginal Cost of Finance

The implicit assumption in the previous section was that the interest rate was the only cost factor in the model, and the marginal efficiency of capital schedule was infinitely elastic at the market rate of interest. According to this assumption, the firm can undertake all investment at a fixed rate regardless of its riskiness. In this respect, Keynes, however, mentioned two types of risk involving in investment decisions; borrower's risk which arises from the borrower's own risk perception about the investment project, and lender's risk which "... may be due either to moral hazard... or to the possible insufficiency of the marginal security." [Keynes (1936): 144]. Keynes defined the second type of risk as "... a pure addition to the cost of investment which would not exist if the borrower and lender were the same person." [Keynes (1936): 144]. By that he recognised the fact that there exists a differential between the cost of

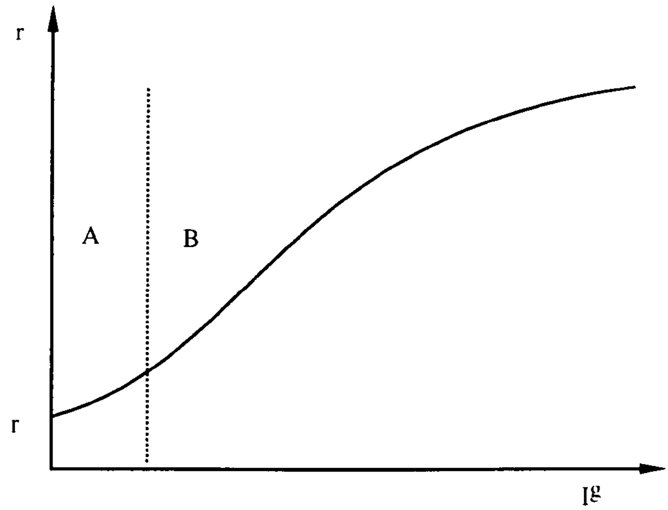

Figure 3.4

internal and external finance in contrast to the Modigliani and Miller proposition. The issue has recently drawn more attention in the Post Keynesian literature [Davidson (1993), Vickers (1987), and Fazzari and Mott (1986)], and led to many studies in this tradition that sought evidence in favour of finance constraints affecting investment decisions.

The argument of the marginal cost of financial funds was advanced by Duesenberry (1958) by taking into account four different sources of finance (depreciation allowances, retained earnings, borrowing, and equity issuing). The first two are taken as internal, and involve an opportunity cost to the firm. The last two sources are external, and their costs to the firm are represented as an increasing function of the balance sheet structure of assets and liabilities of the firm. The justification of the cost of external funds is similar to that in Section 3.2 where the interest rate cost to the firm is considered as an increasing function of the debt-equity ratio. The marginal cost of fund schedule is illustrated in Figure 3.4. The marginal cost of financial funds is perfectly elastic at a relatively lower interest rate (in region A). As the level of investment exhausts internal funds and requires an increasing amount of borrowing and equity financing, it then rises at first slowly and then steeply at higher levels of external funds (in region B). The more such external funds are used, the greater the deterioration in the balance sheet of the firm, and the higher their costs. The cost of external funds including a certain amount of risk premium depending on the balance sheet account are then involved in the monotonically increasing marginal cost of fund schedule. Therefore the marginal cost of fund schedule is written as a function of the availability of internal funds, the balance sheet structure of assets and liabilities (i.e. the debt-equity ratio), the current level of interest rates, and the rate of return to equity,

$$m.c.f. = mcf(I, F, y, v) \tag{68}$$

where F: the availability of internal funds, y: the debt-equity ratio as a measure of the balance sheet structure, v: the rate of return on equity.

Finally, we have a simultaneous-two-equation system, comprising equations (67) and (68), which can be solved for the rate of investment to obtain a single reduced form, such as

$$I = I(q^s, Q^r, F, r, y, v) \tag{69}$$

4.2. Keynes and Stock Market Prices

Keynes attached particular importance to the level of stock market prices as a determinant of investment because the stock exchange gives the market's judgement about commitments that an individual makes every day, and facilitates an opportunity to the individual to revise his investment decisions. In his best-known statement in General Theory, he noted that "*...the daily revelations of the Stock Exchange, though they are primarily made to facilitate transfers of old investments between one individual and another, inevitably exert a decisive influence on the rate of current investment. For there is no sense in building up a new enterprise at a cost greater than that at which a similar existing enterprise can be purchased; whilst there is an inducement to spend on a new project what may seem an extravagant sum, if it can be floated off on the Stock Exchange at an immediate profit.*" [Keynes (1936): 151]. According to this, when stock prices are low, a potential investor finds it cheaper to acquire capital assets by purchasing control of existing firms rather than by ordering new capital assets to be produced. If the stock prices are high, it may be cheaper to invest directly in the new capital assets. By that, Keynes noted that "*...certain class of investment are governed by the average expectation of those who deal on the Stock Exchange...*" [Keynes (1936): 151]. James Tobin picked up this idea about the importance of stock market price, and developed a new theory that makes the aggregate investment depend on the so-called Tobin-q, a ratio of the aggregate market value of the outstanding equities plus bonds to the replacement cost of the aggregate stock of capital assets [see Tobin (1969)]. This is a very crucial variable connecting real investment decisions to financial sectors of the economy.

5. Tobin's q Theory of Investment

According to Hall (1977), the major competitor to Jorgenson's theoretical framework for investment has been Tobin's q theory of investment. The popularity of Tobin's q model is particularly related to the fact that it allows for the investigation of the interaction between real investment and financial decisions. The idea is that the rate of investment is an increasing function of q, a ratio of the market value of the existing capital stock to its replacement cost [Brainard and Tobin (1968), Tobin (1969)]. Theory argues that q will be unity when the market value and the reproducing cost of capital assets are equal. If q is higher than unity (i.e. the market value is higher than the replacement cost), then there will be an incentive for firms to invest, *vice versa*. For Tobin's q is the variable providing the connection between real and financial sectors, in a way that monetary policies influence the stock exchange, thereby the market value of real capital assets. For example, a high interest rate policy may reduce the price index of the stock exchange and then the market value of capital. A fall in the market value of the existing capital stock, on the other hand, may generate a situation where the wedge between the market value and the replacement cost is zero, or even negative, so that the firm would never invest.

The present literature has been dominated by various extensions of Tobin's q. This literature considers lags in delivery as a reason for q to depart from unity. This explanation has been very popular in deriving Tobin's q variable within the neoclassical framework of a firm's optimisation problem. Abel (1979), for example, showed that with a simple modification by including adjustment costs, Tobin's q theory of investment can be derived from Jorgenson's neoclassical model [see also Yoshikawa (1980)]. All these considerations in the end lead us to the following very simple implicit Tobin's q investment model for empirical studies,

$$\frac{I}{K} = G(q), \qquad G'(.) > 0 \tag{70}$$

where $q = V/K$, V is the market value of capital assets [e.g. see Summers (1981), Hayashi (1982)]. G(.) is, in many studies, assumed to be a linear function in q [e.g. see Cuthbertson and Gasparro (1995), Alonso-Borrego and Bentolila (1994), and Hoshi *et al.* (1991)]. As will be argued latter, the functional form of (70) depends entirely on the adjustment costs function.

Despite the theoretical appeal of the q theory, its empirical performance has been disappointing. There have been several attempts to extend the simple framework of the model to improve its empirical performance. Even though the q variable has appeared to be significant in the empirical investment model, the proportion of investment explained by q has been quite small, and the unexplained portion has usually been highly serially correlated (this might be an indication of misspecified functional form). The estimated adjustment cost parameters are generally so high (therefore the speed of adjustment is too slow) that they seem economically implausible. In relation to the autocorrelation in disturbances and misspecification problem, empirical q models have generally ignored some crucial variables that seem to significantly influence investment, such as profit, output and the cost of capital [see Chirinko and Schaller (1994)].

Tobin's q theory is derived from an explicit optimisation of a firm's market value, and rationalised how expectations about the future play a crucial role. If adjustment costs arising from delivery lags are the only reasons for the inequality between the market value of capital and its replacement cost, then q departs from unity by the amount of adjustment costs. The argument is quite straightforward, and was advanced by Abel (1979) as follows.

5.1. Tobin's q and The Neoclassical Theory of Investment:

Incorporating the cost of capital adjustment into Jorgenson's optimisation problem, Abel obtained the market value of an additional unit of capital stock, that is marginal q. Assume that an equity holder requires a rate of return on capital to induce him to hold capital assets, and that there are no retained earnings. The expected total return from holding capital assets will be the sum of dividend payments to equity holders and the expected capital gains (or losses) arising from changes in the market value of capital assets that the equity holder holds. This relation can be formulated by the following arbitrage equation,

$$r_K V_t = D_t + \dot{V}_t \tag{71}$$

where r_K= the rate of return on capital, V_t= the stock market value of total capital assets, D_t= dividends to be paid. The left-hand side of (71) shows the total expected return from holding capital assets. As can be easily noticed, equation (71) is a simple first-order differential equation, and its solution forward yields the following

$$V_t = \int_{t_0}^{\infty} e^{-r_K \tau} D_\tau d\tau \tag{72}$$

In other words, the expected market value of capital assets equals the sum of the discounted value of all expected future dividend payments to the equity holders. Dividends can also be defined using the firm's revenue-expenditure identity, that is

$$D_t = p_t Q(K_t, L_t) - w_t L_t - q_t^I I_t - \Gamma(I_t) \tag{73}$$

where $\Gamma(.)$ is a strictly convex adjustment cost function with $\Gamma'(.)>0$, $\Gamma''(.)>0$. The crucial element of q-theory is the presence of the adjustment cost function in (73). For the sake of expositional simplicity, I assume that there is no tax levied on profits and capital allowances, and that the future paths of output and input prices are perfectly known. By maximising (71) subject to the capital account identity ($\dot{K}_t = I_t - \delta K_t$), the optimal demand for capital (along with labour) and investment, that also maximise the market value of the firm, can be found by solving the following current value Hamiltonian function,

$$H = \left[p_t Q(K_t, L_t) - w_t L_t - q_t^I I_t - \Gamma(I_t)\right] + \mu_t (I_t - \delta K_t) \tag{74}$$

The first-order conditions for investment and capital are given by

$$q_t^I + \Gamma'(I_t) = \mu_t \tag{75}$$

$$\dot{\mu}_t = (r_K + \delta)\mu_t - pQ_K \tag{76}$$

Suppose that the transversality condition, $\lim_{t\to\infty} \exp(r_K t)K_t = 0$, holds, then (76) can be written as

$$\mu_t = \int_t^{\infty} e^{(r_K+\delta)(\tau-t)} pQ_K d\tau \tag{77}$$

In a neoclassical world, this is called the demand price of capital which depends upon all future expected marginal returns from a unit of capital at time τ. Abel (1979) regarded this as the marginal market value of an addition to the capital stock. Marginal q will, then, be the ratio of (77) to the supply price of capital goods. Assuming that the price of capital goods is the numeraire ($q_t^I = 1$), the shadow value of capital in (77) also defines the marginal-q [see Precious (1987)]. In general, the investment function can be derived from the first-order optimality condition of investment (equation (75)) by inverting it for investment as follows

$$I_t = G(q^m - 1) \tag{75a}$$

where q^m is the marginal q; $G(\cdot) = \Gamma'^{-1}(\cdot)$ assuming invertibility. In a neoclassical world, the optimality of investment is ensured by the equality between the demand price of capital and its supply price. Including adjustment costs into Jorgenson's intertemporal framework, Abel brought in a wedge between demand and supply price (arising from the presence of adjustment costs), and then related this wedge positively to investment. However, because marginal q is not observable, many empirical works have relied on average-q, an observable market value of the firm, to summarise all information about the future. But the empirical performance of these studies has been very poor as explained earlier. Alternatively, a new method to test Tobin q theory of investment has been developed in Abel (1980) and Abel and Blanchard (1986), in which a series of marginal q has been constructed using equation (77). They define an auxiliary equation -along with the original investment demand equation- and then use it to forecast the future value of the marginal revenue product of capital. However, although marginal q is quite significant as an explanatory variable for investment, this new method[8] was also subject to the same problems as the previous one (including low explanatory power, and serially correlated error term etc.).

5.2. Adjustment Cost Function in Tobin's q Theory:

Empirical testing of q-theory of investment requires the parameterisation of the adjustment cost function C(.). Unlike Lucas (1967), Gould (1968) and Treadway (1969), Uzawa, in a number of papers, developed a new modified adjustment costs function, and took into account the managerial and administrative efforts of increasing the existing capital stock [Uzawa (1968) and (1969)]. The crucial feature of managerial and administrative efforts devoted to capital stock expansion is that they are not usually bought and sold in the market. Thus their prices practically do not exist. This feature hence brought about the problem of how to measure them. Taking such efforts as another factor of production, he directly related them to the existing capital stock. Instead of relating net investment, $\dot{K}_t$, to gross investment, I_t -as in the traditional capital accumulation identity-, Uzawa modified the capital accumulation equation as follows:

$$\dot{K}_t = \psi(I_t, K_t) - \delta K_t$$

where $\psi(.)$ is increasing and concave in gross investment [Hayashi (1982) and Blanchard and Fischer (1989)]. In this formulation, I_t units of gross investment do not necessarily turn into capital; only $\psi \times 100$ per cent of investment does.

In order to obtain an equation for investment, the parameterisation of the adjustment cost function becomes necessary. There are different plausible specifications of adjustment cost functions in empirical models. Following Lucas (1967), Gould (1968) and Treadway (1969), Abel (1983) discussed Hayashi's results

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[8] This approach is quite significant particularly for developing countries where stock markets are not well developed and thereby the market value of firms cannot be found. Using the similar approach to Abel (1980) and Abel and Blanchard (1986), one can construct the series of marginal q as described in equation (52). Solimano (1992) adopted the similar approach to investigate the reaction of the Chilean economy to changes in macroeconomic conditions. In his simultaneous equation system, he related Tobin's q (or, as he denoted, aggregate profitability index of investment) to some macroeconomic variables such as the expected level of demand in the goods market exchange, interest rate etc. then he estimated the investment equation together with Tobin's q simultaneously.

by introducing a quadratic convex adjustment cost function (e.g. $\Gamma(I_t) = \alpha I_t^2$) and writing the capital accumulation equation as usual.

However, the most commonly used specification has been introduced by Summer (1981), and adopted by Poterba and Summer (1983), Whited (1992), Hubbard and Kashyap (1992), Jaramillo, Schiantarelli and Weiss (1993), and Galeotti, Schiantarelli and Jaramillo (1994). It is assumed that the firm faces convex adjustment costs which are proportional to the square of the ratio of gross investment to the capital stock as follows:

$$G(I_t, K_t) = \frac{c}{2}\left(\frac{I_t}{K_t} - \varepsilon\right)^2 K_t \qquad \text{if } \left(\frac{I_t}{K_t} - \varepsilon\right) \geq 0$$

$$G(I_t, K_t) = 0 \qquad \text{if } \left(\frac{I_t}{K_t} - \varepsilon\right) < 0$$

where $c > 0$, and ε can be interpreted as a required minimum level of investment.

5.3. Marginal-q and Average-q:

While Jorgenson's model is basically concerned with the long-run demand for capital stock, the q-theory deals with the short-run disequilibrium resulting from the divergence between the market value of existing capital stock and its replacement cost. As is well known, the relevant q is the marginal one, that is the ratio of the stock market value of an additional unit of capital to its replacement cost. However, because the marginal q is not readily observable, empirical studies have used average q, that is the ratio of the market value of capital assets to its replacement costs, being based on the assumption that the average q is a good approximation of marginal one [see Abel and Blanchard (1986): 250 for a support of this assumption]. Tobin's intuitive framework has been extended by Abel (1979) and (1980), Yoshikawa (1980), Hayashi (1982), Precious (1987), Chirinko (1987), Galeotti and Schiantarelli (1991) in order to obtain good approximation of average q to the marginal one by defining some necessary assumptions. However, the equality of average and marginal q is plausible only in certain circumstances, that have been demonstrated by some studies (Hayashi, 1982, Chirinko, 1987, Precious, 1987). Hayashi proved that instead of marginal q, average q can be used in special yet important cases where the firm is a price-taker and the production function and adjustment costs are homogeneous. He then formulated the following proposition;

Proposition: *Assume that the firm is a price-maker in the output market, and a price-taker in factor markets. If the production function and adjustment function are both linearly homogeneous, then the relationship between marginal-q and average-q is given by*

$$q_t^m = q_t^a - \frac{1}{q_t^I K_t} \int_t^\infty \exp[-r_K(s-t)] \eta p_t \tilde{Q}_s(K_t, L_t, I_t) ds \qquad (78)$$

where q_t^m*: marginal-q,* q_t^a*: average-q,* η*: the inverse of the elasticity of demand for the output the firm produces, and* $\tilde{Q}_s(K_t, L_t, I_t)$ *is net output, which* $\tilde{Q}_s(K_t, L_t, I_t) = Q(K_t, L_t) - G(I_t, K_t)$ *where* $G_s(I_t, K_t)$ *is the internal adjustment cost.*

Proof: see the appendix.

In addition to homogeneous production and adjustment functions and a price-taker-firm assumption, Precious (1987) extended Hayashi's attempt to analyse the implications of rationing in both output and production factor markets. He demonstrated that when the firm is rationed by demand and/or the supply of any production factor, marginal and average q are not equal, and the response of investment to an increase in demand would always be positive in the long-run. His model includes rationing in output, labour and investment goods markets, and each introduces one Lagrange multiplier in association with each constraint, then the relationship between marginal and average qs becomes as follows:

$$\begin{aligned} q_t^m = q_t^a &- \frac{1}{q_t^I K_t} \int_t^\infty \lambda_t^Q Q_s(K_t, L_t) \exp[-r_K(s-t)] ds \\ &- \frac{1}{q_t^I K_t} \int_t^\infty \lambda_t^L L_s \exp[-r_K(s-t)] ds - \frac{1}{q_t^I K_t} \int_t^\infty \lambda_t^I I_s \exp[-r_K(s-t)] ds \end{aligned} \qquad (79)$$

where λ_t^Q is the Lagrange multiplier reflecting the fact that the firm may be demand constrained; λ_t^L is the multiplier for the labour supply constraint; λ_t^I reflects only an upper constraint on investment (for proof, see Precious, 1987: 65-66).

In addition to the conditions presented in Hayashi (1982) and Precious (1987), Chirinko (1987) argues that only when financial policy is exogenous (that is, when borrowing does not explicitly depend on investment), average q is equal to marginal q. If investment decisions are not separable from other financial decisions, then average-q may be a misleading proxy for marginal-q, which serves as the signal for alteration in the capital stock. He introduced a debt financing into the model along with agency costs of having debt, which is an addition to the usual riskless interest costs. This additional cost factor leads to a wedge between marginal and average-q, such that

$$q_t^m = q_t^a - (\mu_t + 1)\frac{D_t}{q_t^I K_t} \tag{80}$$

where D_t is the existing debt stock, and μ_t is the Lagrange multiplier associated with the debt accumulation equation.

6. Conclusion

This chapter has reviewed the literature about the influence of financial factors on the optimal capital and investment decisions, and then summarised the theories that take account of these factors. It has been noted that the Jorgenson type of neoclassical models fail to take into account the financial considerations in empirical modelling. I have indicated that the perfect capital market assumption (that had also led Modigliani and Miller to their irrelevance theorem of finance in real decisions) provided the theoretical back-up for this research. It is also shown that the recognition of imperfections in capital markets ruled out the Modigliani and Miller theorem, and introduced the substantial influence of financial factors on the optimal decisions of a firm. In this regard, I have specified financial market imperfections in two different forms. According to the first one, a representative firm faces a quantitative financial constraint on borrowing, and becomes dependent on its internally generated funds (current profits and retained earnings). The second form of imperfection is characterised by an increasing cost of borrowing. Assuming that there are no quantitative constraints, the firm's cost schedule of borrowing is considered as an increasing function of the debt-equity ratio at the margin. To provide a theoretical justification for the most recognised way of modelling the effects of financial factors in developing countries, I have also shown that such a form of imperfect capital market assumption directly influences the optimal adjustment path of the capital stock through the speed of adjustment (see Chapter 4 for details). This modelling approach does not take into account binding borrowing constraints.

In connection with Chapter 2, the present chapter has imposed a specific form of upper and lower constraints. The main distinction between the two chapters is that constraints in the previous chapter were permanently binding, and did not give rise to dynamic effects of these constraints. However, the present chapter considered that either the upper or the lower constraint is binding over a certain interval of time; i.e. they are temporary. As an essential part of the model in this chapter, the lower bound on investment has been assumed to be zero. This is widely known as the irreversibility constraint on investment. According to the upper constraint, it was considered that capital market imperfections force firms to rely on internally generated funds. In the absence of external borrowing, it has been assumed that the firm might be constrained by two types of internal funds, namely current period profits, and retained earnings accumulated in previous periods. The results of a binding financial constraint, described by either of them, varied according to the choice of one of these constraints. It has been shown that a binding profit constraint caused the firm to accumulate excess capital stock before the constraint became binding, whereas the retained earning constraint led the firm to follow the same optimal path of investment as any unconstrained firm until the previously accumulated retained earnings is exhausted. This opposite conclusion was a result of different *anticipation* effects of any future financial constraint. In the profit-constrained model, the anticipation effect causes the firm to accumulate excess capital stock before the constraint. On the other hand, in the retained earnings model, the anticipation of future constraint leads the firm to retain more earning from present profit. Therefore, retained earnings in this model act as a buffer stock to smooth the level of investment. Later, the Keynesian theory of investment and Tobin-q theory, as a extension of the Keynesian theory, have been presented.

The significance of financial factors in the determination of private investment behaviour is the subject of three empirical chapters of the thesis (Chapter 6, Chapter 7, and Chapter 8). However, both the increasing convex function of cost of borrowing and liquidity constraint on bank borrowing are modelled in Chapter 8, and tested with Turkish data.

Appendix

The Relationship Between Marginal q and Average q under Hayashi's Assumptions

In this appendix, Hayashi's result is re-produced. However, I show that the same result holds with the different assumption on the form of adjustment cost. Unlike Hayashi, I explicitly include the adjustment cost function in the firm's cash flow equation, but not in the equation for capital accumulation. Perfect output market assumption of Hayashi's model is also relaxed in this appendix.

Proposition: *Assume that the firm is a price-taker in factor markets. If the production function and adjustment function are both linearly homogeneous, then the relationship between marginal-q and average-q is given by*

$$q_t^m = q_t^a - \frac{1}{v_t K_t} \int_t^{\infty} \exp[-r_K(s-t)] \eta p_t \tilde{Q}_s(K_t, L_t, I_t) ds$$

where q_t^m*: marginal-q,* q_t^a*: average-q,* η*: the inverse of the elasticity of demand for the output the firm produces, and* $\tilde{Q}_s(K_t, L_t, I_t)$ *is net output, which* $\tilde{Q}_s(K_t, L_t, I_t) = Q(K_t, L_t) - G(I_t, K_t)$ *where* $G_s(I_t, K_t)$ *is the internal adjustment cost.*

Proof: Assume that the manager of the firm wishes to maximise dividends, which is net of all production costs and internal adjustment costs for instalment of new capital goods. The problem can be described in a rather simple form in which all taxes are assumed to be non-existent. Let the output market be imperfect and adjustment costs be internal. Unlike Hayashi (1982), I assume an adjustment cost function as described in Lucas (1967), Gould (1968), Treadway (1969), and Abel (1980). The formulation of the problem is the usual one, except for the inclusion of imperfect output market and internal adjustment cost:

$$\text{Max.} \qquad V_0 = \int_0^{\infty} \exp(-r_K t)\left[p(Q_t)\tilde{Q}_t(K_t, L_t, I_t) - w_t L_t - v_t I_t\right] dt \qquad \text{(A.1)}$$

s.t.
$$\dot{K}_t = I_t - \delta K_t \tag{A.2}$$

where $\tilde{Q}_t(K_t, L_t, I_t)$ is net output, and defined as

$$\tilde{Q}_t(K_t, L_t, I_t) = Q_t(K_t, L_t) - G(I_t, K_t) \tag{A.3}$$

where $G(I_t, K_t)$ is a convex internal adjustment cost function. The current value Hamiltonian can then be written as follows:

$$H_t = \left\{p(Q_t)\left[Q_t(K_t, L_t) - G(I_t, K_t)\right] - w_t L_t - q_t' I_t\right\} + \mu_t (I_t - \delta K_t) \tag{A.4}$$

where μ is the Lagrange multiplier. The first order conditions therefore are,

$$p(1-\eta)Q_L = w \tag{A.5}$$
$$\mu_t - q' - p(1-\eta)G_I = 0 \tag{A.6}$$
$$\dot{\mu}_t = (r_K + \delta)\mu_t - p(1-\eta)Q_K + p(1-\eta)G_K \tag{A.7}$$

Multiply (A.6) by I_t and (A.7) by K_t, and add altogether

$$\mu_t I_t + \dot{\mu}_t K_t - (r_K + \delta)\mu_t K_t = p(1-\eta)\left[G_K K_t + G_I I_t\right] + q' I_t - p(1-\eta)Q_K \tag{A.8}$$

Assume that the adjustment cost and production functions are both *homogeneous*, so

$$G(I_t, K_t) = G_K K_t + G_I I \tag{A.9}$$
$$Q_t(K_t, L_t) = Q_K K_t + Q_L L_t \tag{A.10}$$

Using (A.5), (A.10) becomes

$$Q_K K_t = wL_t / p(1-\eta) - Q_t(K_t, L_t)$$

Substituting this into (A.8) along with (A.9) yields

$$\mu_t I_t + \dot{\mu}_t K_t - \mu_t r_K K_t - \delta\mu_t K_t = p(1-\eta)\left[G(I_t, K_t) - Q_t(K_t, L_t)\right] + wL_t + vI$$

Make use of (A.2) for I_t and re-arrange the right hand side of the above equation

$$\mu_t K_t + \dot{\mu}_t K_t - \mu_t r_K K_t = p\left[G(I_t, K_t) - Q_t(K_t, L_t)\right] + wL_t + q' I_t$$
$$-p\eta\left[G(I_t, K_t) - Q_t(K_t, L_t)\right]$$

or

$$\mu_t K_t + \dot{\mu}_t K_t - \mu_t r_K K_t = -\left[p\tilde{Q}_t(K_t, L_t, I_t) - wL_t - q' I_t\right] + p\eta\tilde{Q}_t(K_t, L_t, I_t) \tag{A.11}$$

Recall the arbitrage equation in the text, which is

$$\dot{V}_t - r_K V_t = -D_t \tag{A.12}$$

where

$$D_t = p(Q_t)\tilde{Q}_t(K_t, L_t, I_t) - w_t L_t - q^I I_t$$

Therefore (A.11) becomes

$$\mu_t \dot{K}_t + \dot{\mu}_t K_t - \mu_t r_K K_t = -(\dot{V}_t - r_K V_t) + p\eta\tilde{Q}_t(K_t, L_t, I_t)$$

or

$$(\dot{V}_t - r_K V_t) = -(\mu_t \dot{K}_t + \dot{\mu}_t K_t - \mu_t r_K K_t) + p\eta\tilde{Q}_t(K_t, L_t, I_t) \tag{A.13}$$

Following Hayashi (1982: 219), (A.13) can also be written as

$$\frac{d}{dt}[V_t \exp(-r_K t)] = -\frac{d}{dt}[\mu_t K_t \exp(-r_K t)] + p\eta\tilde{Q}_t(K_t, L_t, I_t) \tag{A.14}$$

Integrating both sides gives

$$V_t = \mu_t K_t + \int_t^\infty p\eta\tilde{Q}_s(K_s, L_s, I_s)ds \tag{A.15}$$

provided that the transversality condition, which $\lim_{t\to\infty} \exp(-r_K t)\mu_t K_t = 0$, holds. Hence,

$$\frac{\mu_t}{q^I} = \frac{V_t}{q^I K_t} - \frac{1}{q^I K_t}\int_t^\infty \exp[-r_K(s-t)]p\eta\tilde{Q}_s(K_s, L_s, I_s)ds$$

Since $q_t^m = \frac{\hat{q}_t}{q^I}$, and $q_t^a = \frac{V_t}{q^I K_t}$,

$$q_t^m = q_t^a - \frac{1}{q^I K_t}\int_t^\infty \exp[r_K(s-t)]p\eta\tilde{Q}_s(K_s, L_s, I_s)ds \tag{A.16}$$

Chapter 4

Modelling Private Investment In Developing Countries

1. Introduction

Even though private investment has been studied in detail for industrial countries for many years, private investment in developing countries (LDCs) has very recently started receiving increasing attention mainly for two reasons. First, analysis of data from a large sample of countries has repeatedly shown that the rate of accumulation of physical capital is a crucial determinant of economic growth [see De Long and Summers (1993), and Levine and Renelt (1992)]. For developing countries, there is also some evidence that private investment has a greater impact on growth than public investment [see Khan and Reinhart (1990)]. Second, despite its importance for economic growth, the share of private investment in GDP has declined considerably in many developing countries during the 1980s. The global shocks and the world debt crisis in the form of lack of external financing, sharp increase in the world interest rate, and restrictive demand management followed by developed countries have been seen as the main causes of this decline. This disappointing performance of private investment in developing countries has been the subject of numerous policy debates [e.g. see Chhibber et. al. (1992) and Serven and Solimano (1993)], and stimulated research on what determines private investment in a developing country. There is already a fast growing literature on the determinants of private investment in LDCs that mainly assesses the impacts of changes in demand and trade policies.

There has been a broad consensus on the significant role of the neoclassical determinants of private investment (namely, the accelerator variable, and the cost of capital). There has, however, been ambiguity about the role of financial factors in this process. The debate over the interrelationship between financial and investment decisions has focused on the perfect capital market assumption of Jorgenson's version of the neoclassical model, and the relevance of the Modigliani and Miller theorem. One goal of recent research activities has been to take explicitly into account capital market imperfections and their influences on the investment behaviour of a firm. It is, accordingly, argued that the cost of capital to the firm is not exogenous, but depends on the financial structure of the firm. Besides, the timing of investment expenditures is dependent on the availability of financial funds (see Chapter 3 for details).

Regarding a departure from the traditional perfect capital market and full information assumptions, the research agenda of the recent literature of empirical investment models has emhasised mainly the imperfections in capital markets arising from asymmetric information between lenders and borrowers. The interdependence arises because lenders impose an additional risk premium on the principle interest rate (i.e. risk-free rates) according to the financial structure of the firm (that can be proxied by the leverage ratio). The higher the debt-equity ratio, the greater the cost of capital of the marginal financial funds to the firm. It is also argued at the theoretical level that the interdependence of financial and investment decisions occurs if investment is limited by quantitative constraints on debt financing. This may be not only because of the absence of well developed capital markets, but also because of asymmetric information in the markets.

Considering the capital markets in developing countries, a high degree of segmentation, severe asymmetric information, lack of supervision, incomplete markets and non-price credit rationing, and intensive government involvement in the capital markets are not at all uncommon. The reliance on debt finance is substantial in many developing countries partly because of the absence of equity markets, and partly because interest rates on loans are kept below their equilibrium levels for various reasons. Unlike developed economies, such imperfections in capital markets are structural in developing countries, in the sense that they impose a higher degree of stringency on the financing of private investment by the use of retained earnings and bank credit, and have been the objective of financial liberalisation attempts by some developing countries (including Turkey) [see McKinnon (1991), and Fry (1988)].

As explained earlier in two chapters, literature indicates two theories of investment; the *neoclassical theory* in which capital markets are assumed perfect, and the accelerator and the cost of capital turn out to be main determinants of investment, and the *financial theory of investment* that takes into account the influences of financial factors [e.g. see Steigum (1983)]. The question of which theory explains investment better is, however, ambiguous, and requires more research in the context of different countries. Considering developing countries, testing these two different theoretical approaches to the determination of investment behaviour becomes even more important for two main reasons. First, the financial factors (such as asymmetric information, borrowing constraints) in imperfect capital markets - giving rise to the financial theory of investment - play a more important role in developing countries than in developed countries. Second, the structural characteristics of these countries (such as high public involvement in economic activities) introduce additional factors that should be considered in modelling investment behaviour in developing countries. In this respect, there is no unified theoretical approach to modelling investment that explains private investment in all developing countries. Instead, the role of different determinants and the form of the private investment function may vary from one country to another due to the different structure of the economies of each developing country and the additional constraints under which that economy operates. One of the most frequently used modelling strategies is to adopt the neoclassical accelerator model subject to some additional structural modifications.

In the last decade, the theory of investment has, in general, developed in two directions. On the one hand, the theory has become more and more structural in the sense that the derivation of the investment function is based on an intertemporal optimisation of the value of a 'representative firm'. This then allowed researchers to incorporate more interactions between financial and real decisions and to provide more realistic assumptions about market conditions and about the dynamics of investment behaviour that arise from both the formation of expectations and the adjustment technology of capital.

On the other hand, empirical studies based upon this new theory have concentrated on the aggregation problem, and begun to relax the assumption that the behaviour of the representative firm is typical of the behaviour of all firms at the aggregate level by employing panel data rather than time series [e.g. see Fazzari *et al.* (1988)]. This theoretical development particularly paved the way for an analysis of the effects of various variables on investment behaviour within an explicit theoretical optimisation framework. The use of panel data in estimations, in particular, has given us a better understanding of the impact of some crucial variables, such as financial ones, on the investment behaviour of heterogeneous firms. This new approach, which is increasingly popular nowadays, has been applied not only to industrial countries but also to developing countries [see Athey and Laumas (1995), and Harris *et al.* (1994)].

Despite the fact that the theoretical literature on private investment is very rich, the application of the theory for a developing country is usually limited by various difficulties associated with both the absence of data which is necessary to test a particular theory, and with structural and institutional differences of that developing country. Among others, lack of sufficiently long time series, measurement errors, and the absence of reliable data on some crucial variables at the aggregate and disaggregate level, can be considered as the most common data problems that one may encounter in modelling investment for a developing country. Regarding structural and institutional differences, the most remarkable economic differences arise from imperfections in various markets and distortions in the price system. For instance, interest rates are heavily regulated in many LDCs, and may not be allowed to fluctuate freely to reflect the real cost of borrowing. It is also common to believe that there is a strong relationship between public and private investment in developing countries [see Green and Villanueva (1991), Blejer and Khan (1984), Sandurarajan and Thakur (1980)]. But the direction of the effects of public investment on private investment is subject to uncertainty. High public investment may, in general, be required to create special infrastructure facilities for transport, communication, energy and irrigation etc. which can be complementary to private investment. Public investment of this kind can stimulate private investment by possibly raising the productivity of private capital. Governments also participate in production for the market in many developing countries, sometimes along with the private sector (which has to compete with the state-owned firms), sometimes alone (in some sectors whose production is essential but not profitable enough to attract the private sector). In this sense, public investment could crowd out private investment as it uses economic resources that would be available otherwise to the private sector.

When modelling private investment for a developing country, one should consider all these difficulties, and modify the assumptions underlying the neoclassical theory. In adopting a standard investment model such as the neoclassical flexible accelerator model, additional economic and technological constraints should be imposed on the model. Most of such studies in the existing literature have emphasised a particular feature(s) of countries in their samples and define investment functions by imposing some constraints that define those features. In the view of this thesis, the inclusion of capital market imperfections in the form of quantitative constraints and using a structural model has been a novel development in the recent investment literature for developing countries, and there have been a few attempts to apply an approach based on an intertemporal optimisation of the value of a representative firm.

This chapter reviews the investment literature and discusses some well-known modelling approaches to the private investment function in developing countries. Section 2 discusses empirical modelling issues at the micro and macro level with a special reference to the accelerator and financial factors. Some additional factors affecting private investment in developing countries are presented in Section 3. Conclusions from this chapter are summarised in the last section.

2. Modelling Neoclassical and Financial Factors in Private Investment Models

There has been a considerable volume of theoretical and empirical studies on the determinants of private investment in developing countries. The performance of empirical models with different data sets has still been subject to the quality of data and the modification of the theory in accordance with the different social and institutional structure of these countries. Given the unsatisfactory empirical performance of the neoclassical investment models in industrial countries [see Chirinko (1994)], the empirical specification of private investment has still remained 'art'. In the light of the theoretical discussions above, the present section raises issues associated with modelling the accelerator, the availability of financial funds and capital market imperfections in investment models suggested for developing countries. Empirical studies have not been concerned only with the neoclassical theory itself but rather with the modifications necessary in applying it to developing countries.

Since there is no accepted theoretical framework of analysis for determining the level of private investment in developing countries, most writers have used an eclectic approach in the sense that there is no exclusive formal microeconomic modelling. This type of study has used the neoclassical theory of investment with some modifications at the micro and macro level. Although many of these studied have been *'eclectic'*, a few have tried to test neoclassical theory by presenting an explicit microeconomic foundation of the behaviour of firms leading to a specific demand for input function which is applied at the micro or sectoral level [Tybout (1983) and Behrame (1972)]. At the macro-level, various studies have examined the role of the accelerator effect, supply factors (such as the availability of credit, foreign exchange availability) and the effects of public investment without any explicit microeconomic modelling attempt. This section reviews well-known investment models in accordance with the type of data and the use of a microeconomic foundation through which an investment demand model is derived as a function of its neoclassical determinants and additional constraints raised from specific economic structure of developing countries. In the view of the theoretical debate on the interrelationship between financial and investment decisions in the recent theoretical literature, the structure of capital markets and the poor intermediation of the banking system deserve special attention in modelling private investment in devloping countries.

2.1. Financial Repression

The relationship between interest rates and private investment in developing countries has received considerable attention. Until the early 1970s, the conventional wisdom had been that low interest rates would promote private investment and growth in accordance with Keynesian and neoclassical theories. Since the seminal work of McKinnon (1973) and Shaw (1973), financial repression has, however, been considered as one of the main factors influencing private investment by limiting the amount of loanable funds available for investment. They raised the problem that poor financial intermediation would drastically reduce the quantity and quality of capital formation. On the other hand, they suggested that higher interest rates would raise domestic savings, increase the volume of domestic credits extended by better intermediation of the financial system and by reducing quantitative constraints on credit. This is mostly as a result of two characteristics of financial markets in developing countries. One is severe informational imperfections in financial markets because of some characteristics of these markets, such as the lack of well-developed equity markets, weak prudential supervision, and pervasive government interventions. Second is the practice of administratively determined interest rates that set up the deposit rate on monetary assets lower than the market equilibrium rate to provide cheap credit to some firms or industries. With the ongoing high level of price inflation, lower interest rate policies, amplified by poor financial intermediation and informational imperfections, very often lead to negative real deposit rates on monetary assets, and then to the reduction in the volume of savings which itself determines the level of total investment at the macroeconomic level.

In addition to the financial repression literature, possible saving constraints on the level of investment have been also examined by the 'two-gap' model [McKinnon (1964), Chenery and Strout (1966)]. According to this model, provided that domestic saving, the world demand for exports and external financing are given, the sum of domestic savings plus foreign financing sets up an upper constraint on total investment that is considered as a saving gap, whereas the sum of exports and foreign financing puts an upper bound on imports giving rise to a foreign gap.

Empirical studies of equilibrium models have placed the emphasis on two main mechanisms through which the effects of credit availability are transmitted from the financial to the real sector. One mechanism is the direct interest rate adjustment mechanism. Where there exists a highly developed financial system and interest rates are allowed to adjust freely to market conditions, the excess demand for credit will raise the interest rate and then the cost of borrowing. The second mechanism relies directly on the quantity of credit as a link between the financial and the real sector. The second seems to be more relevant in tightly regulated financial markets where interest rate ceilings and controls limit interest rate movements towards the equilibrium level. Freeing interest rates in the last case will increase the supply of credit to finance investment. The following section assesses the role of neoclassical and financial factors in detail with a reference to modelling issues of private investment in developing countries.

2.2. Micro Level Studies:

How significant is the role of the accelerator and financial variables in determining the level of investment in developing countries? Most studies use aggregate data, and in the absence of data on relevant variables use a number of proxies [Blejer and Khan (1983)]. In this section, some empirical works that use micro-level data are examined with the special reference to their theoretical set-up. The micro level application of the neoclassical theory to LDCs has appeared to borrow many elements of the theory with minor modifications. Empirical works that investigate the link between internal funds, the accelerator and investment using micro-level data are Athey and Laumas (1994), Leite and Vaez-Zadet (1986), Tybout (1983), Bilsborrow (1977) and Behrame (1972). These studies report on attempts to estimate real physical capital investment function from sectoral level time-series or cross-section data of a developing country. They contribute to the existing controversy over the determinants of investment with evidence from LDCs. They also suggest well-known investment models as an instrument to understand the effects on investment of various economic constraints that may exist in a typical developing country, and thereby on economic growth in LDCs.

Using an eclectic model, Bilsborrow (1977) analysed the significance of the availability of internal and external financial funds and foreign exchange constraint in Colombia. Bilsborrow (1977) assumed that investment is derived by the intersection of marginal efficiency of investment curve with its marginal cost of funds [see Chapter 2]. Writing the former as a function of capital utilisation, real prices of capital goods and investment spending, and the latter as a function of the volume of internal funds, some measure of cost of external funds and balance sheet risk from obtaining external funds, the cost and availability of foreign exchange and investment expenditure, he obtained a single-reduced form investment function from the simultaneous system of marginal efficiency of capital and marginal cost of funds including internal and external funds:

$$m.e.i. = f(S,q,I) \tag{1}$$

$$m.c.f. = g(F,B,A,I) \tag{2}$$

where *m.e.i.*: the marginal efficiency of investment; *m.c.f.*: the marginal cost of funds; *S*: the expected rate of capital utilisation proxied by the rate of growth of deflated sales; *q*: real prices of capital goods; *F*: the net internal funds available; *B*: some measure of cost balance sheet risk from obtaining external funds; *A*: the availability of foreign exchange. Assuming that the optimality condition of marginal efficiency of capital and the marginal cost of financial funds holds, (1) and (2) can be solved for investment;

$$I = h(S, B, A, F) \tag{3}$$

if

$$m.e.i. = m.c.f. \tag{4}$$

where *q* is incorporated in the deflator for investment [see Chapter 3]. Then he tested the reduced form of investment equation (3) with a cross-section of 68 Colombian firms. Data problems influenced the formulation of the model to be tested. Particularly, the lack of adequate data on the capital stock variable made him unable to examine either the accelerator model by means of a capital stock adjustment model or the distributed lag formulation of the capital adjustment. However, strong evidence was found for the accelerator effect: more output in general requires more of all inputs. Having aggregated data across firms, cash flow and foreign exchange availability were also found to be a slightly more important determinant of annual variations in investment than the accelerator. The difference appeared when the model was applied to foreign and domestic firms separately. The accelerator model functioned well for the former in terms of high R^2 and of the significance of both the accelerator and internal funds flow variables. This performance of the naive accelerator model can be attributed to the fact that the managers of foreign-owned firms in Colombia behave in accordance with the expectations of the neoclassical model of the managers in industrialised countries. However, Bilsborrow (1977) was unable to assess directly neoclassical price variables due to unsatisfactory information on past level of output prices at the level of the firm. The risk premium variable arising from the composition of the balance sheet of an individual firm was found to be the best of the variables studied in time-series regressions. As a result, Bilsborrow could not test the neoclassical price variables mainly due to the lack of data, but he concluded that "[he] *did find persuasive evidence in support of a more eclectic, less pure approach.*" [Bilsborrow (1977): 715].

Leite and Vaez-Zadet (1986), using firm level data, accommodated an eclectic model to assess the effect of changes in the availability of credit to small and medium size firms and foreign exchange earning industries. The paper seeks to answer whether or not such a selective credit allocation has been effective in the case of the manufacturing sectors in Korea. Their *eclectic* method is to regress the investment expenditure on interest rates (in order to test the existence of the interest rate adjustment), value added (as an accelerator variable) and a change either in a single financial variable or in different combinations of those variables. In addition to an investment demand function, they also estimate functions for inventories and working capital to assess the interactive influence of the selective credit policy implemented by the Korean government. Having estimated all three equations, they suggested that if the coefficient of bank borrowing is significant, then it would be concluded that selective credit controls have an influence on investment spending decisions of Korean firms. If the variable is found to be insignificant, then the conclusion would be either 1.) bank credit is not used to finance investment, or 2.) bank credit is used to finance investment, but because of rationing, more and more additional sources of finance are used to fill the gap created by the credit rationing, or 3.) there is no credit rationing so that the bank credit variable should not appear in the investment equation. All of them imply that selective credit policy will have no influence on investment expenditure. The substitutability between different sources of credit (such as bank borrowing, nonbank borrowing, foreign borrowing, trade credit and internal financing) is analysed through changes in the statistical significance of the financial variables when either of the financial variables noted above separately, or as a combination, are substituted for each other. They reported the basic source of investment in small and medium size Korean firms come out to be internal finance while others such as bank borrowing also a play minor role. On the other hand, for large firms, the source of financing investment expenditure becomes bank credit, foreign borrowing, and there is also significant substitutability among those options. Consequently, a selective credit policy seems to have had direct but rather insignificant impact on investment expenditure of small and medium enterprises, whereas although its effects on the investment of larger firms are direct and more significantly negative, these firms had been able to substitute another financial source for bank credit.

Advances in panel data econometrics[1] have recently allowed empirical researches to examine the link between internal funds and investment very accurately. Due to the importance of this issue in development finance, empirical studies using firm-level panel data have received considerable amount of attention in the literature. Athey and Lauma (1994) very recently investigated this link between internal funds and investment for India through an eclectic approach. They represented the accelerator variable by current and lagged values of the changes in real net sales (ΔS), and internal

[1] see Hsiao (1986) and Baltagi (1995) for the further discussion on panel data econometrics. Blundell et al. (1992) reviews the use of firm-level panel data in econometric models of company investment with a reference to financial factors.

funds variable by current net profit (*NP*). Investment is then expressed as a function of the sale accelerator, internal funds, and replacement investment

$$(I/K)_{it} = a + \mu_i + \lambda_t + f(\Delta S/K)_{it} + g(NP/K)_{it} + h(depr/K)_{it} + e_{it} \tag{5}$$

where (*depr*) is the current depreciation used for replacement investment; a is the mean intercept; μ_i represents the all omitted factors affecting the error term that are time invariant and specific to each firm; λ_t reflects time-specific factors that affect all firms equally over time; e_{it} is independently identically distributed error term over i and t with mean zero and variance σ_e^2. The model was estimated using a panel data set consisting of 256 firms over the period of 1978-1986. Two important results emerged from this empirical study. First, the accelerator variable, net profit, and depreciation are important determinants of investment spending in Indian manufacturing firms. Second, the internal funds variable is relatively more important for large firms. This rather unexpected conclusion is a result of the objectives of the Indian government to promote small industries through selective credit policies. Therefore, in India, small firms should have relatively easier access to the limited investment funds.

So far, eclectic models have been presented without any reference to the micro foundations of the behaviour of firms. The paper by Tybout (1983) attempts to suggest a model examining McKinnon's thesis using directly micro level data. The usual empirical practice in the financial repression literature is that all firms in the economy, more or less, suffer from market imperfections and credit rationing equally. However, they ignore the micro process through which inefficient intermediation translates into poor economic performance. This last argument requires more detailed examination at the micro level. Tybout assumes that firms are constrained by the level of current period profit, which itself determines the level of investment. The quite interesting implication of adjustment costs led him to a micro theoretical interpretation of the effects of credit constraints. He introduced a Jorgenson type of investment model with a convex adjustment cost function by which he defined the optimal paths of investment of constrained and unconstrained firms. Tybout theoretically specified two channels through which credit rationing influences the optimal paths of investment; namely liquidity and cost channels. The liquidity channel, which is more commonly considered in the literature, becomes effective when a rationed firm has difficulty in obtaining cash quickly when investment opportunities arise. As one borrows, optimal investment behaviour requires an equality between the rate of return on investment projects and borrowing and lending rates. In an Modigliani-Miller world, lending rates and borrowing rates of funds would be equal. However, in an imperfect environment, there always exists a wedge between the lending and borrowing rate of financial funds.

From the point of view of firms' owners, the use of internally generated funds for investment involves an opportunity cost which is considered to be the lending rate. As the credit rationing becomes more and more binding, the owners of constrained firms would require a higher rate of return investment in order to lend their money to their firms. From the managers' point of view, credit rationing thus increases the opportunity cost of internal funds at the margin. This cost effect was represented by discounting the earnings on rationed firms' assets at a relatively higher rate.

Tybout (1983) introduced the flexible accelerator model of investment expenditures:

$$I_t = \theta\left(K^* - K_t\right) \tag{6}$$

Here K^* satisfies the first-order condition $\pi_K = rC'(0)$ and

$$\theta = -(1/2)\left\{r - \sqrt{r^2 - 4\left(\pi_{KK}/C''(0)\right)}\right\} \tag{7}$$

where π: the profit function as described in earlier chapters; r: the discount rate; C(I): the adjustment cost function[2]. An increase in the cost of capital as a result of a rise in the opportunity cost of using internal funds will increase the marginal product of the rationed firm in the long run (see the first-order condition), then slows down the adjustment process $(\partial\theta/\partial r < 0)$.

Tybout (1983) defined a general investment function covering rationed and non-rationed firms. His investment model representing unconstrained firms is a simple "putty-putty" model in which the level of output is the most dominant factor among others, and the effect of relative prices does not appear in the equation directly. By a simple accelerator model, the desired level of capital is assumed to be a constant proportion of expected output level;

$$K^* = \gamma Q^* \tag{8}$$

where γ is the constant capital-output ratio which is indirectly determined by relative prices; Q^*: the expected output. The level of expected output is given as a linear function of the actual levels of all past outputs. The flexible accelerator mechanism is the common bridge connecting investment to capital stock; that is

$$I_t = \theta\left[\sum_{i=1}^{T} \gamma\omega_i Q_{t+1-i} - K_{k-1}\right] \tag{9}$$

[2] For the formal derivation of the adjustment coefficient similar to (7), see Chapter 3.

Alternatively, for the firm that faces a binding credit rationing, he suggested that investment demand is determined by a distributed lag in earnings:

$$I_t = \sum_{i=1}^{T} \eta_i \pi_{t+1-i1} \tag{10}$$

The general model will thus be the sum of the investment functions of constrained and unconstrained firms so that depending on the significance of either the accelerator or the internal funds variable, we are able to determine whether or not the binding constraint is effective;

$$I_t = \theta\left[\sum_{i=1}^{T} \gamma\omega_i Q_{t+1-i} - K_{k-1}\right] + \sum_{i=1}^{T} \eta_i \pi_{t+1-i1} \tag{11}$$

In order to avoid the need for data on the book value of the capital stock, he differenced both sides to eliminate the capital stock variable on the right-hand side. Therefore the general investment demand equation becomes identical to the following

$$I_t = \theta\sum_{i=1}^{T} \gamma\omega_i \Delta Q_{t+1-i} + \sum_{i=1}^{T} \eta_i \Delta\pi_{t+1-i1} + (1-\theta)I_{t-1} \tag{12}$$

where $I_{t-1} = K_{t-1} - K_{t-2}$. The very restrictive assumption of Tybout (1983) is that there is no replacment investment in his model. This implicitly accommodates a putty-putty technology assumption, in the sense that the technology is completely malleable both in net investment and in replacement investment. This means that replacement investment can also be represented by the same equation as net investment.

The excellent study by Behrman (1972) used a neoclassical investment model to analyse sectoral investment behaviour in Chile. This study has been the only one investigating sectoral investment functions under 'putty-putty' and putty-clay' technology assumptions. He employed time series data for the period 1945-1965 of six sectors (20 observations for each) including agriculture, mining, manufacturing, transportation, housing, and utilities. Another novel aspect of the study is the definition of the optimal capital stock term which is assumed to be a function of the ratio of the output price to the price of capital goods (p/q), real output Q, the capacity gap variable (Q/Q^c) where Q^c is the capacity of real output, and the standard derivation of the ratio of the output price to the GDP deflator $SD(p/def.)$ (to capture the effect of price volatility or of inflation in general);

$$K^* = b\left(\frac{p}{q}\right)Qe^{\tau(\sigma-1)t} + c\left(\frac{Q}{Q^c}\right) + dSD\left(\frac{p}{def.}\right) \tag{13}$$

where τ: rate of Hicks neutral exponential technological change; σ: elasticity of substitution between capital and labour; b, c, d, are constant coefficients. if the effect of capacity gap variable is significant in the estimation, the sign of (c) will be expected to be positive. The sign of (d) will be negative if risk-aversion is predominant.

Under putty-putty assumptions, the gross investment is the sum of the investment for expansion and investment for replacement; $I^G = I^N + I^R$. Behrman examined three different functional specifications, two of which are basically putty-putty models but classified as complete and partial putty-putty models. Recalling the discussion in chapter 1, the putty-putty technology assumption means the malleability of capital. If capital is completely malleable, there would be no differences between the determinants of investment for expansion purposes (i.e. net investment) and investment for replacement. Therefore, the same function would be enough to describe both types of investment. If the replacement option is limited because of the constant characteristics of the existing capital stock, then replacement investment is determined by the depreciation of the existing capital stock. In such a situation, the technology is called partial putty-putty; i.e. putty-putty in net investment, but not in replacement investment. On the other hand, if the assumption that capital is not malleable holds, then the determinants of replacement investment differ from those of net investment. The common practice is usually to assume that replacement investment is given by the rate of depreciation of the fixed capital stock [Jorgenson (1963)]. Since this method requires the value of the capital stock, which is in general difficult to obtain accurately in developing countries, Behrman suggested that replacement investment is a distributed lag function of past capacities of real output. This model is described as a partial putty-putty model. Following Jorgenson and others, the net investment is considered as

$$I^N = \sum_{i=0}^{n} a_i \Delta K^*_{t-i} \tag{14}$$

which corresponds to real gross investment covering both net investment and replacement investment under the complete putty-putty technology assumption. The real gross investment model with the partial putty-putty assumption will be the sum of the net investment and replacement investment, which can described as

$$I^G = \sum_{i=0}^{n} a_i \Delta K^*_{t-i} + \left[\sum_{i=0}^{m} f_i Q^c_i \right] e^{\tau(\sigma-1)t} \tag{15}$$

where

$$I^R = \left[\sum_{i=0}^{m} f_i Q_i^c \right] e^{\tau(\sigma-1)t} \tag{16}$$

Under a putty-clay assumption, real gross investment is written as a non-function of the price of output, the price of capital services, real output, the elasticity of substitution between labour and capital and the rate of Hicks neutral exponential technological change, and the rate of depreciation,

$$I^G = be^{\tau(\sigma-1)t} \left(\sum_{i=0}^{n1} w_{1i} P_{-i}^{\sigma} \right) . \left(\sum_{j=0}^{n2} w_{2j} DQ_{-j} \right) \tag{17}$$

where $P = p/q$, $DQ_{-j} = Q_{-j} - (1-\delta)Q_{-j-1}$, and δ is the rate of depreciation. A first-order Taylor expansion of this expression around the lagged values of (P) and (DQ) gives a very complicated investment demand function depending basically on relative prices and real output [see Behrman (1972): 829]. Chilean investment expenditure was found substantially to be consistent with the putty-putty type of investment model. Empirical results confirmed the significance of the use of CES production function, as described in (13), and price uncertainty, and to a lesser extent, of capacity utilisation. The manufacturing sector, among others, was found to be very responsive to changes in the price of output and in the relative price of capital services. The government's fiscal and monetary policies that increase the degree of capacity utilisation and decrease price uncertainty might lead to increases in investment in various sectors.

2.3. Macro Level Studies:

Macroeconometric investment studies attempt to examine the importance of poor financial intermediation among the other determinants of private investment. As explained earlier, financial repression and fragmented financial markets in developing countries are regarded as the main reason for this poor intermediation. Like microeconometric studies, there is no accepted general framework to analyse the macroeconomic determinants of private investment. However, the present literature has considered two different modelling approaches to study the extent to which financial variables influence private investment and in turn economic growth. One closely follows the financial liberalisation literature and considers the volume of private investment spending to be determined by the volume of domestic saving. The second approach has been in the line of neoclassical flexible accelerator models, and mostly incorporates some additional variables in accordance with the different structural characteristics of developing countries (other than the accelerator and the relative price of capital goods), through the variable coefficient of the partial adjustment mechanism.

This section reviews these macroeconometric models with special reference to corresponding theories.

2.3.1. Macroeconomic Adjustment and The Role of Saving in the Determination of Private Investment:

Economic stabilisation can be defined as an attempt to improve disequilibrium between demand and supply, aiming to reduce inflationary pressures and correct the balance of payment positions. Excess demand for domestic and foreign resources (as a result of ambitious growth targets) and structural rigidities on the supply and demand side of developing economies result in two types of disequilibrium, namely disequilibrium between domestic savings and total investment, and disequilibria between imports and total foreign earnings. These two main disequilibria, that impose additional constraints on investment, have been considered by the two-gap model [Chenery and Strout (1966), Weisskof (1972) and Gersovitz (1982)]. To see these disequilibria, consider that the following national income identity holds *ex post*,

$$Y = C + I + (X - M) \tag{18}$$

where Y: gross national product; C: aggregate consumption including public and private sector; I: the sum of public and private investment; X: exports including factor income from abroad); M: Imports including factor payments to foreigners. Assuming that S=Y-C, the following also holds in equilibrium,

$$(I - S) + (X - M) = 0 \tag{19}$$

In disequilibrium, the first term on the left-hand side gives the saving gap $(I > S)$ while the foreign exchange gap, $(M > X)$, is given by the second.

Macroeconomic stabilisation and adjustment policies, in a broad sense, involve eliminating these disequilibria by various means. Exogenous foreign capital inflows (such as external borrowing, foreign investment, and aid) is one of them. Assume that a country runs a trade deficit, $(M > X)$, which is financed through external borrowing, F; then (19) becomes

$$S + F = I \tag{20}$$

The right hand side of the equality is a simple expenditure item described in the national income identity; the left hand side represents the source of finance of that expenditure. This is a simple *ex post* investment-saving identity which postulates that all commodity markets are cleared at the equilibrium price level. External borrowing, F, here fills the gap between saving and investment. Given the exogenous nature of foreign borrowing, this option is yet not controllable, and sometimes rationed in international capital markets, as imposing an external borrowing constraint on investment. To see this, I follow Weisskopf (1972), and write the *ex ante* savings function as follows

$$S^* = a_0 + a_1 Y + a_2 F + a_3 X \tag{21}$$

where S^*: desired savings. If the country runs a trade deficit, the realised level of saving becomes higher than its desired level, that is $S^* < S$. Substituting (21) and (20) into this inequality yields that

$$I \leq a_0 + a_1 Y + (1 + a_2) F + a_3 X \tag{22}$$

where I is realised investment. Equation (32) gives the maximum level of the investment demand in the saving-constrained economy in the case where the inequality constraint in (22) is strictly binding. If the inequality is not binding, realised investment demand will be determined by other variables (such as described earlier) than those determining savings.

Having excluded the foreign capital inflows as a controllable instrument for macroeconomic adjustment, three main possibilities to equilibrate savings and investment can usually be considered in developing countries, namely output adjustment (i.e. accelerator effect), inflationary adjustment, and deficit financing and credit creation [Leff and Sato (1980) and (1988)]. The first option is rather subject to the response of output to excess demand in the short-run. Provided that investment and saving are also responsive to the short-run changes in output, they adjust themselves to the *ex post* equilibrium. Where output is not sufficiently responsive in the short-run (e.g. because of full capacity utilisation in the economy), demand stimulus resulting from excess demand in the commodity market would affect the aggregate price level. In other words, excess of ex ante investment over (S+F) rises the general price level under the demand pressure, and leads to new market equilibrium at a higher price level. But price inflation, for many reasons, is undesirable in LDCs. In particular, the low interest-rate policy is considered as one of the policy instruments to stimulate investment and economic growth rate. Thus interest-rate changes are not allowed to clear the financial market. In such a situation, the gap is filled by relaxing the saving constraint through changes in the volume of real credit usually in response to the government deficit. The increased volume of credit is expected to support insufficient domestic savings and allowed to raise the realised investment demand towards its desired level. Credit expansions to meet the *ex ante* investment target, however, are subject to the balance-of-payment constraint. More precisely, since the excess demand for investment over savings in an open economy causes a fall in international reserves, the Central Bank becomes less eager to expand the supply of credit, and even tightens it [Eshag (1971)].

Considering both the fact that demand for investment is constrained by the supply of domestic savings *ex post*, and the possible effects of different adjustment options upon savings and investment decisions, some empirical researches estimate an investment-saving system simultaneously as follows [see Leff and Sato (1975), (1980) and (1988)];

$$S = a_0 + a_1\dot{P} + a_2\Delta Y + a_3 S_{-1} \tag{23}$$

$$I = b_0 + b_1\Delta Y + b_2\dot{P} + b_3\Delta Cr \tag{24}$$

where ΔY: the change of real GNP; $\dot{P}$: the rate of inflation; ΔCr: the change in the real volume of credit. It is expected that a_1 and $a_3 > 0$. The sign of a_2 is ambiguous because of the different saving behaviour of public and private sector. An increase in inflation may cause the private sector to save more, but also could reflect the government dissaving which is being covered by money creation. It is also expected that $b_1 > 0$ because of the accelerator effect. An increase in real credit positively influences investment because LDC firms are generally very dependent on credit to finance investment ($b_3 > 0$). The effect of the increase in inflation enters the investment equation positively due to the fact that higher inflation creates higher profit ensuring higher rates of return ($b_2 > 0$).

Macroeconomic adjustment, particularly in LDCs, is usually not as easy as described in the preceding paragraph. Inefficient and less-developed commodity and financial markets, direct government interventions and a number of market imperfections may prevent the economy from reaching equilibrium. In the following section, one of the well-known financial market imperfections in LDCs and the role of financial intermediation in the elimination of the gap between investment and saving are discussed.

(i) Financial Intermediation and Investment

Some research on investment has been stimulated by the well-known financial repression theory of McKinnon and Shaw postulating that substantial improvements in financial intermediation are a precondition of an increase in the level of domestic savings and of the better allocation of those savings from low-return projects to high return ones [see e.g. Galbis (1977) and Fry (1988)]. It is for this reason that many developing countries started reforming their financial system in the 1980s. The original theoretical model of the McKinnon and Shaw hypothesis which provided a rationale for financial liberalisation as a means of financial development and economic growth emphasised particularly on interest rate ceilings on lending and deposit rates in terms of financial repression. The formal model assumes that the private sector consists of a single entity without any formal distinction between household and corporate sector, although their saving behaviour differs totally in response to an increase in interest rates. A crucial, (and also the most controversial) assumption of this theory is that investors constrained by the availability of financial funds must accumulate money balances before undertaking investment. The underlying presumption of the theory is that higher real rates of return on domestic financial assets, especially bank deposits, that are dominant in the case of financial markets in developing countries, would encourage both savings and capital accumulation. It is argued that where the rate of interest on bank deposits is below the equilibrium level, a higher level of real deposits would increase the willingness to save and thus reduce the saving-constraint on investment. Increases in the volume of domestic savings are not the only impact of financial liberalisation.

Following a relaxation of the saving-constraint on investment, a high interest policy allows the market to distinguish poor projects from relatively more productive ones but with a high risk premium. In other words, under the fixed and low interest rate policies, some profitable but risky projects could not be undertaken because lenders would ration such projects by non-price means, and finance relatively safe projects at the given interest rates. However, if interest rates are allowed to adjust freely, then lenders can charge risk premium over the principle rates (or risk-free rates) to protect themselves from the possible bankruptcy risk of the borrower, and then they relax the high degree of stringency of borrowing constraints on firms' financing and investment decisions. Therefore, potentially profitable but risk projects could find an oportunity to be financed through bank credits at the rates determined according to riskiness of borrowers.

Empirical research in the financial liberalisation literature stresses on modelling the causality from increased saving and investment. McKinnon focuses essentially on the response of the *demand for real money balances* to the real interest rates, which is the only financial source of investment in the McKinnon model. He assumes two assets held by agents; namely money and risky capital. According to him, these two assets are complements, but not substitutes. Since physical capital is indivisible, a potential investor, who is initially constrained by the availability of financial funds, first accumulates money balances and then undertakes investment project by using these accumulated funds. From McKinnon's point of view, increases in the real return on money assets will raise the demand for real money balances under the complementarity assumption. This theoretical explanation can be summarised by the following two equations describing the real money balance and the demand for capital asset respectively [Fry (1978)]:

$$\left(\frac{M}{P}\right)^{*} = f\left[\frac{Y}{P}, \frac{I}{Y}, \left(d - p^{*}\right)\right] \tag{25}$$

Likewise, the demand for investment can also be written as a function of r and (d-p*):

$$\left(\frac{I}{Y}\right) = g\left[r, \left(d - p^{*}\right)\right] \tag{26}$$

where $(M/P)^*$: the demand for real monetary balances including savings and deposits; Y: real income; I/Y: the ratio of gross investment to GNP; d: the interest rate of deposit.; p^*: the expected inflation rate; r: the average return to physical capital.

According to the McKinnon complementarity, the real return on capital positively affects the demand for real money balances. In a partial derivation representation, this can be shown as

$$\frac{\partial (M/P)^{*}}{\partial (I/Y)} > 0, \quad \frac{\partial (I/Y)}{\partial \left(d - p^{*}\right)} > 0 \tag{27}$$

Note that the positive relationship between the ratio of investment to GNP and the real interest rate will become negative when the real interest rate reaches positive values [see Roe (1982)].

McKinnon's explanation of the financial repression is based on the assumption that household-firms are the main units of the economy of a LDC, and rely only on self-finance [Fry, (1988)]. Shaw (1973), on the other hand, considered the number of financial assets intermediating between savers and investors, and introduced debt finance into the model. In Shaw's model, the demand function for real money balances is defined in a similar way, but a variable showing the average opportunity cost of holding money, v, for the rate of return on capital is replaced for (I/Y) as follows.

$$\left(\frac{M}{P}\right)^{*} = f\left[\frac{Y}{P}, v, \left(d - p^{*}\right)\right] \tag{28}$$

There is no complementarity assumption in Shaw's model because investment is not self-financed. If the internally generated funds are not enough, it is assumed that investors would borrow from formal and informal markets.

A substantial amount of empirical research has been carried out to assess the validity of the McKinnon-Shaw hypothesis through the model described in (35)-(38). Although the tendency is to accept the hypothesis [see Fry (1978), (1980), (1988), McKinnon (1992)], the results of some papers have been ambiguous [see Galbis (1979), de Melo and Tybout (1986), Giovannini (1983)]. In a number of papers, Fry has argued the importance of finance in economic development, and tested the McKinnon-Shaw hypothesis for a group of countries. He found supportive evidence, in favour of the hypothesis, for the Asian countries over the time period of 1962-72, reporting that the real interest rate has a positive effect on domestic saving and growth. Giovannini (1983) questioned Fry's results, however, and assessed the robustness of the results obtained for the same countries but over a different sample period. Then he concluded that *"a positive and significant real interest rate elasticity of savings [as claimed in Fry (1978)] is hard to come by"* [Giovannini (1983): 601]. Giovannini's results were, to some extent, supported by Gupta (1987). Gupta examined the role of interest rates and financial intermediation as determinants of aggregate savings for a large group of heterogeneous countries which were selected from Asia and Latin America. He reported that the coefficient of nominal interest rates is insignificant for the entire sample group. Disaggregating sample countries, some supportive evidence for the McKinnon-Shaw hypothesis was found for Asian countries, but not for Latin American countries.

(ii) An Alternative Modelling Approach

Empirical application of the theory developed by McKinnon and Shaw disregards the negative effect on investment of high real interest rates above the equilibrium level via increases in the user cost of capital as defined in the neoclassical model [see Roe, (1982), Rittenberg (1991)]. Note that the positive effect of a rise in the real interest rates is a consequence of the excess demand for investment. During the financial liberalisation, however, an economy that was previously rationed by the available funds (as postulated by the McKinnon-Shaw hypothesis) may go into another disequilibrium situation where the excess supply of investable funds due to the high real interest rate over the equilibrium level is constrained by the shortage of investment demand. In other words, in the wake of financial liberalisation the economy may switch between excess demand for and shortage of investment. Any model assessing the effect of financial liberalisation on investment demand must recognise these different disequilibrium situations and the endogeneity of saving constraints.

Consider the equilibrium condition described in the McKinnon-Shaw model as follows

$$I \equiv I^n \equiv S^n \tag{29}$$

where I: realised investment; I^n: the notional investment; S^n: the notional savings. According to this identity, the demand for and supply of investable funds, I^n and S^n respectively are identical to the realised investment. The real notional interest rate is to be determined by the intersection of I^n and S^n. In a disequilibrium situation, in which the realised investment diverges from its desired level, the actual level of investment is determined according to

$$I = \min\left(I^n, S^n\right) \tag{30}$$

where

$$I^n = A_1 x_1 + \omega_1 \tag{31}$$
$$S^n = A_2 x_2 + \omega_2 \tag{32}$$

where x_i is a set of exogenous variables, A_i is an unknown coefficient matrix, and w_i is normally distributed random variables. The important aspect of the model is that only the realised investment, I, is observed in reality. It is not known a priori whether any value of I is determined by I^n or S^n.

In the financially repressed economy described by the McKinnon-Shaw model, the desired investment demand function generates excess demand for investment at the disequilibrium (negative) real interest rate, and the realised investment function is determined by the desired savings function;

$$I^n > I = S^n \tag{33}$$

On the other hand, if the real interest rate is too high (over the equilibrium rate), the binding function will be the desired investment function which set the upper bound on the supply of investable funds;

$$S^n > I = I^n \tag{34}$$

At this stage the problem is to estimate the parameters of the market in disequilibrium simultaneously. Maddala (1993), at the theoretical level, suggests a method for the estimation. A similar method has been used, by Gersovitz (1982), to develop a methodology in order to assess the prospects for estimating a two-gap model in LDCs. The problems with disequilibrium estimations are that we can observe only realised investment, I_t, but not desired investment and savings. However, it may be possible to estimate the joint likelihood of having dependent variable conditional sometimes on $I^n<S^n$ in the case of excess demand for investment (transactions in the market is determined by the volume of savings supply), and sometimes on $I^n<S^n$ in the case of excess supply of savings (transactions in the market is determined by the demand for investment) . For this purpose, let h(I) denote the likelihood of the realised investment and $g(I^n,S^n)$ be the joint likelihood of the desired investment and savings functions. Therefore

$$h(I)=\int_I^{\infty} g(I,S^n)dS^n+\int_I^{\infty} g(I^n,S)dI^n \tag{35}$$

The first part of the likelihood function h(I) refers to a situation where $I^n>I=S^n$ whereas the second part refers to a situation where $I^*>I=S^*$. w_1 and w_2 are independently distributed with variances σ_1^2 and σ_2^2. Then the probability density function, $f(I_t)$, and cumulative density function, $F(I_t)$, of the error terms are

$$f_i(I)=\left(1/\sqrt{2\Pi\sigma}\right)\exp(-1/2\sigma_i^2)(I_t-A_i x_i)^2 \tag{36}$$

$$F_{I^n}(I)=\int_I^{\infty} f_{I^n}(I^n)dI^n,\quad F_{S^n}(I)=\int_I^{\infty} f_{S^n}(S^n)dS^n \tag{37}$$

Therefore, the joint likelihood function is

$$h(I)=f_{I^n}F_{S^n}+f_{S^n}F_{I^n} \tag{38}$$

However the sample separation according to two different disequilibrium regimes is still unknown. Gersovitz (1980) developed a method for regime membership. Accordingly, the probability that an observation comes from one particular regime, say the regime where $S^n>I=I^n$, is written as

$$P\left(I^n|I,x_1,x_2\right)=\frac{f_{I^n}F_{S^n}}{f_{I^n}F_{S^n}+f_{S^n}F_{I^n}} \tag{39}$$

Gersovitz (1982) applied this technique to a group of developing countries in Latin America to determine which constraint, the saving or foreign exchange constraint, hold at different times. The results suggested that economic growth is more often constrained by savings than foreign exchange.

(iii) The Modified Flexible Accelerator Model

Many models used to distinguish the determinants of private investment have been a modified accelerator model that includes variables designed to capture the constraints and structural characteristics of a typical developing country [Sundararajan and Thakur (1980), Blejer and Khan (1984), Morisset (1993)]. The investment function for the private sector is written as follows:

$$I_t^p = \theta K_t^{p*} - (\theta - \delta) K_{t-1}^p \tag{40}$$

where I_t^p: private investment; K_t^{p*}: the optimal capital stock for the private sector; θ: the speed of the partial adjustment; δ; the rate of depreciation. The models in this line incorporate various constraints of concern through the definition of the partial adjustment mechanism θ. Following Coen (1971), they assume that the speed of the capital adjustment process is influenced by some factors (such as the availability of credit to the private sector, public capital stock); that is

$$\theta = f(x) \tag{41}$$

where x is a set of exogenous variables affecting the speed of adjustment. In this section, some well-known adapted flexible accelerators are reviewed with their ways of dealing with some characteristics of LDCs (such as credit rationing).

Sundararajan and Thakur (1980) is one of the first attempts to formulate aggregate private investment in developing countries in this line. Their main concerns are the roles of public sector, relative prices and domestic savings in the determination of private investment. They make an effort to formulate the private investment model particularly in line of the neoclassical model. The same model has been used subsequently with minor modifications [Tun Wain and Wong (1982), Blejer and Khan (1984), Chhibber and van Wijnbergen (1992), Morisset (1993), and Voridis (1993)].

Modelling starts with the minimisation of the sum of the present and future costs of production and capital. As easily noticed, the model does not have any adjustment cost, but assumes an *ad hoc* partial adjustment mechanism. Three production factors -labour, private and public sector capital stocks- are included in a Cobb-Douglas production function, supposing that the elasticities of substitution between these factors are unity.

$$Y_t = A\left(K_t^g\right)^{\alpha_1}\left(K_t^p\right)^{\alpha_2}\left(L_t\right)^{\beta}, \qquad A, \alpha_1, \alpha_2, \beta > 0 \tag{42}$$

where K_t^p: public capital stock; L: labour; A: constant. They treat public capital stock as exogenous. The first-order conditions of the cost minimisation give the definition of the user cost of capital and the optimal capital stock in connection with the Cobb-Douglas production function assumption.

$$c_t = q_t^I\left(r_t + \delta - \hat{q}_t^I\right),\ \hat{q}_t^I = \dot{q}_t^I / q_t^I \tag{43}$$

$$K_t^{p*} = a_0\left(c_t / w_t\right)^{a_1}\left(K_t^g\right)^{a_2} Y_t^{*a_3} \tag{44}$$

$$a_1 = -\beta/(\alpha_2+\beta),\ a_2 = -\alpha_1/(\alpha_2+\beta),\ a_3 = 1/(\alpha_2+\beta)$$

where c: the implicit user cost of capital; w: wage rate; q^I: the price of capital goods; r: the short-term interest rate; $\hat{q}^I$: the rate of inflation in the price of capital goods. In the absence of adjustment costs, firms are able to adjust their capital stock instantaneously. Despite this, the net investment function is assumed to be derived from the *ad hoc* partial adjustment mechanism as follows

$$\Delta K_t^p = \theta\left(K_t^{*p} - K_{t-1}^p\right) \tag{55}$$

Even though Sundararajan and Thakur use the elements of the Jorgenson model without adjustment cost, the adjustment mechanism noted above confirms the existence of a lagged adjustment process which itself indicates adjustment costs.

So far, the model is quite identical to the original neo-classical representation. However, like Coen (1971), they presume that the speed of adjustment, given by the adjustment coefficient θ, is a variable determined by the funds available to finance investment expenditure [see Chapter 3]. In other words, an increase in credit availability to the private sector generally will encourage real private investment. In the case where the volume of such funds is low, the adjustment towards the optimal capital stock would take relatively more time than it would be otherwise. Consider the partial adjustment formulation given above. As will be noticed readily, the adjustment coefficient might be defined as a ratio of actual investment to the desired investment. But in the light of the discussion made above, the correct representations of θ in a constrained and unconstrained situations respectively ought to be

$$\theta = \frac{\Delta K_t^p}{\left(K_t^{*p} - K_{t-1}^p\right)} \text{ if } S_t^{net} > \Delta K_t^p \tag{46a}$$

$$\bar{\theta} = \frac{S_t^{net}}{\left(K_t^{*p} - K_{t-1}^p\right)} \text{ if } S_t^{net} \le \Delta K_t^p \tag{46b}$$

where S_t^{net}: net savings; $\bar{\theta}$: the constrained level of the adjustment coefficient for the capital stock. The adjustment would slow down only if $S_t^{net} < K_t^p - K_{t-1}^p$. Following Coen (1971), Sundararajan and Thakur, therefore, apply the model to LDCs at the macroeconomic level, assuming that the financial constraint is given by the amount of saving net of public investment. Unlike our presentation of θ, they write the following formula to indicate the speed of adjustment without any distinction between constrained and unconstrained situations:

$$\theta = b_0 + b_1\left[\frac{(S_t - I_t^g)/q_t^p}{(K_t^{p*} - K_{t-1}^p)}\right], \quad b_0, b_1 > 0 \tag{47}$$

where I_t^g: public investment; q_t^p: the price index of private investment goods. This definition of θ now requires a little attention. First of all it is quite misleading, since it does not represent any binding credit constraint at all, and gives our derivation of θ, we believe that it is relatively more consistent with the fact that the desired investment level is rationed by the amount of saving available to private sector, only if b_0=0 and b_1=1 [see McKay and Whitley (1992)]. This can easily be seen in the following representation of the above equation;

$$\Delta K_t^p = b_0\left(K_t^{p*} - K_{t-1}^p\right) + b_1\left[\left(S_t - I_t^g\right)/q_t^p\right] \tag{48}$$

The right-hand side terms represent the partial adjustment effects of capital adjustment and savings, indicating that the savings constraint is not strictly binding (b_0, b_1>0). According to the ex post savings and investment identity however, the realised investment demand will be limited by savings at the macroeconomic level. If b_0=0 and b_1=1, then the first term on the right-hand side will be eliminated, and a more accurate form of the adjustment coefficient will be derived:

$$\bar{\theta} = \frac{(S_t - I_t^g)/q_t^p}{(K_t^{p*} - K_{t-1}^p)} \quad \text{if } \Delta K_t^p = \left(S_t - I_t^g\right)/q_t^p \tag{49}$$

Remember that gross investment is the sum of net investment ΔK_t and depreciation δK_{t-1}. But with respect to the constraint above, savings cover only net investment, not depreciation. In order to keep the capital stock unchanged, the assumption that savings are net of depreciation is required. Sundararajan and Thakur's formulation can actually be used only when the actual level of investment is always equal to total saving available to private sector; in other words, when $\left(S_t - I_t^g\right) \le I_t^p$. Moreover their specification of θ says nothing about what happens when $\left(S_t - I_t^g\right) > I_t^p$. In the last case where the constraint is not binding, firms would follow the optimum paths of investment and adjustment. The optimality in that sense would require an optimum investment level between zero and the upper bound set by the savings constraint $(S_t - I_t^g)$. Assuming that $(S_t - I_t^g) = I_t^p$, when the constraint is actually not binding, and using the formula of θ defined as in Sundararajan and Thakur (1980) would therefore not be optimal since firms would be able to invest by the amount of desired investment. In practice, an economy might move between those two situations defined here. Which situation is prevailing in the paper is unfortunately not well defined, however.

At the next step, they simply substitute θ and the optimal capital stock derived above into the formulation of gross investment, and derive the following investment function:

$$I_t^p = B_0 + B_1(c/w)_t + B_2a(L)Y_t + B_3K_t^g + B_4\left[\left(S_t - I_t^g/q_t^p\right)\right] + B_5K_{t-1}^p \tag{50}$$

where a(L) is the lag polynomial of income. The model is able to capture the accelerator effect of aggregate income by B_2. The crowding-in effects of government capital stock is expected to be given by B_3 whereas the crowding-out effects of public investment, by competing for the existing volume of credit in the domestic economy and creating financial constraint on investment, are given by B_4.

Their model is a three-equation system including private investment, savings and production functions. The estimations of the neo-classical private investment function fit the data of India and Korea (adjusted R^2s are 0.95 and 0.99 respectively). All explanatory variables are statistically significant, except public capital stock, and have the expected signs. The accelerator effect is highly significant in both countries, but its effect on private investment is higher in Korea than in India. The financial resources measuring the crowding-out effect of public investment are highly significant and very strong; for comparison, it is 0.63 in India, 0.26 in Korea which is lower than in India. But this is not once-for-all effect. Since the model includes the public production equation, which is a positive function of public capital stock, then the positive effect of an increase in public investment on output overall will influence output expectations, saving, and in turn may offset the immediate crowding-out effect either partly or completely.

Tun Wain and Wong (1982) is another well-known study in the field. The theoretical structure is similar to that of Sundararajan and Thakur's model but with a number of modifications. First, unlike Sundurarajan and Thakur, Tun Wain and Wong do not include any relative price variable. Second, they suppose the speed of adjustment is determined by two different factors, namely changes in bank credit to private sector and net capital flows, including foreign capital, to the private sector:

$$\theta = f\left(\frac{\Delta Crp_t}{K_t^{p*} - K_{t-1}^p}, \frac{Cmp_t}{K_t^{p*} - K_{t-1}^p}\right) \tag{51}$$

where ΔCrp: changes in bank credit to the private sector; Cmp: net capital inflow including foreign credit. The function relating those variables to the adjustment coefficient is assumed to be linear. They then derive the gross investment function through an *ad hoc* adjustment mechanism. From the naive accelerator model, the desired level of capital stock is assumed to be proportional to the level of private sector output, which is itself a function of public investment and private investment. Going one step further, since the costs of credits from different sources are assumed not to be significantly different (i.e. they are perfect substitutes), the origins of credit may be immaterial. Thus, instead of defining two different variables of credit they employ only one variable which is the sum of changes in bank credit and net capital inflows. They derived two similar equations by assuming that (51) is linear. In the first linear one, private investment is a function of the private sector output (Qt), bank credit to the private sector, net capital inflow to the private sector, and the private capital stock.

$$I_t^p = B_0 + B_1 Q_t + B_2 F_t^p + B_3 K_{t-1}^p + u_{1t} \tag{52}$$

In the second one, they assumed that private sector output is a linear function of government investment and private investment, and they then reached a single linear investment equation (53) in which government investment, total credit and the lagged value of private capital stock appear on the right-hand side.

$$I_t^p = B_0 + B_1 I_t^g + B_2 F_t^p + B_3 K_{t-1}^p + u_{1t} \tag{53}$$

where F_t^p: the sum of the change in domestic credit to the private sector and the net capital inflow to the private sector. Government investment in the equation seems to have a positive impact on private investment but it may exaggerate the crowding-in effect if the likely crowding-out effect through financial variables is not considered . This problem is simply sorted out by specifying two additional equations to the previous one:

$$F_t = F_t^p + F_t^g \tag{54}$$

$$F_t^g = g_0 + g_1 I_t^g + u_{2t} \tag{55}$$

where F_t^g: the change in banking system's claim on the government net of government deposits plus net foreign capital inflow to the government. The first equation above simply shows that the volume of total credit is allocated between public and private sectors. The amount of credit used by public is determined by government investment as given in the second equation. Having substituted F_t^p -in terms of F_t and I_t^g- into the investment function defined earlier, the final reduced form, that is the second equation to be estimated, is written in the following form:

$$I_t^p = k_0 + k_1 I_t^g + k_2 F_t + k_3 K_{t-1}^p + v_t \tag{56}$$

$$k_0 = B_0 - B_2 g_0,\ k_1 = B_1 - B_2 g_1,\ k_2 = B_2,\ k_3 = B_3$$

They estimated two single equations (52) and (53) for each of Greece, Thailand, Malaysia, Korea and Mexico. In the context of the single equation estimation, they use two different forms, one of which is estimated under the assumption that changes in bank credit and net capital flow are not perfect substitutes, therefore each of them exhibit different effects on private investment. This equation did pretty well for all countries in terms of the goodness of fit. Although the t-statistics of the estimations are not very promising, they judged the relative importance of each variable on the basis of partial correlation. Accordingly, apart from other variables, public investment appears to be the most significant variable in Greece, Korea and Malaysia. In Thailand, bank credit comes out significant whereas capital inflow is the most important factor in Mexico. The results of the equations estimated under the perfect substitution assumption are similar. Through the reduced form of a three-equation recursive system, they were able to assess the net effect of public investment. The net effect, the crowding-in effect less crowding out effect, seems to be positive in Greece, Korea and Malaysia.

Blejer and Khan (1984) is, in many respects, similar to previous models. Their main concern is upon the data problem with net investment, capital stock and public investment. The model developed by them, to some extent, deals with that problem as in what follows. Unlike the others, keeping the assumption that the desired stock of capital is proportional to expected capital stock, they write the partial adjustment equation for gross investment in steady state:

$$\Delta I_t^p = \theta\left(I_t^{p*} - I_{t-1}^p\right) \tag{57}$$

where I_t^{p*} is defined in terms of K_t^{p*}, using the capital accumulation equation:

$$I_t^{p*} = \left[1 - (1-\delta)L\right] K_t^{p*} \tag{58}$$

where

$$K_t^{p*} = \gamma Y_t^e \tag{59}$$

Y_t^e: the expected level of output; γ: the capital-output ratio. The speed of adjustment, given by θ, is assumed to be determined by a linear function of capital utilisation indicated by the difference between actual and trend output (GAP), changes in real bank credit to the private sector plus net private capital flows (ΔDCR), and real public sector investment (GIR);

$$\theta = b_0 + \frac{1}{\left(I_t^{p*} - I_{t-1}^p\right)}\left(b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t\right) \tag{60}$$

The effects of credit constraints are captured by ΔDCR. The credit constraints formulated in the form of (60) are assumed not to be strictly binding. Substituting all these equations into the adjustment equation yields a dynamic reduced form for gross private investment including financial constraints and public investment

$$I_t^p = b_0 \gamma \left[1 - (1-\delta)L\right] Y_t^e + b_1 GAP_t + b_2 \Delta DCR_t + b_3 GIR_t + (1 - b_0) I_{t-1}^p \tag{61}$$

The model is applied to a cross-section of 24 developing countries over the time period 1971-1979. The study supported the direct link between government policy variable and private investment. They also showed empirically that private investment in LDCs is constrained by monetary policy by varying the flow of credit to the private sector. The variable *ΔDCR* has positive effects in the estimation, and its estimated coefficient is significantly different from zero at the 5 percent level. If the overall quantity of financial resources is given, then any increase in the share of the government's use of financial resources would lead to crowding out and to a decline in the level of private investment. Blejer and Khan (1984) suggested that such a decline in the share of private investment would also result in a fall in total investment.

3. Some Other Theoretical Issues

Although different groups of studies have given different weights to their relative effects on investment, the empirical literature on investment in industrial countries has consistently revealed three variables to be important in explaining the fluctuation in private investment. These are changes in output (that can be taken as an 'accelerator' variable), the cost of capital, and the financial position of a firm. A number of additional factors can also be included to reflect the complexity of the investment process in developing countries. In addition to those given for industrial countries, public spending, trade and exchange rate policies, credibility of economic policies and instability in the economic system can be considered to be significant influences on private investment behaviour in LDCs. The present section deals with examining possible additional factors, other than financial ones, that have been widely studied in the context of the determinants of private investment in developing countries.

3.1. Public Spending:

Public spending in most LDCs is effectively used as a policy variable to stimulate economic growth. However, recent research activities have repeatedly shown that the contribution of public investment to economic growth is lower than that of private investment [Khan and Reinhard (1990)]. The effect of public spending on private investment has, on the other hand, been ambiguous, and been shown to depend on two fundamental opposite forces (as described below). In the wake of the World Bank-IMF supported structural adjustment programmes, reshaping the composition of public spending in favour of infrastructure investment has been the main policy recommendation of structural adjustment programmes to encourage the private sector.

There are a number of reasons to believe that public spending has a positive effect on private investment. First, if economic resources are not fully utilised, an increase in public spending would increase the level of income through the Keynesian multiplier effect and raise the profitability of the production of the private sector by augmenting the demand for output produced by that sector. Second, public spending on social and economic infrastructure capital formation would also have a positive effect on the private sector through the elimination of some supply-side bottlenecks such as lack of transportation and communication facilities, or the shortage of qualified labour force. Third, public investment in certain areas such as transportation, communication, energy, education, health etc. would generate externality effects on the private sector, and increase total factor productivity. These effects together define the crowding-in effect of public spending.

Having indicated the positive effects of public investment, one can also find arguments indicating the opposite effect. On the real side of the economy, public investment undertaken by heavily subsidised and inefficient state-owned firms may, in general, discourage the production of the private sector. Public investment competes with the private sector not only for scarce real resources, but also for financial resources. For example, the government would finance public investment through borrowing from the domestic financial market which eventually pushes up the rate of interest or reduces the volume of credit available to the private sector, or both, thus crowding out private investment.

There has been some empirical work on the effects of public investment on private investment. Despite the recognition of the distinction between different kinds of public investment, such as infrastructural and noninfrastructural public investment, the detailed analysis of the impacts of each type of public investment is limited by the lack of disaggregate data at that level. Instead, many studies have used real aggregate public investment [Wai and Wong (1982), Sundararajan and Thakur (1980), Greene and Villanueva (1991), Shafik (1992), Bairam and Ward (1993), and Ramirez (1994)]. The only exception appears to be Chhibber and van Wijnbergen (1992), who employed infrastructural and noninfrastructural public investment separately for the estimation of Turkish private investment; however they were forced to use a shorter time series because disaggregated public investment data is available only form 1970 onwards. In Schmidt-Hebbel and Müller (1992), crowding in of private investment in response to public investment in infrastructure capital was captured by employing the public sector capital stock of Morocco.

Blejer and Khan (1984), however, generated proxy variables for infrastructural and noninfrastructural public investment by suggesting two different methods. Assuming that infrastructural public investment is a long-term investment because of a long gestation period, and cannot be adjusted in the short run, they took the trend level of real public investment to represent the infrastructural component. The noninfrastructural component is, on the other hand, calculated as a difference of real public investment from its trend level. According to the second method they employed in their seminal paper, they distinguished the expected and unexpected levels of public investment. Since the infrastructural component of public investment cannot be changed by surprises in the short run, the expected value of real public investment is assumed to be the infrastructural component of public investment. Because of the lack of insufficiently long time series data, they assumed that the expected level of public investment was determined by a first-order autoregressive data generation process (i.e. AR(1)). Having estimated the AR(1) process of real public investment, they calculated predicted values, and then regarded them as the expected value of real public investment. Besides, the residuals from that autoregressive process were also considered as the unexpected component, and substituted for the noninfrastructural public investment. Blejer and Khan found that the level of public investment has positive effects on private investment, whereas changes in government investment has a negative effect. When they proxied public infrastructure investment by the trend of real public investment, they found complementary effects of public sector infrastructure investment, whereas other kind of public investment exhibits substitution effects. The same pattern was obtained from equation in which the distinction is made between the expected and unexpected increase in public investment. Accordingly, an expected increase in public investment raises private investment, but an unexpected increase has the opposite effect.

3.2. Trade Liberalisation and Exchange Rate Policies:

Contractionary economic shocks facing many developing countries (such as an increase in the world interest rate, the decline in foreign lending and the deterioration of terms of trade etc.) led them to re-examine their development strategies with the guidance of international institutions such as the World Bank and International Monetary Fund. Many countries have then implemented relatively liberal market-based reforms which have been expected to stimulate economic growth via capital accumulation. Trade liberalisation aims to reduce the disparity between domestic and world relative prices, created by intensive government interventions, and to ease the flow of goods and services between countries. Trade liberalisation can, besides, influence the incentive structure of private investment. The existing theoretical literature emphasises the two potential impacts of trade liberalisation on private investment: i.) direct impacts through easing to import the foreign components of investment goods; ii.) indirect incentive effects through the implicit cost of capital. Since developing countries must import most capital goods, trade liberalisation in the form of removal of quantitative restrictions and reductions in tariff dispersion is expected to encourage investors to invest more by enabling them to import more easily. If capital goods, however, had the lowest tariffs, reductions in tariff dispersion could penalise capital goods [see Bleaney and Fielding (1995)].

Given the dependence on imports not only of investment goods but also of materials inputs, the cost of capital and production (thereby profitability) are also indirectly affected by trade liberalisation. For example, tariff reduction might decrease the cost of imported components of investment. To be more precise and to show the direct and indirect incentive effects of trade liberalisation on the cost of capital, consider the following optimality condition between the marginal productivity of and the cost of capital[3]

$$\frac{\partial}{\partial K_t} F\left(w_t/p_t, v_t/p_t, K_t\right) = c_t = \frac{q_t\left(r_t+\delta\right)(1-\Gamma)}{p_t(1-\tau)} \tag{62}$$

where $F(.)$: the neoclassical indirect production function; w_t/p_t : real product wage; v_t/p_t : the real price of materials inputs; q_t : the price of capital goods; r_t : the real discount rate; δ : the rate of depreciation; τ : the corporate tax rate; p_t : output prices; Γ

[3] see Chapter 2 for the derivation of a relatively simple version of this optimality condition in Jorgenson tradition.

: the present value of the after tax cash flow attributable to depreciation allowances, investment grants and investment tax credits received by the firm [see Auerbach (1990)]. To show the indirect effects of the real price of wages and materials inputs, assume that the production function, F(.), has the separable form in which each component determined by relative prices and the capital stock is separated as in $F(.) = \theta(w_t/p_t, v_t/p_t)G(K_t)$. Then (1) can be rewritten as

$$\frac{\partial}{\partial K_t}G(K_t) = c_t = \frac{q_t(r_t + \delta)(1-\Gamma)}{\theta(w_t/p_t, v_t/p_t)p_t(1-\tau)} \tag{63}$$

The indirect incentive effects of trade liberalisation emerge through the function θ. Interventions into trade such as imposing tariffs, and quantity restrictions might distort the domestic prices of capital goods and materials inputs from world prices. A tariff on materials inputs at rate t_m, for example, acts as an indirect tax on investment by increasing their prices to $v_t = (1+t_m)v_w$ where v_w : the world price of material inputs. On the other hand, a tariff at t_p rate would also increase the output price, relative to the world prices, to $p_t = (1+t_p)p_w$ where p_w : the world price of output.

To sustain external balance as considered in the two-gap models, trade liberalisation in many developing countries has been accompanied by a combination of a reduction in public spending and expenditure switching policies including changes in the incentive structure between tradable and nontradable industries and a real depreciation of domestic currencies. Devaluation, in fact, affects private investment through various channels: i.) Since devaluation, other things being equal, raises the demand for domestically produced goods and therefore their profitability, one might expect it to increase private investment in sectors where those goods are produced; ii.) because investment goods in developing countries combine domestic components (nontradable goods such as constructions, infrastructure) and imported components, a real depreciation of domestic currency raises the real cost of imported components of investment goods and discourages the production of investment goods; iii.) real devaluation affects private investment through the supply price of capital. A real devaluation lowers the overall supply price of capital in sectors that depend heavily on traded capital goods and raises the supply price of capital in sectors in which nontraded goods have the largest share of investment cost. The net effect depends on the relative shares of traded and nontraded goods in total investment cost. iv.) Given that nominal wages remain fixed, a real devaluation lowers real wages, and leads to an increase in profitability and then investment; v.) In an open economy, the real domestic interest rate is regarded as the sum of the real foreign interest rate and the real expected depreciation. It is then expected that a real depreciation decreases the real domestic interest rate to the level of foreign interest rates if the domestic and foreign assets are perfect substitutes; vi.) A real devaluation also influences the real value of foreign liabilities. Depreciation of the domestic currency will automatically raise the debt burden of firms with foreign debt, reducing the net worth of firms producing home goods.

3.3. Credibility and Instability:

While uncertainty has been recognised as one of the important factors affecting private investment decisions, the direction of this effect has been controversial. One branch of research has argued that private investment of a risk-neutral firm always reacts positively to an increase in output price volatility [Hartman (1972), Abel (1983)]. This line of research has ignored both the irreversibility of investment decisions and the curvature of the adjustment cost function [see Chapter 2 for details in adjustment cost functions]. But Pindyck (1982), using different curvatures for adjustment cost functions, suggested that an increased uncertainty in output prices tends to raise investment only if the marginal adjustment cost function is convex. If the function is concave, then this causes a positive relationship between the increased volatility of output price and investment.

The recent literature on investment, however, has emphasised the irreversibility of investment [Pindyck (1991), and Dixit (1992)]. According to this literature, uncertainty plays a key role in investment decisions because of its three important characteristics [Pindyck (1993)]: i.) investment expenditures are largely irreversible in the sense that once put into place, the reallocation of capital involves an additional cost (the sunk cost argument); ii.) the economic environment where investment decisions are taken is uncertain and all relevant information about the feasibility of investment projects arrive gradually, and these are the costs of acquiring this information; iii.) investment expenditure can be delayed. Given all these factors, an increased uncertainty leads firms to spend more money and time on acquiring precise information before committing their financial resources. Particularly in a highly volatile environment, they wait and postpone investment until more information about the factors that might affect the future return of the project arrives. Instead of investing now and obtaining less return from the project, firms anticipate to increase the expected cash flows of the project to be owned in the future. The difference between the cash flows of owning the project now and some time in the future is called *the option value of waiting to invest* in the future [see Dixit and Pindyck (1994)].

From a policy perspective, the incomplete credibility of policy is another important source of uncertainty in developing countries. The aim of policy reforms like those that have been put into place in many developing countries in the 1980s is to move resources from economically less productive sectors towards relatively more productive ones. During this adjustment of capital, some costs may arise due to the facts that i.) capital is in fact not malleable but is sector specific, ii.) entry to new sectors and exit from unprofitable ones involves some sunk costs, iii.) the presence of other investment options with relatively less risk creates an option value to waiting in an uncertain economic environment. All those cost elements of adjustment are sunk in nature and cannot be recoverable once capital is put into place in the new sectors, and if these sectors become less productive as a result of policy reversal. The success of any type of reforms can be measured by the extent to which economic agents respond to incentives created by the reform. For this, economic agents must first be convinced that the reform is to be sustainable and there will be no policy reversal in the future, so that there is no incentive to delay in fixed capital investment.

There are several sources of credibility problems that have been considered in the literature [e.g. see Rodrik (1989)]. First, the lack of credibility may arise from inconsistent and conflicting policies implemented by the government. As such, expansionary fiscal and monetary policies (that violate internal and external budget constraint), over-valued exchange rate (because of nominal exchange rate policies designed to lower the rate of inflation) and declining trend in export performance lead entrepreneurs to anticipate the reversal from prevailing policies. Second, dynamic inconsistency of policies may be another source of unsustainability. In trade liberalisation, for example, after the private sector adjusts to signals of the liberalisation, the government sometimes wishes to behave according to the interest of beneficiaries of the previous policies as a result of pressures of lobbying groups. If the investors in the export-oriented sector understand the real intention of the government, then they may refuse to respond to the liberalisation policies. Third, the government may create an unclear environment regarding its real intention. Agents may wonder if the government fully commits itself to the reforms or is just trying to make some international institutions happy. Fourth, economic agents may anticipate possible political resistance to the reform from some social groups (such as trade unions) that may jeopardise the sustainability of the reforms.

Recently several authors have argued that lack of confidence regarding the future paths of economic reforms may induce failure of the reforms. Van Wijnbergen (1985) and Rodrik (1991a) attempted to conceptualise the relationship between the credibility of trade liberalisation, aggregate (and private) investment and capital flight.

At the macroeconomic level, van Wijnbergen (1985) demonstrated that after a trade reform, foreign exchange acquires an option value if there is a large probability of future reversal because of irreversibility of fixed capital investment. Increasing uncertainty regarding the future of the reform will decrease fixed capital investment, and induce capital flight. His conclusion is derived from a model where there are three assets (namely physical capital in import-competition sector, physical capital in export-oriented sectors, and foreign assets) with three different returns, that depend on the probability of policy reversal except for the foreign asset. He also pointed out the role of international institutions that could provide the loans necessary to sustain the credibility of reform attempts. He noted that by providing conditional loans to a developing country, those institutions may reduce the probability of such a reversal.

Using a simple model Rodrik (1991a), on the other hand, investigates the causal relationship between policy uncertainty and private investment at the microeconomic level. He particularly considered the irreversible nature of fixed capital investment in the presence of sunk cost of entry and exit between sectors with different rate of returns to capital. His model benefited mostly from the theoretical development in the irreversible investment literature, and was built upon the results of van Wijnbergen (1985). He proved that "uncertainty regarding the lasting power of reforms can act as a tax on investment, even when entrepreneurs are risk-neutral." [Rodrik (1991a): 230]. He argued that uncertainty of that type creates an option value to waiting, and results in the postponement of investment in the desired sectors until more information about the sustainability of the reform arrives.

He derived a basic equation which determines the factors influencing the entrepreneur's response to the trade reform with a degree of uncertainty. In a simple model he assumes that there are two options to employ capital. If an investor employed his capital in the first option, then he earns $(r-t_0)$ where r is the marginal product of capital, t_0 is the cost of distortions induced by economic policies. Or he alternatively earns r^* (for example in investing in foreign assets) that $r^* \geq (r-t_0)$. Assume that after the trade reform for instance, the distortion costs of economic policies is reduced to t where $t_0 > t$ (so that $(r-t_0) < (r-t)$), and $r^* < (r-t)$. The investor also expects that the reform has a constant probability of reversal, π, in the future. When the policy reversal occurs, the distortion cost returns to its level prior to the reform. Since capital is irreversible, adjusting capital from one sector to another requires sunk costs of entry and exit (θ and ε respectively). The risk-neutrality assumption of the investor also holds. Given the probability of policy reversal, the problem faced by the investor is how to allocate his capital between leaving capital assets in the existing sector where he earns r* or moving it to where he earns (r-t).

To find which option makes him better off, the investor calculates the values of each option. If he keeps his capital in foreign assets after the reform, his behaviour will be independent of the probability of policy reversal, and the option value of keeping capital in foreign assets will be

$$V_0 = r^*/\rho \tag{64}$$

where ρ is the discount rate, and "0" indicates the case where the investor does not change behaviour in response to the reform. Holding capital in the alternative option at the moment when the reform takes place also has the option value V_1, and depends both on the probability of the reversal and the cost that might occur if the reform is reversed. If we note that the value of holding capital after the reform is reversed is V_1^R, then $\pi(V_1 - V_1^R)$ is the expected capital loss that may be caused by the reversal. Then the option value of having capital in this option can be written as

$$V_1 = \{(r-t) - \pi(V_1 - V_1^R)\}/\rho \tag{65a}$$

or

$$V_1 = (\rho + \pi)^{-1}\left[(r-t) + \pi V_1^R\right] \tag{65b}$$

After the policy reversal occurred, the marginal rate of return to capital returns to $(r - t_0)$, and remains constant at that rate forever by assumption. In deciding whether to move capital to foreign assets or hold it where it is, the investor considers exit costs, θ as well. If $(r - t_0) < r^* - \rho\theta$ where $\rho\theta$ is the present value of exit costs, the value of V_1^R will be $(r^* - \rho\theta)$. Substituting V_1^R in (4), V_1 can then be rewritten as

$$V_1 = (\rho + \pi)^{-1}\left[(r-t) + \pi(r^* - \rho\theta)\right] \tag{66}$$

Having calculated the option values of two options, namely holding capital in foreign assets and investing in the domestic sector, consider now an investor who possesses capital in foreign assets in the beginning of the reform period. The rational investor would re-allocate his capital to the distorted domestic sector only if the option value of doing so is greater than holding capital in foreign assets, that is $V_1 \geq V_0 + \varepsilon$ where ε is entry costs to the domestic sector. Substituting this in (66) yields the following inequality rule for the re-allocation of capital between two options,

$$(r-t) - r_t^* \geq \pi(\varepsilon + \theta) + \varepsilon\rho \tag{67a}$$

or

$$t \leq (r - r^*) - \varepsilon\rho - \pi(\varepsilon + \theta) \qquad (67b).$$

This expression indicates the conditions under which the reform will be meaningful to an investor possessing foreign assets. The first term is the benefit that the investor might earn if he moves his capital to the domestic sector after the trade reform. The second term is the discounted entry cost that occurs if the investor decides to move capital to the domestic sector. The final term stands for the expected sunk cost of the reversal from the reform. According to (67b) the reform can induce this investor only if the difference of marginal benefits of alternative uses is higher that the policy-induced distortions. The conclusion from this result is that policy reforms would not be sustainable if there is doubt about their likely survival, and if they do not cover the investor's possible sunk costs arising from entry and exit costs of capital allocation. The higher the uncertainty regarding the survival of the reforms, the higher the inducement created by the reforms to convince the investor. Otherwise, the high probability of policy reversal may cause the investor to call off his investment plan until uncertainty on the future of the reform is resolved.

Ibarra (1995) has very recently provided empirical evidence for such an effect from the Mexican trade liberalisation experience. He quantified the probability of the policy reversal using a simple probit model in which the likelihood of the reversal is estimated depending on a set of values of the explanatory variables. In his simpler model, he considered the case where the balance of payments and a certain limit on the level of international reserves may determine the probability of reversal of the trade liberalisation. He assumed that the balance of payment deficits comprises two components, namely the component that is determined by the behaviour of rational economic agents and a random shock term, that is

$$B_t = \tilde{B}_t + e_t \qquad (68)$$

where $e_t \sim iid(0, \sigma^2)$. These deficits may be financed by either external borrowing or by international reserves that also impose an upper constraint on deficits. Then

$$R_{t-1} - B_t < R_t^{min} \qquad (69)$$

where R_t^{min} is the lower limit of the level of international reserves. Therefore the probability of policy reversal can be written as

$$\pi_t(B_t, \sigma^2, R_t^{min}) = prob.(e_t > R_{t-1} - \tilde{B}_t - R_t^{min}) \qquad (70)$$

In a more general model, he linked the likelihood of policy reversal to the balance of payments position, the trends of the real exchange rate, the type of fiscal policy followed by the government, monetary policy, and to other relevant information. The empirical results showed that the higher probability of reversal is associated with the deterioration of the balance of payments, the failure of the exchange rate to increase at the beginning and towards the close of the liberalisation period, and use of expansionary fiscal and monetary policies. He then predicted the probability of reversal from the estimated probit model, and then used them in the investment equation in which the accelerator variable and the relative cost of capital are two other explanatory variables in addition to the proxy variable for the probability of policy reversal. The results provided evidence that lack of credibility has been harmful to the rate of capital accumulation in Mexico.

George and Morisset (1995) re-examine the relationship between investment, the capital price and the accelerator in the presence of price uncertainty. They demonstrate that the sensitivity of private investment to variations in the price of capital and the accelerator variable declines once uncertainty regarding the capital and output prices are included. They also criticise the irreversible investment literature, which provides an explanation for the opportunity cost of investment in an uncertain environment, on two points: First, it is *too* restrictive in assuming that private investment will always react negatively to an increase in uncertainty. Second, the possible linkage between different sources of uncertainty (for example between uncertainty on the price of capital and uncertainty on the capital price) is omitted. One important conclusion emerging from their paper then is that private investment is *more sensitive* to changes in the price of capital or in the accelerator variable *if* i.) uncertainty about the price of capital is low, ii.) variations in output and the price of capital are *positively correlated*, iii.) the investor is *risk averse*, iv.) the volatility of output price is *higher than* the volatility of the capital price. George and Morisset applied their theoretical model to the Chilean economy, and estimated the following semi-log investment equation,

$$\ln I_t^p = \beta_0 + \beta_1 \ln Y_t + \beta_2 q_t + \beta_3 \left(\frac{\sigma_p^2}{\sigma_q^2} \right) + \beta_4 Cov.(p_t, q_t) + u_t \qquad (71)$$

$\beta_1, \beta_3, \beta_4 > 0$ and $\beta_2 < 0$

where σ_p^2, σ_q^2 are variances in the price of output and the capital prices respectively, $Cov.(p_t, q_t)$ being the covariance between the output and capital prices. Accordingly, if uncertainty of the price of capital is higher than uncertainty of the output prices (measured by their variances), then the optimal choice is less movement in private investment than in output. Given this, they argue that in order to obtain a desirable outcome from fiscal incentives, the priority should be given to the reduction of the volatility of the price of capital goods when the volatility of the output prices is already too high. Unlike the conventional belief that tax incentives induce private investment, they show that the type of policies that may create more uncertainty on the capital price than that on the output prices will reduce private investment. This is challenging because the main policy recommendation to stimulate private investment has been tax cuts, investment allowances or exchange rate policies that are more likely to cause more uncertainty about the price of capital. Therefore, the overall result from such incentives may be ambiguous. To obtain a desirable result, incentives must be reasonably high to cover the option value of waiting.

Aizenman and Marion (1993) investigate a causal link between macroeconomic uncertainty and private investment in developing countries. Despite the vast amount of theoretical literature concerning the interrelationship between uncertainty and investment, empirical testing of this relationship is quite difficult mostly because of the problem of the measurement uncertainty. They constructed measures of macroeconomic uncertainty and added them to investment equations that have previously been estimated in the endogenous growth literature. The measure of uncertainty they used is derived from a first-order autoregressive data generation process of each relevant macroeconomic variable. First, they estimate the AR(1) process for a variable with only fifteen observations, and then calculate the standard deviation of the residuals from the estimated AR(1) process. Variables, for which they constructed a measure of uncertainty, are government consumption expenditure, the share of public investment, the growth of government consumption expenditure, average tax rate (measured as a ratio of government revenue to GDP), government budget deficit scaled by GDP, domestic credit expansion and money growth. Then they estimated a cross-section investment equation using 40 countries. Their results supported the argument of the irreversible investment literature by estimating highly significant coefficients on the macroeconomic uncertainty variable. Therefore they concluded that uncertainty on macroeconomic variables has an important influence on private investment in developing countries, and for a successful macroeconomic policy, this uncertainty must be minimised.

Conway (1991) is the only study of the effects of relative price uncertainty on private investment at the aggregate as well as sectoral level (that are agriculture, housing, manufacturing, transport). He applied a standard Keynesian model, augmented by proxies for price instability, to the Turkish annual data. Instability in two relative prices, the expected variance of real interest rate and the expected variance of real exchange rate, are taken as measures of uncertainty. He regressed private investment on the real gross domestic product, expected values of the real exchange rate and real interest rates, and the variances of the real exchange rate and real interest rates. He set up forecasting rules of the real exchange rate and real interest rate for investors, and then estimated the optimal forecasts as the expected mean of the variable conditional on information available at the forecast period by using the *Kalman filter* method, which also provides the conditional variance of forecast of each price variable. His empirical results suggest that the measures of relative price uncertainty have negative and statistically significant coefficients. From the sectoral estimations, Conway also finds strong negative effects on private investment in all sectors (particularly in manufacturing).

4. Conclusion:

This chapter has reviewed the literature on modelling private investment in developing countries. In addition to conventional determinants of private fixed capital formation (namely the accelerator, the cost of capital, and financial factors), some other factors significant in the case of developing countries, such as the implications of fiscal and monetary policies, credibility of economic policies, have been discussed along with the empirical modelling issue. This chapter reveals that there is no acceptable general framework for analysing the determinants of private investment in LDCs. Most studies have used an *eclectic* approach in the sense that there is no exclusive formal microeconomic modelling on which the investment demand function is derived. Some studies have preferred the eclectic approach to highly theoretical modelling due to its more flexible structure to include additional variable of concern. The data availability to test the more standard model (like those in neoclassical tradition) has been a major problem facing researchers. To deal with this problem, some have used micro level data from a cross section of firms or industries. In terms of specification of models, these studies have shown much closer similarities to those for industrial countries. However, at the macroeconomic level, specifying a more structural investment model which is built upon the microeconomic foundation of firm behaviour still remains an unsolved issue in the empirical literature, and indicates the direction of possible future contributions to literature in this regard.

The recent research efforts in the empirical investment literature have been devoted to developing dynamic investment models with a rich microeconomic backround. These reseach efforts have already given rise to the Euler equation approach (i.e. a direct estimate of the first-order conditions of a firm's cash flow optimisation). This approach has increasingly been very popular recently for investigating the determinants of investment in developed countries. However, as seen from our survey of literature, there has been no contribution in this respect to the empirical investment literature in developing countries. To the knowledge of the author, testing the significance of an increasing risk premium function and binding borrowing constraint in a similar set up in particular has not been applied to any developing country yet. This constitutes another direction of the research agenda on the determinants of private investment in developing countries.

Part 2

An Empirical Analysis of the Determinants of Turkish Private Investment

Chapter 5

The Turkish Economy from A Historical Perspective

1. Introduction

This chapter mainly deals with an overview of the development experience of the Turkish economy from a historical perspective. Four distinctive sub-periods (each of which ended with internal and external imbalances and with the implication of stabilisation policies) are defined to analyse the sample period of 1960-1992 covered in the following empirical chapters. Private investment in this period shows a great variability in response to changes in economic policies. General trends in the share of private investment in GNP are analysed from both an historical and an international perspective. The sectoral composition of private investment over the 1973-1990 period is also part of the aim of this chapter.

The experiences of two different industrialisation strategies before and after 1980 determine the nature of economic problems and crises in each corresponding period. The interactions between the possible determinants of private investment and macroeconomic policies are also analysed in the chapter. Suggestive evidence can be found for the following factors affecting private investment in Turkey: high interest rates, public investment and availability of credit to the private sector. For a more detailed investigation, the present chapter reviews previous findings on Turkish private investment, and distinguishes modelling approaches of the thesis from those in the literature on developing countries in general, and Turkey in particular.

The chapter comprises seven sections. Following this introductory section, Section 2 analyses economic development and problems pre- and post-1980. Section 3 investigates the general trend in investment over the 1970-1990 period, together with comparisons of investment with some developing countries, as well as looking at changes in the sectoral composition. Being crucial factors in the determination of private investment in Turkey, financial constraints and the causes of these constraints are briefly explained in Section 4, together with some other factors. Section 5, on the other hand, summarises the previous studies on Turkish private investment, and distinguishes the differences of the modelling approach of the thesis from previous studies. Section 6 introduces the data sets that are used to estimate empirical models of the following three chapters, and discusses some problems associated with data. The chapter ends with some conclusions in Section 7.

2. Brief Economic History

Turkey's first experience with liberal economic policies dates back to the early 1920s. By the terms of the Lausanne peace treaty in 1923, Turkey was held responsible for the large amount of commercial debt of the Ottoman Empire, and was obligated to maintain a low tariff schedule until 1929 [see Kepenek and Yentürk (1994) for details]. In the early years of the Republic, the economy inherited from the Ottomans was heavily dependent on the agriculture sector and on the imports of manufactured capital and intermediate goods. Although the ultimate aim of the leaders was full *national economic sovereignty*, the first ideological initiative in favour of import-substitution industrialisation strategy in the 1960s and 1970s, they had no option (but liberal policies) due to terms of the treaty until the Great Depression hit the world as well as Turkey. The first years of the Republic between 1923-1928 ended with a disappointing performance of this liberal strategy because there was little evidence of structural transformation and improvement in income distribution. Besides, Turkey first encountered its traditional problems, balance of payment and domestic imbalances triggered by the Depression, in these years.

In the late 1920s, the country's leaders also realised that a fully market-oriented development strategy, relying only on the private sector, was not adequate strategy to achieve higher growth and ambitious development targets. In the beginning of the 1930s, internal political pressures forced a substantial shift in economic policy toward a relatively restrictive state-led economic policy. Accordingly, the state was assigned to become involved directly in industrial development in some fields where the private sector was unable to operate. What was done by this so-called *étatist* policy (a unique mixture of capitalism and socialism) was to create state-financed, state-owned, and state-run enterprises [see Okyar (1975)].

The Second World War, and authoritarian policies followed by the ruling single party (the Republican Party) during the war, caused them to lose popularity, and created a large public support for a newly formed right wing opposition that criticised the state intervention in economic activities, and that campaigned in favour of free enterprise and less public involvement. Increasing political unrest led the leaders of the Republican Party to allow for the legal formation of the first opposition party (the Democratic Party) in 1946, and ended with the loss of the first free election in the history of Turkey by the Republicans in 1950.

Changes on the political front came with a significant shift in economic policies toward more liberal, market-oriented policies. The new strategy was pursued successfully in the first three years of the 1950s partly because of expansion of the land for cultivation and strong demand for agricultural commodities during the Korean war, and partly because of foreign aid received through the Marshall plan [see Kepenek and Yentürk (1994)]. Once these external factors disappeared, and the agricultural production level and the level of public investment started falling, the Turkish economy then encountered its traditional balance of payments problem once again. The ambitious rate of growth in the early 1950s (11.5 percent in the period 1950-53, and 4.3 in 1953-60) could not be financed through a rise in domestic savings (but rather through money creation and external resources). A continuously rising rate of inflation, import shortages, and in turn increasing repressive measures against political opposition were general characteristics of the 1950s. Finally, in 1958, the government decided to adopt a stabilisation programme that had been called by the International Monetary Fund long before 1958. Measures of this first stabilisation programme consisted of a devaluation of the Turkish Lira, increases in the price of commodities produced by state economic enterprises (SEEs), and setting a ceiling on Central Bank credit and on government expenditures.

The 1960s started with political turmoil, and political opposition to the stabilisation programme gradually intensified. As political unrest erupted again, the army took over the government for the first time in May 1960. But the transitional period ended very quickly following the approval of a new constitution by the parliament in 1961. The notable features of this new era between 1960 and 1970 were a high growth rate (nearly 7 percent per year), and a reduction of dependence of the economy on imports (mainly by encouraging domestic production). For these purposes, the new constitution introduced the State Planning Organisation (SPO) that was made responsible for formal economy-wide planning through five-year plans and annual programmes. The SPO prepared three five-year development plans before the post-1980 period (1963-67; 1968-1972; 1973-1977) which lost their policy

Table 5.1 Basic Economic Indicators of The Turkish Economy (1963-1980)

(%)

	Growth Rate	Investment/GDP	Saving/GDP	The Ratio of Exports to Imports	Current Account Deficit/GDP
1963-67	6.6	17.4	17.7	71.1	-1.8
1968-72	6.2	21.2	21.5	61.7	-0.8
1973-77	5.3	22.3	20.7	40.3	-2.5
1978-80	-0.7	21.1	16.2	43.7	-2.9

Source: The author's calculation from SPO (1993) *Economic and Social Indicators (1950-1992).*

significance in the post-1973. The performance of the economy under the first and second plans were achieved remarkably impressively with 6.5 percent and 6.6 percent average realised rates of growth respectively.

While the import-substituting industrialisation (ISI) strategy was institutionalised under five-year plans, the economy went through a significant structural transformation. The first phase of the ISI between 1963-1967 put emphasis on the production of consumer goods, and was achieved without any serious external imbalances. On the contrary, current account deficits inherited from the previous period were markedly reduced from $ 300 million in 1963 to $ 109 million in 1964, and then to $ 78 million in 1965. This was not because of improved export performance (which was, in fact, adversely affected by the trade regime), but rather due to severe restrictions on imports. The second phase of the ISI, corresponding to the second planning period between 1968-1972, aimed at the substitution of imported intermediate inputs and producer and consumer durable goods. However, sustainability of the ISI at this stage remained dependent on the availability of domestic and external resources.

The aim of high growth rate in this period increased the dependence of the economy on imported intermediate and capital goods, and started to cause trade deficits in the late 1960s. The overvalued currency also put an additional strain on the external balance. The response of the government to this negative effect of the ISI was to intensify import restrictions, and to pursue the same policies without any modification. The situation was not unlike the previous crisis that Turkey had faced in the late 1950s. The government was eventually convinced once again to introduce an IMF-supported stabilisation policy in 1970, involving a devaluation of domestic currency and curbing public expenditures. But the liberalisation and stabilisation policies were largely reversed after a partial military intervention in 1971 when civil social disorder erupted again.

Table 5.2. The Effects of The First Oil Shock on Some Selected Foreign Trade Figures

	1970	1971	1972	1973	1974
			The Rate of Change (%)		
Exports[a]	9.6	15.0	30.8	48.8	16.3
Imports[a]	18.3	23.6	33.5	33.5	81.1
			Million s of US Dollars		
Balance of Foreign Trade[a]	-359.1	-494.2	-677.6	-769.1	-2245.4
	(35.8)	(37.6)	(37.1)	(16.5)	(192.0)
The Price Index of Oil Imports (1986-1987=100)[b]	7.8	9.3	13.9	36.6	45.2

Sources: a.) SIS (1993) *Statistical Indicators* (1923-1992); b.) Quarterly Bulletin of the Central Bank of Turkey. The figures in brackets shows the percentage change from the previous period.

2. 1. Dynamics of The Pre-1980 Economic Crisis

Over the period covering the years 1970-1979, external shocks were of considerable magnitude in the world economy, and Turkey experienced a large number of economic and social difficulties. Despite the changes in the world economy, Turkey chose expansionary economic policies parallel to the economic objectives of five-year development plans. Ambitiously high growth rates in these plans implied a particular pace of investment. These growth rates and associated investment targets were, however, subject to two constraints, namely a foreign exchange constraint (to the extent that exogenously determined foreign capital inflows fell short of the import requirement), and a saving constraint (to the extent that domestic saving fell short of investment). Table 5.1, in general, displays the magnitude of both constraints for three five-year-plan periods and the period corresponding to the crisis (1978-1980). As seen in the table, the saving gap (indicated as the excess of the investment share above the share of savings in GDP), and the share of current account deficits (as a simple indication of the foreign exchange requirement) seem to deteriorate after the 1968-72 period.

In the early 1970's, the foreign exchange constraint appeared to have been overcome partly because of the primary commodity price boom, and partly because of short-term capital inflows from Euro-currency markets. In the mid-1960s, large numbers of Turkish workers had emigrated to seek employment in Europe. The increasingly growing inflows of their remittances (see Table 5.3) also contributed to the optimism about the sustainability of the economic policies of the period. This bonanza in workers' remittances was considered, by the government, almost as "a fact of life",

Table 5.3. The Bonanza of Workers' Remittance

Year	Remittance ($ Mill.)	Foreign Trade Deficit ($ Mill.)	Remittance/ Trade Deficit (%)
1971	471	-494	95.3 (25.7)
1972	740	-678	109.1 (14.5)
1973	1183	-769	153.8 (41.0)
1974	1426	-2246	63.5 (-58.7)
1975	1312	-3101	42.3 (-33.4)
1976	983	-2912	33.8 (-20.1)
1977	982	-3753	26.2 (-22.5)
1978	983	-2081	47.2 (80.2)
1979	1694	-2554	66.3 (40.5)
1980	2071	-4603	45.0 (-32.1)

Source: SPO (1993) *Economic and Social Indicators* (1950- 1992). The figures in brackets are the rate of changes from the previous period.

rather than a passing, temporary phenomena. Although the rate of growth of overall output was quite respectable (on average 6 percent over the period 1972-75 period), the import- substituting strategy had finally generated an economy highly dependent on imports and foreign capital inflows. The optimism of the early 1970s disguised the main weakness of the Turkish economy, namely an excessive dependence on imports of intermediate and capital goods *with no ability* to increase the export performance to finance the import bills. Hence the economy became more vulnerable to external shocks. In Table 5.1, the ratio of exports to imports is given as a simple measure of import dependence which fell from 71.1 percent in the 1963-67 period to 40.3 percent in the 1973-77 period. It is evident from the table that the trade policy associated with the overall development strategy was considerably biased against exports. The adverse effect of increasingly growing import demand and falling export performance can also be seen in the ratio of current account deficit to GNP. The favourable conditions in the world economy helped the reduction in the current account deficit in the 1968-72 period (-0.8 percent of GNP). However, increasing import dependence and a drastic rise in the import bill after the first-oil shock resulted in an increase in the ratio of current account deficits to GNP, first to -2.5 percent in the period 1973-1977, then to -2.9 in the 1978-1980 period.

Three factors that have generally been considered as being responsible for the economic crisis in the pre-1980 period, can be mentioned to describe the dynamics of

Table 5.4. Supply and Uses of Resources (percentage change from previous period)

(%)

	Fixed Capital Investment			Consumption		
Years	Total	Public	Private	Total	Public	Private
1971	-5.1	-8.7	-0.9	12.5	6.5	13.6
1972	14.8	13.9	15.7	6.6	7.3	6.4
1973	11.3	8.4	14.4	2.1	8.5	1.1
1974	2.1	0.7	3.5	7.2	4.7	7.7
1975	16.8	29.4	4.7	8.1	11.4	7.5
1976	15.6	17.3	13.5	9.1	16.1	7.8
1977	7.4	13.4	0.0	4.7	15.8	2.5
1978	-10.9	-13.8	-6.8	1.3	-3.3	2.4
1979	-5.5	7.3	-19.3	0.8	3.0	0.4

Sources: OECD *Economic Surveys*: Turkey, various issues.

the Turkish economy in the 1970s: i.) the adverse impact of the world economy largely because of oil shocks, and the recession in industrial countries; ii.) the inadequate response of the government of the time to the shocks; and finally iii.) the short-run nature of liabilities and the irrationality of external borrowing strategy.

Regarding the first factor, Turkey, like other countries, was hit very hard by the first oil shock. Table 5.2 clearly shows the decline in the Turkish exports partly because of the recession in industrial countries (falling from 48 percent growth rate in 1973 to 16.3 percent in 1974), and an increase in the volume of imports from the growth rate of 33.1 percent in 1973 to 81.1 percent in 1974. The balance of foreign trade shows a steadily rising pattern, and reached $2.2 billion in 1974 from almost $ 0.4 billion in 1970. The effect of the oil price shock becomes more evident from the price index of oil imports that rose by almost 23 points from 13.9 in 1972 to 36.6 in 1973. In addition to this direct effect on foreign trade, the first oil shock also influenced the current account balance of the economy indirectly through the inflows of remittances of the workers living in Europe. Even though the inflows of workers' remittances continued after the shock, the recession in Europe slowed down the growth rate of remittance inflows. As a consequence, the first oil shock in 1973-1975 took back what a remittance bonanza in 1972-73 had given (see Table 5.3). Celasun and Rodrik (1989) calculated the overall effects of the oil shock on the Turkish economy by extending Balassa's (1984) calculations. They noted that although Turkey also suffered losses arising from the deterioration of the terms of trade and a reduction in export earnings, the real effects of the shock would be underestimated unless the

Table 5.5. Public Sector Deficits

(TL billion)

	1975	1976	1977	1978	1979
Public Sector Deficit	-3.7	-11.0	-13.3	-37.3	-63.1
Central Government	-1.4	-4.3	-4.4	-24.1	-66.2
SEE	-2.3	-6.7	-8.9	-13.2	3.1

Sources: OECD *Economic Surveys*, and SIS (1993) *Statistical Indicators* (1923-1992)

adverse effect of a fall in remittances was taken into consideration in the Turkish case. According to their calculation, the total remittance-adjusted effect appeared to be 9.2 percent reduction in GNP for the 1974-76 period in comparison with 4.9 percent GNP losses for 24 developing countries in Balassa's sample. Only the indirect effect of oil-shock on the Turkish economy through decreases in the inflows of workers' remittances was estimated at 1.7 percent GNP losses in the same period.

Despite changes in conditions of the world economy, Turkey continued an ambitious development programme by setting the target of the growth rate around 6 percent in the third five-year plan. However, the government should have chosen an expenditure reducing strategy by limiting its aggregate demand to correct the balance of payment deficits fuelled by the oil shock. Table 5.4 displays the response of the government of the time to the shocks by increasing public investment and consumption. The most striking performance of this expansionary policy was observed in 1975 with 29.4 percent increase in public investment (following 0.7 percent increase in 1974), and 11.4 percent increase in public consumption (after nearly 5 percent increase in 1974). This pattern of the public sector demand continued until 1978. Consequently, public sector deficits, and in turn, public sector borrowing requirements, accelerated largely because domestic resources could not be mobilised to achieve such high rates of investment. Table 5.5 documents the steady state increase in public deficits rising from TL 3.7 billion in 1975 to TL 63.1 billion in 1979. Although the budget deficits of the central government were the major factor, the losses of the State Economic Enterprises (SEEs) also placed a heavy, and increasing burden on public sector deficits (increasing from nearly TL 2 billion losses in 1975 to TL 13 billion losses in 1978).

Table 5.6 presents the adverse influence of these expansionary policies on the external balance in general. This table gives a simple idea about how current account deficits over the 1975-1979 period were financed. In the last column of the table, the cumulative figures of each corresponding account are given. The table shows that the

Table 5.6. Financing Current Account Deficit (1975-78)

($Million)

	1975	1976	1977	1978	1979	Cumulative
Current Account Deficit	-1648	-2029	-3140	-1265	-1413	-9495
Nondebt Financing	597	89	359	-188	131	988 (10.4)
Direct Investment	114	10	27	34	75	260 (2.7)
Changes in Reserves	433	49	349	-187	102	746 (7.9)
Long-term Debt	154	525	874	1091	4032	6676 (70.3)

Sources: SIS (1994) *Statistical Indicators* (1923-1992); Long-term debt stock flows are from World Table (1990).

cumulative current account deficit over the last half of the 1970s amounted to almost $9.5 billion. Approximately 10 percent of this cumulative deficit was financed through non-debt means of financing such as foreign direct investment (which accounted only for a negligible amount, 2.7 percent of deficit), and changes in reserves (7.9 percent of deficit). However, a more striking feature of the period was the high borrowing pattern. Almost 70 percent of the cumulative current account deficits was financed through long-term borrowing. It was the major factor behind the high growth rate in this period, so that total outstanding external debt stock reached $15.9 billion in 1979 from $4.8 billion in 1975 (with 231.3 percent growth rate). As 24.2 percent of total outstanding debt had the short-term maturity, this also rose to 48 percent in 1978. The reason for this dramatic increase in the outstanding debt stock (particularly in its short-term component) can best be explained by the borrowing strategy. To attract capital inflows, the government of the time invented a borrowing strategy which was named the Convertible Turkish Lira Deposit (CTLD) scheme. By this scheme, non-residents were allowed to open accounts with Turkish commercial banks, of which principal and interest payment were guaranteed by the government against all foreign exchange risks arising from devaluation of the Turkish lira. Besides, the interest rate on these deposits was set above the Euromarket rate for the corresponding currency[1]. Despite the fact that most of such funds were short-term, they were largely used to finance investment projects with long gestation periods. As a result, Turkey plunged into a full scale debt crisis in March 1979. Celasun and Rodrik (1989) noted that Turkey alone was responsible for 69 percent of the total volume of debt negotiated by developing countries in the 1978-80 period.

Table 5.7 shows that the majority of this debt stock was public sector liabilities. The figures in brackets display the growth rate of debt stock. In particular, the

[1] see Celasun and Rodrik (1989) for the nature and the dynamics of the CTLD scheme in practice.

Table 5.7. Medium and Long-term Outstanding External Debt of Turkey

($Million)

	1974	1975	1976	1977	1978	1979
By Borrowers	2901 (9.3)	3256 (12.2)	4214 (29.4)	4819 (14.4)	6749 (40.0)	9883 (46.4)
Consolidated Budget	2456 (6.4)	2786 (13.4)	3239 (16.3)	3448 (6.5)	5184 (50.3)	5511 (6.3)
Other Public Sector	209 (32.3)	191 (-8.6)	585 (206.3)	736 (25.8)	806 (9.5)	3630 (350.4)
Central Bank	5 (0)	5 (0)	5 (0)	5 (0)	6 (20.0)	2845 (472.2)
SEEs	203 (32.7)	186 (-8.4)	580 (211.8)	731 (26.0)	799 (9.3)	784 (-1.9)
Local Administration	-	-	-	-	1	1
Private Sector	237 (27.0)	279 (17.7)	390 (39.8)	635 (62.8)	759 (19.5)	742 (-2.2)

Source: SIS (1994) *Statistical Indicators* (1923-1992), and author's calculation; the figures in brackets are percentage change from previous period.

borrowing requirement to finance the consolidated budget deficit through external sources increased almost 50 percent from 1977 to 1978. The unsustainability of economic policies can also be observed from the extremely large increase in the outstanding debt stock of the Central Bank in 1979. In the same year SEEs reduced their external debt stock by 1.9 percent, despite a 211.8 percent rise in 1976.

Along with expansionary fiscal policies and the irrationality of borrowing strategy, the trade regime can also be considered as another reason for current account deficits, and in turn for an accumulation of foreign debt. It is apparent in the trade figures presented in Table 5.8 that trade deficits continued to grow in the late 1970s, not only because of increases in dependence on imports and a rise in the import price of oil, but also because of the poor performance of exports that was intensified by biases in the trade regime against exports, and of overvalued exchange rates. As seen in Table 5.8, nominal exchange rate devaluations starting from 1976 were not enough to offset the adverse effect of ongoing high inflation. Real appreciation also discouraged workers' remittances after 1974 (see Table 5.3), and intensified the balance of payment problems.

Overall, general characteristics of the 1970-79 period, which were of great relevance for the 1980 stabilisation and structural adjustment programme, can be summarised briefly as follows: i.) the rate of economic growth was very high. This was carried out by a rapid expansion of public demand largely because of a investment

Table 5.8. Trade Performance of Turkey (1974-79)

	1974	1975	1976	1977	1978	1979
		(percentage change)				
Export/GNP[a]	3.9	2.9	3.5	2.8	3.4	2.6
Imports/GNP[a]	9.7	10.0	9.6	9.5	6.9	6.2
		(index 1987=100)				
Price of Exports[b]	64.2	63.5	69.6	72.0	78.3	94.6
Price of Imports[b]	60.9	63.8	62.6	67.2	69.9	87.2
Terms of Trade[b]	105.4	99.6	111.2	107.1	112.0	108.5
		(index 1986-87=100)				
Price of Oil Imports[c]	36.6	45.2	47.8	54.2	54.1	72.3
Nominal Exchange Rate[a]	13.9	14.6	16.2	18.1	24.6	35.2
Inflation (%)[a]	29.9	10.1	15.6	24.1	52.6	63.9

Sources: a.) SIS (1994) *Statistical Indicators* (1923-1992); b.) *World Table* (1993); c.) Quarterly Report of the Central Bank (various issues). Inflation figures shows the rate of a change in wholesale price index.

boom; ii.) the period of this expansionary policy, however, corresponded to the recession in the world economy. The high growth rate could not be financed through mobilising the corresponding amount of domestic resources, but was rather financed through foreign savings; iii.) The restrictive trade regime accounted for the poor performance of exports and ongoing trade deficits. High inflation rates and the real appreciation of the Turkish lira can be considered as other reasons for the poor performance of exports and trade deficits.

By the end of 1979, Turkey was under a severe foreign exchange strain (so that the country was unable to import even essential items such as oil). The inflation rate had accelerated and reached nearly 64 percent (see Table 5.8). During the period of economic crisis (1977-79), the economic growth rate declined by 1.3 percent. These worsening economic conditions were accompanied by political instability. Finally in January 1980, the government embarked on a stabilisation and structural adjustment programme, which was the largest operation undertaken by a co-operation of the IMF, the World Bank, and the OECD. The initial objectives of the programme included restrictive monetary and fiscal policies, restrictions on Central Bank funding of public sector deficits, new tax measures, increases in interest rates, and continuous exchange rate devaluation *etc.* [Kopis (1987)]. However, increasing political violence paved the way to the third military take-over on the 12th of September 1980.

2.2. Adjustment and Recovery:

The economic policy package put into practice in 1980 was not only a stabilisation and adjustment package (like the ones Turkey unsuccessfully implemented in 1958 and 1970), but also intended a shift in the pattern of industrialisation strategy by putting emphasis on exports expansion and domestic and international market price incentives (rather than direct public intervention). This reform package has importance in Turkish economic history because of the full commitment of the government to changing the development pattern from the import-oriented development strategy to an export-oriented one. Between 1980 and 1984, the World Bank granted Turkey five one-year structural adjustment loans (SALs), amounting $1.6 billion. They were all used in supporting policy reforms proposed by the adjustment programme [see Kirkpatrick and Önis (1991)]. Among short-term objectives (including reduction in the rate of inflation, immediate improvement in the balance of payment, and fiscal retrenchment), far-reaching long-term aims of the reform package included:

(i) Trade Reform in the form of eliminating quantitative controls on imports such as the quota and licensing system: The trade reform was the most important element of the reform package. The government implemented a rather gradual import liberalisation because of the worry that a rapid import liberalisation would deteriorate the balance of payments. The trade reform between 1980 and 1983 included the reduction of stamp duty from 25 to 1 percent; gradual shifting of goods from most restrictive Liberalised Lists II to Liberalised Lists I [see Baysan and Blitzer (1991), Olgun and Togan (1990)]; simplification of import procedures; the removal of the explicit import quota lists. The export promotion strategy was implemented by introducing a number of export incentives. The improvement in the balance of payments was also of great importance to the government to gain international creditworthiness and to compensate for the depressed domestic demand.

(ii) Liberalisation of the Exchange Rate Regime: According to the very restrictive previous exchange rate regime, a Turkish citizen could be penalised for having a single US dollar in his pocket. But with the new regime, even opening a foreign exchange saving account at any domestic bank was made possible. One of the essential elements of the reform, which played a highly significant role in the Turkish recovery, was to let exchange rates be determined by market forces. Nominal exchange rates were gradually freed, starting with continuous mini-devaluations, and later moving to daily determination in the market after May 1981 [see Asikoglu (1992), and Asikoglu and Uctum (1992)].

Table 5.9. Trade Performance, 1980-1986

	1980	1981	1982	1983	1984	1985	1986
			(Million of US Dollar)				
Exports	2910	4703	5746	5728	7134	7658	7457
	(28.7)	(61.6)	(22.2)	(-0.3)	(24.5)	(11.6)	(-6.3)
Imports	7909	8933	8843	9235	10757	11343	11105
	(56.0)	(12.9)	(-1.0)	(4.4)	(16.5)	(5.4)	(-2.1)
			(Index Numbers, 1984-86=100)				
Export Price	122.1	120.3	106.4	100.1	100.4	98.8	96.3
Import Price	114.5	128.2	126.3	109.9	106.9	103.6	88.0
Price of Oil Imports	131.7	155.5	141.1	125.4	120.5	118.5	61
Price of Intermediates	119.9	125.3	125.9	97.8	97.7	94.4	105.3
			(percentage share in total)				
Export By Major Sectors							
Agricultural	57.5	47.2	37.3	32.8	24.5	21.6	25.3
	(24.4)	(32.7)	(-3.5)	(-12.2)	(-7.0)	(-1.7)	(9.7)
Mining	6.6	4.1	3.0	3.3	3.4	3.1	3.3
	(44.4)	(1.3)	(-9.3)	(7.6)	(26.9)	(1.8)	(1.3)
Total Industry	36.0	48.7	59.7	63.9	72.1	75.3	71.4
	(33.4)	(118.7)	(49.7)	(6.7)	(40.6)	(16.5)	(-11.2)
Food Industry	6.5	7.8	8.7	9.9	9.1	6.6	7.2
	(40.7)	(93.3)	(35.6)	(14.5)	(13.8)	(-18.3)	(1.4)
Textile Industry	14.6	17.1	18.4	22.7	26.3	22.5	24.8
	(12.5)	(89.2)	(31.6)	(22.9)	(44.4)	(-4.6)	(3.4)
			(percentage of total exports)				
Average Export Incentives (%)	22.1	20.7	21.5	23.4	15.1	18.6	16.0
			(percentage share in total)				
Imports By Major Sectors							
Agriculture	0.6	1.4	2.0	1.5	3.9	3.3	4.1
	(39.1)	(145.6)	(40.8)	(-21.6)	(203.0)	(-10.0)	(21.5)
Mining	39.1	38.9	42.3	37.3	33.9	32.0	19.3
	(190.0)	(12.3)	(7.5)	(-8.0)	(5.9)	(-0.5)	(-40.8)
Manufacturing Industry	60.2	59.7	55.7	61.2	62.2	64.7	76.6
	(20.1)	(11.9)	(-7.6)	(14.8)	(18.4)	(9.7)	(15.8)
Imports By Commodities							
Investment	20.0	24.7	26.3	25.1	24.7	22.9	31.3
	(-1.0)	(39.6)	(5.3)	(0.3)	(14.8)	(-2.1)	(33.5)
Consumption	2.1	2.0	2.1	2.6	4.4	8.0	8.6
	(10.5)	(-4.8)	(5.0)	(23.8)	(69.3)	(81.8)	(7.5)
Raw Material	40.5						
	(203.8)						
			(Percentage of GNP)				
Exports/GNP	4.2	6.6	8.8	9.3	11.8	11.7	9.8
Imports/GNP-	11.6	12.5	13.8	15.3	18.2	17.0	14.8
Exchange Rate	90.1	133.6	186.8	282.8	444.7	576.9	757.8

Sources: SIS (1994) *Statistical Indicators*, The Quarterly Bulletin of The Central Bank (1993), Baysan and Blitzer (1990); growth rates in brackets.

(iii) Financial-Sector Deregulation and Reform: To boost domestic savings and then mobilise domestic resources between sectors, first interest rates were liberalised. The cost of previously repressed financial markets (in the form of holding the interest rate below its equilibrium level) for the 1950-77 period was estimated by Fry (1979), in which he finds that a one percent point fall in the real deposit rate reduces the saving rate by 0.27 of a percentage point and raises the incremental capital /output ratio by 0.25. Following the financial crisis in 1982, caused partly by the oligopolistic market structure of the Turkish banking system [see Atiyas (1990) for details], new regulation and institutions (such as the Capital Market Board in 1982, a new banking law in 1985, the Istanbul Stock Exchange in 1986, an interbank money market in 1986), and external financial liberalisation in 1984 followed by the full convertibility of the TL in 1990 were introduced to promote financial market development [Atiyas and Ersel (1995), Arslan and Celasun (1995), Akyuz (1990)].

(iv) Fiscal Reform: The aims of the fiscal reform were reforming the tax system, improvement in the operation of the state economic enterprises (SEEs), fiscal decentralisation away from the central government to a greater fiscal autonomy for the local authorities. The introduction of the value-added tax was the first development on the fiscal front. To provide resource mobilisation, and to reduce public sector deficits (in turn, public sector borrowing requirements), the prices of commodities produced by SEEs were allowed to increase according to prevailing market conditions. The priority in public investment was shifted towards investment in infrastructure rather than investment in non-infrastructure [see Celasun (1990)]. In order to make the economy more responsive to market conditions, privatisation was also proposed under this reform package, but still remains the subject of intensive political debate in Turkey.

In the first years of the structural adjustment programme covering the 1980-86 period, the macroeconomic priority was given to the immediate improvement of the balance of payments problem through a rapid increase in exports. A number of incentive schemes were used to promote exports, including export tax rebates, credit subsidies, and foreign exchange allocation that allowed for the duty-free import of intermediates and raw materials. The total value of these direct incentives reached on average 23.4 percent of total exports in 1983 (see Table 5.9). Changes in macroeconomic policies and help from international institutions in the form of debt relief and additional lending also influenced the export performance. As displayed in Table 5.9, exports for the 1980-86 period grew very rapidly, at an annual 24 percent, and then declined 6.3 percent in 1986. Although there is, more or less, a general agreement on internal and international deriving forces of this export boom, the effect of the incentive schemes on this outstanding achievement in exports has been

Table 5.10 Macroeconomic Performance of the Turkish Economy, 1980-86.

	1980	1981	1982	1983	1984	1985	1986
a.) Real Growth Rate	-2.8	4.8	3.1	4.2	7.1	4.3	6.8
Agriculture	1.3	-1.8	3.3	-0.8	0.6	-0.3	3.6
Industry	-3.6	9.9	5.1	6.7	10.5	6.5	13.1
Services	-4.1	5.8	2.3	5.3	8.2	5.0	5.2
b.) Supply and Uses of Resources (%)							
Investment/GNP	16.0	18.3	17.1	16.5	16.5	18.9	21.9
Savings/GNP	19.6	18.7	18.0	18.9	17.9	20.0	23.1
c.) Inflation Rate							
Wholesale (1963=100)	107.2	36.8	25.2	30.6	52.0	40.0	26.7
Consumer Prices	115.6	33.9	21.9	31.4	48.4	45.0	34.6
d.) Monetary Parameters							
M1/GNP	14.3	12.8	13.3	15.0	11.2	9.8	10.6
M2/GNP	17.8	22.2	25.3	25.0	25.0	24.3	24.1
Domestic Credit/GNP	31.3	30.9	34.4	36.4	40.4	41.0	43.7
			(Million of US Dollar)				
Current Account Balance	-3408	-1936	-952	-1923	-1439	-1013	-1465
Foreign trade Balance	-4603	-3864	-2628	-2990	-2942	-2975	-3081
Interest Payments	-1138	1443	-1565	-1511	-1586	-1753	-2134
Remittances	2071	2490	2140	1513	1807	1714	1634
			(in percent)				
CAB/GNP)	-4.98	-2.71	-1.48	-3.18	-2.43	-1.51	-1.95
Debt/GNP	19.34	20.21	25.06	31.80	34.96	38.09	42.70
Debt/Exports	454.59	307.21	280.07	335.87	289.60	320.13	430.50
Debt Services/GNP	0.29	0.63	0.94	6.03	5.91	5.92	5.73

Source: SIS (1993) *Statistical indicators* (1923-1992).

controversial. For example, according to one sceptical view, Celasun and Rodrik (1989) estimated that a maximum 30 percent of exports in this period might be a result of real depreciation. They also found little evidence supporting the effectiveness of export incentives. To them the most significant explanation of the Turkish export boom was Turkey's closeness to the Middle Eastern market, and the war between Iran and Iraq. They found little evidence for the effectiveness of export incentives. However, accepting the fact that external conditions also contributed the export boom, Arslan and van Wijnbergen (1993) calculated 20 percent annual growth rate in exports over the 1980-1987 period on the data corrected for overinvoicing, and they also noted that exports to oil-exporting countries grew by 17.5 percent per year. Therefore according to them the positive effect of export incentives was undeniable in Turkey's case.

In addition to the overall impressive performance of exports, its composition also changed (see Table 5.9). The share of industrial goods exports rose from 36 percent of total exports in 1980 to 75.3 percent in 1985 (at an annual average rate of 44.3 percent), while the share of agriculture declined from 57.5 percent to 21.6 percent in 1985 (by the average growth rate of 5.5%). Within the industrial sector, textile exports grew more rapidly than those of the food industry, 33 percent for the former, 29 percent for the latter from 1980 to 1986. Over the same period, the economy-wide export-GNP ratio also rose from 4.2 percent in 1980 to almost 12 percent in 1985.

Following the relaxation of the foreign exchange constraint in 1980, a substantial jump in imports (at a annual growth rate of 56 percent from 1979 to 1980) was observed. Due to the reduction in the cost of oil imports from $3.3 billion in 1985 to $1.8 billion in 1986 (corresponding to a nearly 45 percent reduction), total imports slowed down almost 2 percent in 1986. The most striking feature of the imports figures is the observation of a rapid increase in imports of consumption goods from 2.1 percent share in total imports to 8.6 percent in 1986 (at an annual rate of almost 28 percent).

As seen in Table 5.10, the overall growth performance of the economy was quite remarkable over the reform period between 1981 and 1986. Following a contraction of growth rate by 2.8 percent in 1980, the economy grew at an annual rate of nearly 5 percent over the period 1981-1986. One striking observation from the sectoral breakdown was the low growth rate of agricultural output (declines in 1981, 1983, and 1985), which was around 0.8 percent on average for the entire period. The industrial and service sector output levels grew by 8.5 percent and 5.3 percent on average for the same period respectively.

Macroeconomic policy in this period also aimed to reduce the rate of inflation. In response to tight fiscal and monetary policies, inflation rates (measured as changes in the wholesale price index) declined from 107 percent in 1980 to 25.2 percent in 1982, and then accelerated to 52 percent in 1984. In addition to reducing the public sector borrowing requirement (by rising taxes, reducing public expenditures and increasing state economic enterprises' prices), a decline in wage costs associated with military rule and liberalisation of interest rates provided a success in reducing inflation rates in the early years. Regarding the interest liberalisation, the implementation of positive real interest rates significantly increased domestic savings, and lowered the velocity of circulation of money. Rodrik (1991b), for example, tested the significance of some variables associated with the public-finance view of inflation. He regressed inflation on public deficits, the real growth of GNP, income elasticity of demand for base money, and the share of base money in GNP. He found supportive evidence for the view that fiscal deficits financed at the margin by money creation have inflationary implications in

Table 5.11 Economic Performance of the Post-1986 Period

	1981-1986	1987-1990	1987	1988	1989	1990	1991	1992
a)Growth Rates (%)								
GNP	5.1	5.2	9.8	1.5	1.6	9.4	0.4	6.4
Exports (Value)	18.1	15.6	36.7	14.4	-0.3	11.5	4.9	8.2
Imports (Value)	6.0	20.1	27.5	1.3	10.2	41.2	-5.6	8.7
Exports/Imports (%)	63.9	71.3	72.0	81.4	73.6	58.1	64.6	64.3
PSBR/GNP (%)	5.2	7.9	7.8	6.2	7.1	10.5	14.4	12.6
CAB/GNP (%)	-2.21	-0.01	-0.94	+1.76	+0.89	-1.74	+0.18	-0.60
b) Prices								
Inflation [1]	34.2	53.7	39.3	60.8	65.0	49.6	52.6	67.1
Wages (1988=100)[2]	---	---	---	100	130	152	229	---
Real Exchange Rate (1985=1) [3]	0.93	0.92	1.00	1.07	0.86	0.73	0.79	0.81

Source: SIS (1993) *Statistical Indicators* (1923-1992), and SPO (1993) *Economic and Social Indicators* (1950-1992), Arslan and Celasun (1995).
1) They have been calculated as a ratio of change in wholesale price indexes (%) of Istanbul Chamber of Commerce.
2) Gross wages are before taxes, including social benefits.
3) Real exchange rates have been calculated by $e(P_{usa}/P_{tr})$, where (e) is nominal exchange rates, P_{usa} and P_{tr} are the consumer price indexes of the USA and Turkey respectively. Consumer price index for the USA is taken from IMF Financial Statistics (various issue).
PSBR: Public Sector Borrowing Requirement
CAB: Current Account Balance

Turkey. Therefore, tight fiscal policies in the early 1980s might have led to a decline in inflation. However, as seen in the panel (c) of Table 5.10, the acceleration of inflation rates in 1984 coincides with the general elections year when fiscal discipline was loosened.

Table 5.10 also shows important evidence on Turkey's response to the debt crises in the early 1980s. Unlike other highly indebted developing countries of Latin America, Turkey was not forced to generate trade surpluses to service or repay its external debt. Turkey was therefore able to continue to have current account deficits. Besides, it received generous capital inflows to support the reform programme from international institutions. However, external debt continued to grow.

2.3. Returning to Macroeconomic Instability (1987-)

Despite being a success story in economic liberalisation [see Saracoglu (1991)], the Turkish experience with structural reforms has not recorded any substantial progress on the fiscal side of the economy, and in fact, failed to yield credible results in attaining fiscal balance. The post-1987 period witnessed a change in the way of financing public

Table 5.12. Some Indicators on Deterioration in Public Sector Balance (% of GNP)

	1981-1986	1987-1990	1987	1988	1989	1990	1991	1992	Δ
Revenue	17.7	17.8	17.2	16.9	17.8	19.2	21.3	22.1	+4.9
Taxes	15.3	15.1	15.5	14.1	15.0	15.8	17.4	18.2	+2.7
Non-Taxes	1.8	1.4	1.4	1.2	1.4	1.5	0.9	1.1	-0.3
Expenditures	20.7	22.1	21.7	20.9	22.3	23.4	28.7	29.4	+7.7
Personnel	5.2	6.7	5.1	5.0	7.4	9.2	10.9	11.8	+6.7
Other Current	3.3	2.5	2.6	2.4	2.4	2.4	2.5	2.6	0.0
Investment	4.0	3.3	3.9	3.1	3.0	3.1	3.8	3.8	-0.1
Transfers	8.3	9.7	10.0	10.4	9.6	8.7	11.6	11.1	+1.1
Net Deficits	-2.9	-4.4	-4.4	-4.0	-4.9	-4.3	-7.4	-7.3	+2.9
Financing									
Debt Payments	1.8	3.8	4.0	3.7	4.0	3.5	4.0	4.5	+0.5
Foreign	1.2	2.1	2.0	2.3	2.2	1.9	2.0	1.9	-0.1
Domestic	0.7	1.7	2.0	1.4	1.8	1.6	2.0	2.6	+0.6
Borrowing	4.3	7.5	7.2	7.5	8.2	7.1	10.1	10.8	+3.6
Foreign	1.2	2.1	1.6	2.6	2.1	1.9	2.4	2.6	+1.0
Domestic	3.0	5.5	5.7	4.9	6.1	5.1	7.7	8.2	+2.5
Central Bank	0.7	0.4	0.6	0.7	0.3	0.1	2.4	2.3	+1.7

Sources: SPO (1993) *Economic and Social Indicators* (1950-1992).

deficits. The adjustment programme in the early 1980s was successful in financing fiscal deficits through price increases of the state economic enterprises, real wage cuts, and restrictions on public expenditures. In the post-1983 period however, bond-financing became a complementary tool of fiscal policy, and its weight gradually increased after 1987.

The 1987-1990 period and afterwards can be considered to be marked by unsustainable public sector behaviour, as well as by further external financial liberalisation and convertibility of the Turkish Lira. Table 5.11 assembles some economic indicators to highlight these and other characteristics of the period. Compared with the 1981-1986 period, the average growth rate of GNP in the period between 1987 and 1990 remained at the same rate (5.2 percent on average) but showed a great fluctuation. As seen in the earlier section, the external components of the Turkish structural adjustment had generated a credible improvement in terms of increasing trade performance of the economy, and easing foreign exchange constraints on import financing. But in the 1987-1990 period, the real appreciation of the TL against US$ (see Panel (b) of Table 5.11) led the average growth rate of exports (in value) to fall while creating an import boom in the same period. In contrast to the important role played by price stability in the adjustment in the earlier period, inflation

Table 5.13. Measures of Currency Substitution in Turkey, 1986-1996.

	1984	1986	1988	1989	1990	1991	1992
Currency Substitution							
FXD/(M2+FXD)[1]	---	18.3	25.7	22.9	23.3	30.7	35.8
FXD/GNP[2]	1.2	3.2	5.6	4.7	4.7	7.2	---
Reserve/GNP[2]	9.4	7.7	7.6	7.0	5.8	5.7	---

Sources: 1) Author's calculation from the Quarterly Bulletin of Central Bank of Turkey.
2) SPO (1993) *Main Economic Indicators* (A Comparison of the Old and New Income Series) in Turkish.
FXD: Foreign Exchange Deposits

in 1987-1990 averaged around 54 percent per year, and continued to destabilise the economy.

The table also draws attention to the growing public sector borrowing requirements, PSBR, in the 1987-1990 period. As a measure, the ratio of PSBR to GNP rose to 7.9 percent in the 1987-1990 period from average 5.2 percent in the 1981-1986 period, and continued to worsen in the early 1990s. In particular, the public sector saving gap, measured by this ratio, became 14.4 percent of GNP in 1992 (an almost 100 percent increase compared with 1987). Most interestingly, the rise in the PSBR coincides with drastic jumps in the index of wages (first to 130 in 1989, then to 152 in 1990, and finally to 229 in 1991).

The Turkish net public deficits widened by almost 3 percent of GNP between 1987 and 1992, increasing from -4.4 percent of GNP in 1987 to -7.3 percent in 1992 (see Table 5.12). Growing public deficits possess great importance due to their impacts on private investment through two main channels in Turkey, and pose a threat to the sustainability of Turkish economic development. One channel is the one by which financing increasingly large fiscal deficits diminishes available financial funds for investment directly. The second channel is rather indirect, and related closely to the way of financing these deficits. Particularly in the Turkish case, financing fiscal deficits started relying increasingly on domestic (as well as foreign) borrowing. Such an option, however, pushed real interest rates upwards, and increased the costs of borrowing and of capital.

Table 5.12 presents some indicators of public revenue and expenditure items (measured as percentage of GNP) from 1987 to 1992 to bring out the source of these fiscal deficits in the post-1986 period. From the table, personnel expenditures emerge as a single source of these deficits. The table reports that between 1987 and 1992,

Table 5.14 Selected Items from Balance of Payments ($ Millions)

	1986-1989	1990	19991	1992
Trade Balance	-3077	-9555	-7340	-8191
Current Account Balance	72	-2625	258	-943
Direct Investment	312	700	783	779
Portfolio Investment	798	547	648	2411
(Credit Received from Capital Mark.)	816	592	592	2806
Other Long-Term Capital	350	-210	-808	-938
Short-Term Capital	-501	3000	-3020	1396
Assets	-578.9	-409	-2563	-2438
Liabilities	78	3409	-457	3834
Deposit Banks	445	2048	-140	2093
Foreign Exchange Deposit	257	1034	-803	-311
Foreign Exchange Credit	189	1014	663	2404
Changes in Official Reserves[1]	-1353	-1308	1029	-1484

Source: Quarterly Bulletin of Central Bank, 1993 IV (Ankara, Turkey)
1) (-) indicates an increase in reserve, *vice versa*.

central government's personnel expenditures have been adversely affected by a sharp reversal of wage trends after 1988.

The downward flexibility of real wages was exploited by the government of the time to implement a successful external adjustment programme in the early 1980s. During the period between 1980 and 1983, some measures were introduced by the Turkish military in power, such as forming a centrally controlled High Board of Arbitration, and banning trade unions. According to Borotav (1990), low real wages in the urban sector in the early years of the 1980s were maintained at about 30-40 percent below the level of the pre-adjustment period, and created attractiveness for international capital. This adverse development in real wages was subsequently supported by currency devaluation in favour of export-oriented sectors. Following general parliamentary elections in November 1983, the government of the time continued to repress real wages in order to compensate the losses of export-oriented sectors arising from a reduction in direct export subsidies and import protection. However, with the gradual return to democracy and emerging severe political competition, real wages started recovering after the 1987 general elections. Given the fact that the public sector employs about 40 percent of formal wage earners [Arslan and Celasun (1995)], the reversal of real wage trends resulted in large fiscal deficits after 1987. Arslan and Celasun (1995) noted that the private sector companies in the post-1986 period absorbed wage shocks better than the public sector by sacrificing some of their profits.

The Turkish liberalisation proceeded in a gradual pattern [see Uygur (1993) and Celasun (1994)]. Following the initial steps of trade liberalisation and the liberalisation of domestic financial markets in the early 1980s, further measures were taken for external financial liberalisation starting from January 1984. As a part of these measures, firstly restrictions on residents' dealings with foreign exchange currencies were gradually lifted, and residents and non-residents were allowed freely to open foreign currency deposit accounts in Turkey. The full convertibility of the Turkish Lira then followed in April 1990. These relaxations of controls on capital flows were used by the government to attract international capital to Turkey to finance public sector deficits, and generated a rapid increase in foreign currency holding. Using some fairly simple measures, Table 5.13 reports the rapid expansion of replacement of the Turkish TL by other currencies (i.e. currency substitution).

Two measures for currency substitution were calculated in the table. The first one is the ratio of foreign exchange deposits to the sum of M2 and foreign currency deposits. By this measure, 25 percent of total deposits in the banking sector was comprised of foreign exchange deposits in 1985. Despite a small fall in 1989, a rapid expansion of currency substitution (together with high inflation of around 70 percent per year) reached almost 36 percent in 1992. The second measure was calculated as the share of foreign exchange deposits in GNP. A drastic rise in foreign currency deposits become more evident with this measure, reaching 7.2 percent of GNP in 1991 from 1.2 percent in 1984. The last measure in the table indicates the demand for reserve money that establishes a base for *seigniorage revenue* of the public sector, and exhibits a decreasing pattern over the period between 1984 and 1991. This pattern is particularly important because according to Rodrik's (1991b) calculations, 1.5-3 percent of GNP was generally used to finance public sector deficits through revenue from money creation (or seigniorage) and inflation taxes in Turkey. Therefore a decline in the demand for reserve money restricts the possible use of seigniorage as a means of financing fiscal deficits. This is because widening deficits cause further currency substitution, and inflation rates become highly sensitive even to a small increase in deficits.

Another implication of external financial liberalisation was that the possibility of currency substitution reduced the government's ability to adopt *independent* monetary and fiscal policies without considering their impacts on internal and external balances. Using a VAR methodology with monthly data covering the sample period of January 1986 to January 1992, Selçuk (1994) found an empirical evidence for currency substitution in Turkey, and showed that there is a positive relationship between the real depreciation of the TL and currency substitution. His empirical results suggested that to stop or reverse currency substitution, the confidence of residents must be re-established. The results also indicated that an increase in nominal interest rates together with a real depreciation of the currency may reverse currency substitution in favour of domestic currency.

Despite the removal of controls on capital movements and weakening independent control of the government on financial markets, fiscal deficits continued to grow in 1991 and 1992 (see Table 5.12). Also, a decline in seigniorage revenue led the government to rely largely on domestic borrowing (with high interest rates) and on short-term capital inflows from abroad between 1990 and 1992. High interest rates in the end became a key element of this mode of deficit financing to avoid capital flight, and encouraged further short-term capital inflows. To see the implications of this policy, Table 5.14 presents some indicators from external accounts.

As noted earlier, trade deficits after 1989 widened, mainly because of further reductions of import tariff, real appreciation of domestic currency (partly as a result of sizeable capital inflows in 1990) and an import boom in 1990. The table also gives strong evidence on the sensitivity of financial markets to changes in market conditions with a large fluctuation in short-term capital inflows between 1990 and 1991 (moving from an average $ 0.5 billion net outflow in the 1986-1989 period to $ 3.0 billion inflow in 1990, then to $ 3.2 billion outflow again in 1991). Increasing public sector borrowing requirements were met largely by net capital inflows through high interest rate policies. In this respect, portfolio investment components of balance of payments reached $ 2.4 millions in 1992 from almost $ 0.7 in 1991 by rising almost 272 percent. Fluctuations in short-term capital inflows were determined mainly by the foreign exchange credit components of deposit banks' liabilities. Interestingly, in connection with the development in fiscal balances, the table indicates that high interest policies in the 1990s strongly encouraged investors to hold government securities. In the same period, the real appreciation of domestic currency also helped investors move in this direction. As seen in Table 5.14, this development was reflected by an increase in the liabilities components of deposit banks between 1991 and 1992. Having risen to $ 1 billion in 1990, the foreign exchange component experienced a decline (decreasing $ 0.8 billion in 1991 and $ 0.3 billion in 1992) towards government securities. However, the reductions in foreign exchange deposits coincided with significant rises in foreign exchange credits (which reached $ 2.4 billion in 1992). The response of the banking sector to high interest policy has been considered as a reason behind such a drastic capital inflows [e.g. see Borotav (1994)]. In connection with real appreciation in 1990 and 1991 (see Table 5.11), real returns on holding foreign exchange decreased, and government securities with high nominal interest rates became a more attractive

Table 5.15. The Shares of Total, Private, and Public Investment in GNP

(% of GNP)

Year	Total	Private	Public	Year	Total	Private	Public
1973	20	12	8	1987	24	11	13
1974	19	11	8	1988	24	13	11
1975	22	11	10	1989	22	12	10
1976	24	13	11	1990	22	13	10
1977	26	13	13	1991	23	12	10
1978	23	12	11	1992	22	12	10
1979	21	11	10	1993	21	12	9
1980	20	9	10				
1981	19	8	11				
1982	18	8	10				
1983	19	8	11				
1984	18	8	10	1973-79	**22.1**	**11.9**	**10.1**
1985	20	8	12	1980-84	**18.8**	**8.2**	**10.4**
1986	23	10	13	1985-93	**22.3**	**11.4**	**10.9**

Source: SPO (1993) *Economic and Social Indicators* (1950-1992), p. 13.

portfolio investment option. Then investors (mainly commercial banks) shifted their resources to government bonds by largely borrowing capital short-term from abroad.

3. General Trends in Investment (1973-1993):

Investment in Turkey shows high volatility in response to changes in economic policies over the period between 1973 and 1993. The distinctive feature of the period before 1980 is the high share of total investment in GNP, indicating the expansionary response of the Turkish economy to the world economic crisis in 1974. Following the first oil shock, Turkey maintained high growth rates by utilising foreign capital inflows (mostly with short-term maturity) from Euro-currency markets and a large volume of workers' remittances from Europe. The deterioration in economic conditions in 1977-79 resulted in the introduction of an economy-wide stabilisation and structural adjustment programme in 1980. The period of 1980-1984 reflects the effect on investment of the stabilisation policy in the early 1980s. The effect was drastic: the share of the total investment in GNP declined to 18 per cent in 1982 from a maximum of 26 percent of 1977; the share of private investment fell from 13 per cent in 1977 to 8 per cent in 1982 while the average share of public investment expenditure remained almost the same compared to the average of 1973-1979 (see Table 5.15). From 1985 onwards, however, an overall recovery in investment expenditures can be observed. Although the share of the total investment has not yet reached the 1977 level, the highest level so far, I believe that the comparison of any figure after 1980 with 1977 may be misleading, since the high performance of the economy in 1977 was not sustainable and attained at the cost of a severe economic crisis in 1979. On the other

Table 5.16. Investment Shares for Some Selected Regions and Turkey

(% of GDP)

Regions	1973-1979			1980-1984			1985-1990		
	Total	Privat.	Public	Total	Private	Public	Total	Private	Public
Forty LDCs	20.7	12.1	8.6	20.7	11.6	9.1	18.1	10.6	7.4
Latin America	19.8	12.4	7.5	18.4	11.1	7.3	16.6	10.3	6.0
East Asia	23.3	15.7	7.6	26.8	16.5	10.4	21.9	14.9	7.1
South Asia	16.2	8.5	7.7	19.6	9.4	10.1	18.2	9.4	8.8
Sub-Sahara Africa	22.0	10.3	11.7	19.7	9.9	9.8	16.1	7.8	8.1
TURKEY	**22.1**	**11.9**	**10.1**	**18.8**	**8.2**	**10.4**	**22.5**	**11.4**	**10.9**

Source: The author's calculation from P. Guy, P. Pfeffermam and A. Madarassy (1992).

hand, total investment in the period 1985-1993 remained at almost 22 per cent of GDP, which is the same rate as the average for the period of 1973-79.

Table 5.15 reveals a number of interesting results. First, the share of public investment expenditures after 1980 remained as high as that in the 1970s. Second, a great deal of the fluctuation in total investment in the stabilisation period of 1980-1984 appears to have been caused merely by private investment, suggesting that private investment was the one that suffered more from the worsening economic environment in the early 1980s. An improvement in private investment, as a share of GNP, contributed positively to the overall recovery in total investment after 1986.

When viewed in the comparative perspective of the other developing countries, the Turkish investment performance, in fact, looks quite respectable after 1984. As Table 5.16 shows, the share of total investment in GDP in the period of 1985-1990 is the highest one among the respective figures for LDCs and regions. The source of this high share seems to be the large proportion of private investment -which is the second highest according to the table- and particularly public investment, which is far above those of all other regions. During the stabilisation period (1980-1984), the share of public investment remained the highest along with the average of East Asian countries. Total investment, though, reflects the severe effect of stabilisation policies, and stayed at around 19 percent of GDP over the period 1980-1984, the lowest except for Latin American countries, many of which undertook a contractionary stabilisation and adjustment programme as a result of the debt crisis in 1982. When compared to Latin America, where many of the countries chose to adjust by cutting public expenditures

Table 5.17. Sectoral Distribution of Investment

(% of Total Investment)

	1973-1979			1980-1984			1985-1990		
Sectors	Total	Pub.	Prvt.	Total	Pub.	Prvt.	Total	Pub.	Prvt.
Agriculture	9.9	9.8	9.9	10.6	9.6	11.9	7.2	8.6	6.1
Mining	3.6	6.9	0.7	5.2	8.8	0.9	3.5	5.3	1.4
Energy	8.6	15.3	0.4	13.3	23.5	0.7	13.1	26.7	1.2
Housing	18.4	2.4	30.8	15.1	2.1	31.0	21.9	2.3	41.5
Manufacturing	**32.3**	**23.1**	**40.0**	**25.8**	**19.4**	**33.8**	**17.1**	**7.3**	**27.4**
Services	28.4	42.4	16.7	29.9	36.6	21.7	37.1	51.9	22.3
Total	100	100	100	100	100	100	100	100	100
Services+Housing	**46.8**	**44.8**	**48.9**	**45.0**	**38.8**	**52.7**	**59.0**	**54.2**	**63.9**

Source: The author's calculation from SPO (1993) *Economic and Social Indicators* (1950-1992).

[see van Wijnbergen (1989)], the stabilisation policies hit private investment mostly in Turkey, while the share of the public investment in GNP continued to expand as a share of GDP. This was because Turkey pursued a high growth strategy mainly by relying on public investment. As discussed in Section 2, in particular in the early 1980s, the government constrained public expenditures on consumption to provide enough room for this public investment expansion.

Perhaps more surprising is the discovery that the recovery in Turkish investment has been accompanied by a drastic change in the composition of investment. This comes across clearly in Table 5.17 which presents the investment share (both private and public) of six sectors (agriculture, mining, energy, manufacturing, housing, and services) in total investment. The share of the manufacturing sector in total investment has declined considerably, from 32 percent, the highest in 1973-79, to 17.1 percent in 1985-1990. This undistinguished performance of the manufacturing sector has gone alongside a dramatic increase in the share of the housing sector, which exceeded that of manufacturing by almost 5 percent in the 1985-1990 period.[2] Overall, the service sector accounted for almost 60 percent of total investment in the period of 1985-1990. This reveals the fact that the investment performance of the service sector -including housing- is, in fact, responsible for the resurgence in total investment in the

[2] This is a quick response of the housing sector to the newly created incentives (low mortgage rate, easily access to housing credit etc.) The government has established extra budgetary funds to direct credit to such selected uses as to finance mass housing scheme.

Table 5.18. The Average Share of Sectoral Outputs

(% of Total Output)

Periods	Agriculture	Manufacturing	Services	Mining	Energy
1973-1979	18.72	40.82	36.71	2.09	1.65
1980-1984	17.31	41.98	36.91	1.82	1.98
1985-1990	14.30	42.75	38.90	1.89	2.16

Source: The author's calculation from Maraslioglu and Tiktik (1991)

last period. When viewed in the comparative perspective of the sectoral breakdown into public and private, the drastic decline in the share of public investment in manufacturing and the rise in services (excluding housing) becomes more evident compared to the period of 1980-1984. This evidence suggests that investment in different sectors responded quite differently to changes in economic environment and to new incentives.

The output levels in these sectors at the same time also presents an interesting pattern. Because of the lack of data, Table 5.18 reports only the total share of sectoral output aggregating public and private sectors. Three sectors appear to be important in Turkey with respect to the shares of their production level in total production; namely manufacturing, services, and agriculture. Among them, the rate of investment in agriculture and the share of agricultural output show a declining pattern. The share of services' output in total, on the other hand, steadily increased investment as well as output over the period 1973-1993. Despite the decline in the share of investment in manufacturing, the output share of manufacturing in total output has increased along with that of services in these periods. Increasing shares of output in manufacturing over time suggest that increased capital utilisation may take responsibility for some part of this decline between 1973 and 1990.

Two important results come out from the discussion above. First, it is quite clear that Turkish public investment has remained at around 10 percent of GDP throughout the whole period of 1973-90 (11.5 in the second half of the 1980s), and did not contribute to a reduction in total investment. Fluctuations in total investment are thus mainly due to private investment. Second, the distribution of investment across sectors has changed drastically, and the share of the manufacturing sector has declined while that of housing has increased significantly. Investment in the non-tradeable sector, namely housing and other components of services, makes up the majority of aggregate investment. Evidence from Table 5.17 suggests that instead of creating new productive capacity, capacity utilisation in the manufacturing sector may have increased despite the decline in the share of investment. On the other hand, economic incentives launched in favour of mass housing, such as a special credit scheme, stimulated the purchase of houses particularly in a high inflationary environment.

4. Some Key Factors Affecting Private Investment

In previous sections, macroeconomic policies and the interaction of these policies with investment performance have been presented. Macroeconomic policies affect investment (as well as other component of aggregate demand) through their impacts on some macroeconomic variables such as the availability of credit for investment purpose, interest rates, relative prices, savings. In this section, several channels by which macroeconomic policies influence private investment demand in Turkey, are considered.

In the earlier theory of investment, such as the neoclassical accelerator model, real and financial decisions of a firm have been assumed to be independent, and thus, financial variables have been excluded from many empirical models. The Modigliani and Miller theorem, according to which firms' financial structures are irrelevant to real investment decisions as a consequence of a perfectly operating capital market assumption [Modigliani and Miller (1958)], has been the main justification for these earlier empirical researches. Following the relatively poor empirical performance of these studies, recent empirical studies have begun to include financial variables in investment models (see Chapter 3 and Chapter 8 for theoretical discussion in detail). Theoretically, imperfections in financial markets arising from asymmetric information and exogenous distortions (such as externally imposed ceilings on interest rates, high reserve requirements etc.) violate the Modigliani-Miller irrelevance theorem, and create a difference between the costs of internally generated and external funds. The empirical evidence regarding the roles of financial factors in the determination of investment demand has been investigated by some studies in assuming that a representative firm was rationed in financial markets and had to rely on its own internally generated funds; then a profit variable has been used as a reflection of such a constraint [as in Driver and Moreton (1992), Catinat *et al.* (1987), Fazzari and Athey (1987)].

Some models, in particular ones for developing countries, have used the credit availability to the private sector, instead of profit, to define credit constraints in their model only because of the nature of the capital market in developing countries [as in Blejer and Khan (1984), Sundurarajan and Thakur (1982)]. Along with the existence of asymmetric information, agency cost etc., financial repression in LDCs provides a good justification for the inclusion of credit constraints (instead of profits or retained earnings) in investment demand equations. Among others, ceilings on deposit and lending rates, credit rationing and subsidised credits to priority sectors, excessive taxation of financial incomes and transactions, high liquidity and reserve requirements and intermediation costs, and excessive reliance of corporations on credit rather than equity finance and other direct security issues are common characteristics of financial repression [see McKinnon (1991), and Fry (1988) also provides an extended survey of the literature]. The literature on financial repression argues that various direct or indirect credit restrictions, which reduce the supply of credit available for investment expenditure, have a direct real effect on investment and thus on production [see Blinder (1986)]. Therefore, the credit constraint becomes a potential determinant of private investment expenditures particularly in financially repressed countries.

In this respect, financial liberalisation in Turkey undertaken in the post-1980 period aimed to eliminate various imperfections in financial markets. Financial liberalisation for this purpose has brought about new financial instruments and facilities for the use of the Turkish corporate sector as presented in Section 2.2. Increased efficiency and competition in the banking sector, and institutional innovations aiming to increase alternative financial possibilities, have been implemented by the liberalisation. Besides, the Istanbul Stock Exchange was re-opened in 1986, and became one of the fastest growing stock exchanges in the world. In spite of the increased number of financial facilities, Ersel and Öztürk (1993) report that bank loans are still a very important financing tool for the Turkish corporate sector. This is clear evidence of the vulnerability of the Turkish firms to high interest rate policies.

Regarding the endogenous constraints of the financial system, the Turkish financial liberalisation has not been so successful in eliminating credit rationing arising from imperfect information in financial markets [see Atiyas and Ersel (1994)]. Despite the removal of government control on interest rates, financial markets in Turkey can still be regarded as imperfect largely because of high government involvement with financial markets and different credit policies to preferential sectors. Atiyas *et al.* (1993) implemented a survey designed to examine the lending behaviour of banks in Turkey. The survey was conducted in 1991, and consisted of 16 large, medium and small size banks. The result of the survey suggests that the Turkish banking system still rations some small companies by non-price measures.

In addition to financial factors, the literature on the Turkish economy emphasises a number of other factors which may also have played significant roles in the private sector's performance. These factors have generally been related to the structural adjustment programme undertaken in the 1980s. Despite its favourable effects on private investment through a rise in the availability of financial funds for investment, financial liberalisation also led to higher interest rates, and caused an increase in the cost of borrowing. The high interest rate policy, which was largely caused by high public borrowing as discussed in Section 2, successive exchange rate deprecations, soaring inflation rates, restricted domestic demand, and the increased rate of capital utilisation are among these factors. The rise in the cost of the Turkish firms' financial requirements, in particular, has been considered as the major factor for Turkish firms in the 1980s [see Ersel and Ozturk (1993), and TUSIAD (1984)].

The effects of the structural adjustment and liberalisation policies on various sectors have been different. At an industry level study, Nas and Odekon (1993) report the influence of the high interest rate policy and devaluation both on profitability and on investment. Some supportive evidence for financial liberalisation shows up in such industries as foods, non-metallic minerals, and metal products enjoying the increased financial funds available to the use of these sectors, although the cost of borrowing is still very high. However, three industries -wood products, chemicals and automotive-have suffered from high interest rate policies via the high cost of capital. While providing competitiveness for the Turkish exportable sectors, the exchange rate policy throughout the 1980s, on the other hand, had a discouraging effect on private investment through the cost of imported inputs. This effect becomes even more evident in import-dependent sectors like chemicals. Some exportable sectors, such as mining, textile, wood products, and basic metals, though, have benefited from exchange rate deprecations.

As seen in Table 5.17, priority in public spending has been given mainly to the service sector which includes most of the infrastructure sectors such as transportation, construction etc., and public investment in manufacturing has been cut drastically. The economic rationale behind this reallocation of public investment relies on the idea that an increase in the share of public investment in such social and economic fields as transportation, construction, education, health etc. raises both total factor productivity and labour productivity through its externality effects on private sector capital stock at margin, and crowds in the private sector. The theory also suggests the negative effects of public investment undertaken by state-owned public enterprises that may reduce the possibilities of investment by the private sector operating in the same sector as public firms. The question of which effect is dominant in Turkey would be a matter of empirical testing. Above all, another mechanism of crowding-out, through which public sector investment influences private investment, is interest rates. In this respect, Chhibber and van Wijnbergen (1992) suggest that high public investment would increase the fiscal deficit, which might necessitate an increase in public borrowing and in turn real interest rates (and in turn the user cost of capital).

5. Previous Studies on Turkey

Private investment is a highly volatile component of GNP. As summarised in the earlier sections, the macroeconomic performance of the Turkish economy in different periods has been affected by economic policies implemented in these periods. Internal and external factors have played an important role in determining different economic policies. Moreover, the question of how these changes in economic policies and environment contribute to the overall growth performance of the economy is related to the determinants of private investment and the interaction between these determinants and macroeconomic policies. In this respect, sections above presented the general trend and the pattern of Turkish private investment over the period 1973-1990. The ultimate aim of these sections was to give some suggestive evidence on the possible determinants of the Turkish private investment and their interaction with macroeconomic policies.

However, more conclusive evidence requires more detailed empirical research. There have been other studies for Turkey in this line. Amongst these, there has been very little attempt to apply existing neo-classical models to Turkey. But, as discussed in Chapter 4 for developing countries in general, there has been no unified approach to studying the determinants of the Turkish private investment. These studies can mainly be grouped in three main sections; 1) those without any consistent microeconomic foundation for their empirical models (i.e. eclectic approach)[e.g. see Uygur (1993), and Rittenberg (1991)], 2) those using some elements of neoclassical flexible accelerator mode without providing any microeconomic foundation [e.g. see Chhibber and van Wijnbergen (1992)], 3) those using a data-oriented approach such as vector autoregression models [e.g. see Conway (1990)]. Data availability and different aspects of the determinants of private investment that can be emphasised by different models determine the use of different approaches. I must, in this regard, note that despite the common acceptance of the q-theory approach in empirical research, there have been no studies using this framework. This is partly because the Istanbul Stock Exchange has recently become efficiently operative (in particularly after 1986) and partly because the stock markets as well as the stock market values of firms in developing countries are subject to speculative attacks and bubbles. Therefore, the use of q-approach has not been appealing to study the determinants of private investment in developing countries in general.

The aim of Uygur (1993) is to test to what extent the Turkish experience of financial liberalisation supports the theoretical expectations of the McKinnon-Shaw hypothesis, or in other words, to what extent financial liberalisation stimulates savings and makes larger funds available for fixed investment. For this, he estimated two regression equations for saving and private investment. His investment model, similar to the ones occasionally used by Maxwell Fry [e.g. Fry (1980), (1982)], is an eclectic one, relating the share of non-housing private investment in GNP to an accelerator variable (which is proxied by a three-year average of the growth rate of real GNP), real deposit rates as a cost variable, the availability of credit, uncertainty, housing investment, public investment, and a dummy for 1974 when the war in Cyprus and the first oil shock hit the Turkish economy. According to this study, all variables are significant at least at 5 percent. The accelerator variable is the most significant one, and has the expected positive sign. The effect of real deposit interest rates comes out significantly negative, indicating that the McKinnon-Shaw hypothesis may not be totally true in Turkey. On the other hand, the effect of credit availability is in accordance with the McKinnon-Shaw hypothesis, and significant. Public investment exhibits a positive, crowding-in effect. Considering the reallocation of public expenditures over consumption and investment, high public investment in infrastructure contributes to growth by stimulating higher private investment. Provided that the volume of credit is very limited, housing investment has become another competitor, along with the government, for the existing financial funds, crowding out non-housing private investment.

Chhibber and van Wijnbergen (1992) assess the effect of public policy on private investment. Their study mainly attempts to measure the extent of the "crowding-out" and "crowding-in" effects of the public sector. Their model is basically the same as the one in Blejer and Khan (1984) which is discussed in Chapter 4 earlier. The model was estimated with annual data over the period 1970-1986 (with 17 observations), and included such variables as the effective cost of borrowing[3] , the availability of credit, capacity utilisation, and the composition of public investment. Three determinants of investment come out strongly significant, namely the real effective cost of borrowing, the stock of credit to the private sector and the expected level of output (which was proxied by the lagged value of actual output). Apart from these factors, the non-infrastructure component of public investment had a negative effect on private investment while the infrastructure one was not significant at all.

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[3] The real effective cost of borrowing was defined as the real lending rate comprising the impacts of special charges and taxes on financial intermediation that were easily passed on the borrowers in Turkey.

The model of Rittenberg (1991) is a simple regime-switching disequilibrium model. She implicitly assumes that economic agents have two lending options for their savings; lending either to *official* financial institutions or to the *unofficial* ones. She follows Roe (1982) in assuming that an increase in the official rate of interest towards equilibrium raises loanable funds in the official market by encouraging economic agents to shift their saving from the unofficial market to the official one. There is, thus, a positive relationship between interest rates and the supply of loanable funds in the official market as suggested by the McKinnon and Shaw hypothesis [see also Roe (1982)]. She notes that the effect of the rate of interest, as a cost factor of her investment model, depends entirely upon its actual position with respect to the equilibrium level. When the rate of interest is liberalised, an increase in an initially below-equilibrium interest rate might raise the volume of loanable funds, and lead to higher investment, and thereby higher growth. This is the expected result of the McKinnon-Shaw hypothesis. But, on the other hand, during some periods of liberalisation, the negative effect of a "too" high interest rate (i.e. an interest rate above equilibrium) could have discouraging effects on private investment. From the empirical results of the study, the real interest rate in Turkey has been sometimes above, sometimes below the equilibrium level[4] . The opposite effects of below- and above-equilibrium rates are particularly obvious in the estimation of non-housing private investment, including investment expenditures in manufacturing and transportation sectors. Accordingly, a one percent increase in interest rate, when it is below equilibrium, results in a 3.4 percent increase in real investment. On the other hand, when it is above the equilibrium rate, the same increase produces a 0.5 percent reduction in the real private non-housing investment. She then concludes that investment in Turkey was highly sensitive to interest rate changes.

Conway (1990) attempts to assess the effects of relative price-based structural adjustment policies on private investment using Sim's VAR methodology. When the economic structure changes, this VAR framework becomes even more valid because a set of coefficients of a structural model will also alter [this is the well-known *Lucas critique* which was put forward first in Lucas (1976)]. Like Rittenberg (1991), he also concentrates on non-housing investment. The overall result of Conway is that, unlike Chhibber and van Wijnbergen (1992), the relative price-based structural adjustment programme has worked to reduce private non-housing investment. He pointed out that nominal interest rates, which have increased steadily with financial liberalisation since

[4] The same approach has been applied to Mexico to test the financial liberalisation hypothesis by Warman and Thirlwall (1994). The procedure to find the unknown equilibrium interest rate was described as a trail and error process, by which the sum of square residual of the proposed investment equation is minimised. Note that the sum of square residual at the equilibrium rate should be zero.

Table 5.19
Empirical Specifications of Investment Models for Turkey

	van Wijnbergen *et al.* (1992)	Conway (1990)[a]	Conway (1991)[a]	Rittenberg (1991)[b]	Chhibber & van Wijnbergen (1992)	Uygur (1993)
Specification	Eclectic Accelerator	Eclectic VAR Model	Eclectic	Eclectic	Flexible Accelerator	Eclectic
Data	Annual 1970-86	Annual 1962-86	Annual 1964-88	Annual 1964-86	Annual 1970-86	Annual 1969-90
Dependent Variable	i_t^p	i_t^p	i_t^p	i_t^{nhp}	i_t^p	$\left(I_t^{nhp}/GNP_t\right)$
Accelerator	y_{t-1}	y_{t-1}	y_{t-1}	y_{t-1} and g_t	y_{t-1}	g_{t-1}
Relative Prices	----	$\left(p_{t-1}^k - p_{t-1}\right)$	----	----	----	----
Financial variable	$\left(crd_t^p - y_t\right)$	----	----	----	$\left(crd_t^p - y_t\right)$	ΔCRP_t^p
Interest Rate	$\left(1 + rr_t^l\right)$	r_{t-1}^b	$\left(r_t^b - \pi_t\right)$	rr_t^d	$refr_t^b$	rr_t^d
Public Sector	$\left(i_{t-3}^{\inf r} - i_{t-3}^g\right)$	i_{t-1}^g	---	----	$\left(i_{t-3}^{\inf} - i_{t-3}^g\right)$ and $\left(i_{t-3}^{n\inf} - i_{t-3}^g\right)$	$\left(I^g/GNP\right)$
Capacity Utilisation	u_t	----	----	----	u_t	-----
Inflation	----	π_{t-1}	----	----	----	----
Exchange Rate	----	e_{t-1}	re_t	re_t	----	----
Uncertainty	----	----	vrr_t^b and $vrer_t$	----	----	$\left(FI_t/GNP_t\right)$

Notes: i^g: Public investment; i^p: Private investment; $i^{\inf}$: public investment in infrastructure; $i^{n\inf}$: Non-infrastructure public investment; y: output (proxied by GDP); g: growth rate of output; p: output prices (proxied by the GDP deflator); p^k: price of capital goods; crd^p: credit to the private sector; rr^l: real lending rate; r^b: nominal borrowing rate; $refr^b$: real effective borrowing rate r^d: nominal deposit rate; u: index for capacity utilisation; e : nominal exchange rate; re: real exchange rate; $vrer$; variance of the real exchange rate: vrr^b: variance of the real borrowing rate; FI: foreign direct investment.

[a] includes sectoral level estimations for four sectors such as agriculture, manufacturing, transportation, and housing.

[b] includes sectoral estimations for two sectors such as manufacturing, and transportation.

1982, led to declines in aggregate investment in the 1980s. Although he argues the importance of credit rationing in the determination of investment, his model does not capture this factor.

Conway (1991) is the only study of the effects of relative price uncertainty on private investment at the aggregate as well as sectoral level (agriculture, housing, manufacturing, transport). He applies a standard Keynesian model, augmented by proxies for price instability, to the Turkish annual data. Instability in two relative prices, the expected variance of real interest rate and the expected variance of real exchange rate, are taken as measures of uncertainty. He regresses private investment on the real gross domestic product, expected values of the real exchange rate and real interest rates, and the variances of the real exchange rate and real interest rates. He sets up forecasting rules for the real exchange rate and real interest rate for investors, and then estimates the optimal forecasts as the expected mean of the variable conditional on information available at the forecast period by using the *Kalman filter* method, which also provides the conditional variance of forecast of each price variable. His empirical results suggest that the measures of relative price uncertainty have negative and statistically significant coefficients. From the sectoral estimations, Conway also finds strong negative effects on private investment in all sectors (particularly in manufacturing).

As explained above, investment studies on Turkey show great variability in terms of the specification of the investment demand model, and the variables that have been included (see Table 5.19 for a brief summary). Nevertheless, all of these empirical models have been estimated by using relatively short samples of annual data [the longest time period contains 25 observations in Conway (1991)], with limited degrees of freedom (see Table 5.19). This thesis has two main advantages in comparison with previous studies. One is the use of a larger sample size covering both the period 1963-1991 for the estimations in Chapter 6 and Chapter 7, and the period 1963-1993 for Chapter 8. The other one is related to the modelling approaches in subsequent chapters. No one, so far, has made any attempt to analyse the determinants of private investment expenditure in line of the neoclassical theory. In what follows, such an attempt is presented with a consistent microeconomic framework.

The present thesis emphasises the use of theory-based approaches. For this purpose, three different models are developed and empirically estimated in the following chapters. The main motivation of doing so is the lack of theory-based models for developing countries in general, and for Turkey in particular. By a theory-based model, it is meant the studies that explain the investment behaviour of a representative firm using a framework of either cash flows maximisation or cost minimisation. As presented in Chapter 4, some studies have adapted neoclassical models to private investment in individual developing countries. These studies have, in general, borrowed two main elements of the neoclassical theory, namely the ad hoc partial adjustment mechanism of the actual capital stock (or the actual level of investment) to its desire level, and a definition of the unobservable optimal capital stock (or the optimal investment level) in terms of some observable variables. Some distinctive features of developing countries are incorporated mainly through two different ways: 1.) by defining the optimal level of the capital stock (or investment) in terms of variables reflecting these features, 2.) by defining a linear relationship between the adjustment cost coefficient and some exogenous variables.[5]

By a theory-based modelling in this thesis, I present three different models which are defined through an optimisation problem of a representative firm. Chapter 6, in this respect, presents a neoclassical model to provide empirical evidence on the importance of the neoclassical determinants (the accelerator, and the relative cost of capital variables) of private investment in Turkey. The relationship between the main neoclassical determinants is derived from a cost optimisation of the firm which produces for a demand-constrained output market. Two different investment models are derived under two technology assumptions about the form of the production function (namely putty-putty and putty-clay technologies). The effects of the availability of credit are also included in an eclectic way in the model to investigate the importance of borrowing constraints in Turkey.

The recent history of applied economics has witnessed a number of developments, one of which has been the co-integration and the error-correction approach. Although this approach is mainly data oriented, and tries to find out the best and the most reliable representation of the data from the statistical point of view only, the theoretical economic framework for this approach has been largely neglected. Most recently this approach has started being used in modelling private investment in developing countries [e.g. see Fielding (1993) and Shafik (1992)], with this defect. With Chapter 7, I attempt, however, to provide some additional support for the neoclassical determinants of the Turkish private investment by proposing a theoretical economic explanation for the error-correction representation of the investment data . However, the inclusion of the effects of borrowing constraints still remains eclectic.

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[5] see Chapter 2 for a theoretical discussion. Chapter 4 also presents the use of this idea to formulate the adjustment coefficient for developing countries in general.

Unlike the earlier model, the dynamic features of the model arise because of the expectations about the future. The model is also applicable to test rational expectation hypothesis with a larger sample size. However, a more general model is reduced to a simple error-correction model by assuming that the future expectations evolve according to a random process with drift.

The final model developed in Chapter 8 aims to discover the role of financial factors (such as imperfections in capital markets and borrowing constraints) in the determination of real private investment decisions. Unlike previous two models, Chapter 8 suggests a new modelling approach to testing the effects of financial factors with an explicit microeconomic foundation. For this purpose, an empirical model with an explicit theoretical framework is developed and estimated. The empirical investment equation (called Euler equation) is derived from a dynamic investment model by a maximisation of the intertemporal discounted cash flow of a representative firm subject to capital market imperfections, borrowing constraints, and capital adjustment costs. The Euler equation for the rate of the capital accumulation is derived by re-arranging the first-order condition for capital, which is influenced by the binding borrowing constraint through an unobservable shadow price. Unlike previous studies [e.g. see Whited (1990)], the novelty in my approach is that the model specifies the unobservable shadow price associated with the borrowing constraint in terms of other observable variables of the model, using the first-order condition for the state variable, the outstanding debt stock.

6. The Description of The Data Used in the Empirical Chapters

This section describes the sample size and the nature of the data that were used in the following empirical chapters, and their sources. The sample period between 1963 and 1993 chosen for the empirical analysis in Chapter 6, Chapter 7 and Chapter 8 was largely determined by the data availability. The main data source is the State Planning Organisation (SPO) from which most data on public and private investment, price indices of public and private capital goods, and the rates of depreciation both at the aggregate and the sectoral level have been obtained. The sources of aggregate and sectoral capital stock data are the newly available *semi-official series* in Maraslioglu and Tiktik (1991). To the knowledge of the author, there is no such time series on aggregate and disaggregate capital stock series that has been published officially. Maraslioglu and Tiktik (1991), which is prepared for the use of the staff at the SPO, comprises official aggregate and sectoral data (on public and private investment, the price indices of private and public investment goods, and depreciation rates), and semi-official capital stock series. The extension of the sample for the period between 1991 and 1993 of the relevant series have kindly been provided by Maraslioglu and Tiktik of the SPO.

The data on credit to the private sector in Turkey was compiled from various IMF Financial Statistics Yearbooks which report it as claims on the private sector. Nominal deposit rates for twelve months deposits, which are reported as end of period, on the other hand, are taken from *The Quarterly Bulletin of the Central Bank of the Republic of Turkey* (various issues). The econometric estimations in Chapter 8, however, require data on riskless interest rate that may be proxied by the net yield of government securities. However, no data on the rate of government securities before 1986 are available. This lack of data led us to use nominal deposit rates instead, although it is not a good proxy for the riskless interest rate.

The other troublesome variable is wages. Unfortunately, no published data on wages for the period of analysis could be found. The SPO generates a general index for wage earners for the purpose of internal research and five-year plans, but this series goes back only to 1975, and cannot capture the real decreasing trend in real wages in the early 1980s. Other series by The Social Insurance Institution (SSK) and the Labour Placement Office are all subject to some severe criticism[6]. The data on wages is taken from Ozmucur (1992), covering the period of 1963-1991, in which total non-agricultural wage and salaries and the total populations of wage and salary earners are reported. The wage series is constructed simply as a ratio of these two series.

7. Conclusion

The chapter briefly analysed the recent Turkish economic history over the period (1960-1990) on which the empirical models in the following chapters are based. In the pre-1980 period, the industrialisation strategy was based on import substitution, and had reached its limits by 1977 by creating internal and external imbalances. As essential elements of this strategy, repressed financial markets, stimulated domestic demand, and high share of public investment in GNP have played an important role in the determination of private investment. Turkey launched an economy-wide stabilisation and structural adjustment programme that proposed to change the entire development

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[6] Employers in Turkey must pay insurance premium for each worker to the SSK, which is determined by his/her monthly wage. In an inflationary economy like Turkey, the majority of employers do not pay the insurance premium to the SSK on time and consider this insurance premium as a cheap financial source. Besides, they usually claim that they would pay minimum wage to employees, even if they paid more, in order to avoid from paying more insurance premium. Since the wage statistics published by the SSK are based entirely on those claims, they are always downwards biased. Because this kind of avasion is the common practice in Turkey, wage statistics by the SSK may be regarded as not reliable at all.

strategy of the country after 1980. Following the 1980 stabilisation policies and the adjustment programme in the following years, Turkey experienced an economy-wide structural transformation, and the economy became relatively export oriented.

The incentives system has shifted from import-substitution sectors towards export-oriented ones. To provide sufficient funds and close the saving gap between investment and saving, financial liberalisation was implemented. The trade policy was liberalised, and foreign exchange constraints were relaxed. However, this new orientation of the economy has brought out new factors affecting private investment. The declining share of public investment in manufacturing has shifted to infrastructure investment with the belief that an increase in public infrastructure investment raises the productivity of the private sector investment at the margin, and crowds in the private sector. The private sector response to the reform programme has been determined, negatively, by repressed domestic demand, high interest rates, uncertainty about the sustainability of the reforms in the future, and positively by low real wages, real depreciation, subsidies given to export-oriented sectors, and easing availability of financial funds for the use of private investment.

The composition of investment, as a result, has changed drastically in the post 1980 period. The services sector made up more than half of total investment while the share of manufacturing was continuously declining. In particular, the investment response of export-oriented sectors was sluggish, partly indicated by slowdown in the share of manufacturing exports.

Previous studies on the determinants of the Turkish private investment have been discussed in Section 5. The main conclusion from these studies is their eclectic structure and the lack of microeconomic foundations on their empirical models. Also, the present chapter has put emphasis on the differences of the empirical models in the following chapters from those in the literature, and concludes that unlike previous counterparts, these models have consistent theoretical microeconomic foundations. The data used on which empirical estimations are based are also described in this chapter by stressing the larger size of the sample in comparison with the earlier studies.

In the following chapters, the roles of different factors in determining private investment behaviour in Turkey are empirically investigated with a special attention to financial factors. I also pay attention to deriving theoretically consistent models with the guidance of the neoclassical theory investment. Despite the eclectic nature of modelling financial factors in Chapter 6 and Chapter 7, Chapter 8 provides a theoretical model including a financial factor in the firm's dynamic optimisation problem.

Chapter 6

Accelerator Effects, Borrowing Constraints, The Cost of Capital, and The Turkish Private Investment Expenditures

1. Introduction

Determinants of private investment have been extensively studied in industrialised countries. Empirical researches are in broad agreement on what determines fluctuations in private investment in these countries. Three main determinants emerge from these researches: namely expected level of output, internal funds availability or cash flows, and the cost of capital relative to labour. However, private investment in developing countries (LDCs) has not drawn so much interest until recently. Some distinctive structural and institutional differences of these countries and the availability of relevant data limit the application of an identical model of investment to LDCs. The most widely accepted practice, though, is that one should adapt the model (which is originally developed for an industrialised country) to take account of those different features of developing countries. A similar approach is adapted in this chapter. However, the model throughout this chapter remains essentially neo-classical.

According to discussions in the earlier chapters, the theories of investment on which econometric specifications of investment expenditures are based, can usually be separated into three distinctive theoretical models: i.) accelerator model in which investment demand occurs as a result of an adjustment of capital stock to expected demand [Chenery (1952), Clark (1917)], ii.) neo-classical models mostly relying upon Jorgenson's studies in which a maximisation of the present and future expected cash flows determines the desired capital stock, and firms invest until they reach that level of capital stock [Jorgenson, (1963)], iii.) profitability theory, originating from the works of Kalecki and developed by James Tobin, in which investment expenditures are implicitly related to a measure of profitability of firms [Kalecki (1954), Tobin (1978, 1969), Tobin and Brainard (1977)]. Kalecki (1954) suggested that investment decisions are closely related to 'internal' accumulation of financial capital (i.e. internal savings), and related the rate of investment to changes in profits. The last profitability theory of investment is also known as the q-theory of investment and copes with the forward-looking characteristic of investment decisions by connecting investment expenditures to the so-called average-q (the stock exchange value of a firm) through which all expectations on the firm's market value are incorporated implicitly. One extension of the profitability approach leads one to the financial theory of investment where financial conditions of the firm and the economy, in which the firm operates, influence investment decisions.

The distinction between different theories depends on the variables included in the empirical investment equations, and gives an opportunity to study the effects of different variables on investment. The debate in the literature, however, focuses mostly upon the question of which theory explains investment expenditures better in industrialised countries. Empirical studies have suggested that no single theory could yield a satisfactory explanation of variations in private investment expenditures. The various combinations of these theories, or modifications of each of them according to different circumstances for different states of an economy, would be a more reasonable way of modelling investment demand rather than simply applying a more specific theory. In the studies for a developing country, this approach is an even more plausible strategy. Above all, such problems as data availability and institutional differences may force someone to combine different theories and to modify them in the light of these problems. This is the strategy pursued in this chapter. Unlike other studies in the literature, the model in this chapter avoids an eclectic modelling approach, and is derived with a strong reference to a microeconomic framework. In the following section a model, which is a combination of accelerator and financial theories of investment, will be discussed, and estimated with Turkish data. However, the inclusion of a financial factor (namely availability of credit to the private sector) is less sound, and serves only to investigate the importance of credit constraints in investment behaviour in Turkey.

The purpose of this chapter is three fold: The first is to answer the question of to what extent the neo-classical accelerator type of models can be successfully applied to a developing country, namely Turkey. The second is to find out what determines Turkish private investment expenditures. The third is to discern the dependence of the Turkish private investment expenditures on finance constraints. For these purposes, I specify an investment function, which can be named as the *flexible-accelerator-relative cost model.* The model is modified on the grounds that under-developed financial markets may impose credit constraints on investment expenditures.

The determinants of private investment in Turkey have been studied by a limited number of researches subject to a severe data availability problem [Uygur (1993), Rittenberg (1991), Chhibber and van Wijnbergen (1992), Conway (1990, 1988)][1]. In this chapter, the sample covers 30 annual observations for the period of 1963-1992. A unique feature of the present chapter, with Chapter 7 and Chapter 8, is the sectoral estimations of private investment demand equation, although the sample size for these estimations is quite small (26 annual observations) covering the time span between 1968 and 1993.

In contrast to many empirical models that have been applied for developing countries, the model employed here is an attempt to implement a theory-based model to Turkey. Some more recent studies, such as Sundurarajan and Thakur (1980), Tun Wain and Wong (1982), Blejer and Khan (1984), Conway (1988), have attempted to incorporate some features of the neo-classical model for groups of LDCs, taking account of data problems and other structural characteristics. The model in this chapter, however, differs from theirs in the sense that different technology assumptions - such as putty-clay, putty-putty, clay-clay - are also tested.

The chapter is divided into seven sections. Following the introductory section, the flexible accelerator model is developed in Section 2. Section 3 describes the effects and significance of some key variables in the Turkish case. Section 4 reports estimation results. In Section 5, the Sundurarajan-Thakur modified flexible accelerator model as well as its estimation results are presented. Following sectoral private investment models in Section 6, conclusions drawn from the empirical practice in this chapter are highlighted in the last section.

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[1] For example, the sample sizes of referred papers have been relatively small. Uygur (1993) uses 26 annual observations covering the period of 1965-1990; Rittenberg (1992) covers the 1964-1988 period (25 observations); Chhibber and van Wijnbergen (1992) estimate a private investment equation with 17 observations for the period 1970-1986; and finally Conway (1990)' estimation benefits 24 observations for the period between 1963 and 1986.

2. Flexible Accelerator-Relative Costs Models with a Credit Constraint

The accumulation of real private physical capital is widely considered as a very important factor in economic development [see Khan and Reinhart (1990)]. The question of what determines real physical capital investment in developing countries, therefore, is as important one. Thus far, the investment theory has revealed three key factors in the determination of fixed capital formation in industrialised countries, namely *demand, the relative cost of capital,* and *profits or cash flows.* These variables in the private investment models for developing countries can be extended according to the different economic structure of these countries (e.g. public investment expenditures, public capital stock, credit to private sector, exchange rates, etc. are the most frequently used additional factors for developing countries depending on the data availability).

This section addresses the role of these factors in the context of the Turkish economy, using two different models. The first one is a naive neoclassical model that highlights the importance of the accelerator variable. This is also known as a partial adjustment clay-clay model, in the sense that substitution between factors of production is not allowed, so that the relative prices of production factors do not play any role in the determination of investment demand. The second model, that is essentially in accordance with Bischoff (1971), is borrowed from Artus and Muet (1990) and Catinat *et al.* (1987), and developed into a very flexible form to contain the impacts of borrowing constraints Unlike the first one, this model allows factor substitution and takes account of the effects of relative prices. I thus call the second one the *flexible accelerator-relative cost model.* The specification of the model rests on assumptions about both market conditions (i.e. competitive or rationed output market) and the form of the production function. The model here particularly focuses on effective demand for output; i.e. the firm determines its investment expenditures according to the level of expected demand for output in the market. The responsiveness of investment demand to the relative cost of capital, as well as to the expected level of output depends on technology assumptions about the production function, which is specified by the elasticity of substitution and the degree of malleability of capital. In what follows, the second model is discussed under two distinctive technology assumptions, namely *putty-clay* and *putty-putty* technologies [see Section 2.3 in Chapter 2].

In putty-clay production technology, the rate of capital-labour substitution is assumed to be fixed *ex post*, but variable *ex ante*, so that the factor proportions can be changed only for new plant and machinery. Putty-putty technology, however, assumes that the rate of factor substitution is variable *ex post* as well as *ex ante*, so that the possibility of substitution between capital and labour does not depend on whether capital goods are new or old. No capital-labour substitution in the clay-clay production technology, and continuous substitution in the neoclassical putty-putty production technology correspond to two extreme cases. An intermediate case arising from making the rate of substitution between capital and labour differ *ex post* and *ex ante* is, however, more plausible in reality. Therefore the putty-clay assumption becomes more appropriate to specify the technology of the production function.

The Model

The model, in general, assumes that there is disequilibrium both in the output market (so that investment demand of a representative firm becomes responsive to changes in the level of expected demand), and in financial markets (so that the firm may be constrained by the availability of external funds). For simplicity I assume that the rate of wages is fixed. The firm's objective is to choose the optimal investment level that minimises the cost of production subject to given demand for output and the production technology, such that

minimise $$TC = WL + CK \tag{1}$$

subject to $$\bar{Y} = F\left[\exp(\alpha t)K, \exp(\beta t)L\right] \tag{2}$$

$$C = q(\delta + r - \hat{q})$$

where TC= the total cost of production; W= wages; L= labour; K= capital; $\bar{Y}$= demand for output which is assumed to be given; C= the user cost of capital; q= the price of capital goods; $\hat{q}$= inflation rate on the price of investment goods $\hat{q} = \dot{q}/q$; r= nominal interest rate; δ= the constant rate of depreciation; α and β are coefficients indicating technological progress embodied in capital and labour respectively Minimising total cost subject to constraint (2), the desired level of the capital stock can be derived as follows [see also Bean (1981)][2]

$$\dot{K}^{*} = \alpha + (\alpha - \beta)b + \frac{1}{\upsilon}\dot{Y} - \sigma b\left(\frac{\dot{C}}{\dot{W}}\right) \tag{3}$$

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[2] Full derivation of the optimal (or desired) level of the capital stock is presented in appendix-B.

where $\dot{K}^*$= changes in the desired level of capital; υ measures returns to scale; $\left(\dot{K}^* = \left(dK^*/dt\right)/K^*\right)$(see appendix B),

$$\sigma = \frac{d\ln(K/L)}{d\ln(W/C)}, \qquad b = \frac{WL}{WL+CK}$$

σ= the elasticity of substitution, b= the share of wage costs. Using the capital accounting identity, $dK^*/dt = I - \delta K^*$, where I is gross investment and δ is the rate of depreciation, the same equation (eq. 3) can equivalently be written as follows (see appendix B for detail),

$$\left(\frac{I}{K^*}\right) = \alpha + \delta + (\alpha - \beta)b + \frac{1}{\upsilon}E\left(\dot{Y}\right) - \sigma bE\left(\frac{\dot{c}}{\dot{w}}\right) \tag{4}$$

where E(.) indicates the expected values of variables, and has been approximated by a distributed lag process. This is the "putty-putty" version of the investment model suggesting that $\left(I/K^*\right)$ is a positive function of the rate of change of demand, and a negative function of the rate of variation of relative prices. If the elasticity of substitution, σ, is zero (the Leontieff production assumption), then the model is reduced to the "clay-clay" technology, where the rate of capital accumulation is only a function of the variation of demand. The clay-clay model is also estimated in the Section 4.1 as a näive neo-classical investment model. To include the capital adjustment process into the model, assume a simple Koyck adjustment mechanism

$$\dot{K} = \lambda\dot{K}^* + (1-\lambda)\dot{K}_{t-1}, \quad 0 \leq \lambda \leq 1 \tag{5}$$

where λ is the partial adjustment coefficient; $\dot{K} = (dK/dt)/K$ in continuous time is identical to $\Delta K/K_{t-1}$ in discrete time; thereby the capital accounting identity can also be written as $(\Delta K/K_{t-1} = I/K_{t-1} - \delta)$ in discrete time. Using (4) and (5), the following putty-putty version of the investment model can be obtained

$$\frac{I_t}{K_{t-1}} = \alpha_0 + \alpha_1(L)\dot{Y}_t + \alpha_2(L)\left(\frac{\dot{C}}{\dot{W}}\right)_t + \alpha_3\left(\frac{I_t}{K_{t-1}}\right)_{t-1} \tag{6}$$

where $E\left(\dot{Y}\right) = \alpha_1(L)\dot{Y}$ and $E\left(\dot{C}/\dot{W}\right) = \alpha_2(L)\left(\dot{C}/\dot{W}\right)$, and the sum of the coefficients of the lag polynomials are equal to $\lambda(1/v)$ and $-\lambda\sigma b$ respectively.

When the production function is putty-clay, factor substitution no longer affects total capital stock but only investment, and the dependent variable of the model should be investment (instead of the rate of capital accumulation as in equation (6)). For the putty-clay version of the model, first write the Koyck's distributed lag scheme (equation 5) as

$$K_t = \lambda K_t^* + (1-\lambda)K_{t-1} \tag{5a}$$

or

$$\Delta K_t = \lambda\left(K_t^* - K_{t-1}\right) \tag{5b}$$

then using the capital account identity, define in terms of gross investment,

$$\Delta K_t = I_t - \delta K_{t-1} \tag{7}$$

Equalising the left-hand sides of equations (5b) and (7),

$$I_t = \lambda K_t^* + (\delta - \lambda)K_{t-1} \tag{8}$$

Lagging (8) by one time period, and multiplying both sides by (1-δ), and then subtracting the product form (8), the Koyck transformation generates the following equation that is not a function of the lagged actual capital stock term, but only of the desired level of capital stock

$$I_t = \lambda\left[1-(1-\delta)L\right]K_t^* + (1-\lambda)I_{t-1}$$

or

$$I_t = \Psi(L)K_t^* + (1-\lambda)I_{t-1} \tag{9}$$

where L is a lag operator by which $LK_t^* = K_{t-1}^*$. However, K_t^* is not directly observable in the model, but can indirectly be derived from equation (3). Integrating (3) over time (by assuming b is constant), the following specification of the desired capital stock is obtained (see appendix B),

$$\ln K_t^* = \left[\alpha - (\alpha-\beta)b\right]t + (1/\upsilon)\ln Y_t - \sigma b \ln(C/W)_t \tag{10}$$

In order to derive the "putty-clay" version of the model, suppose that investment is related only to new plants and machinery (i.e. the most recent vintage, not total capital stock). The additional demand to be met, which is a cause of investment, hence relates to the difference between total output before and after the installation of the new vintage, net of depreciation. Hence, instead of using Y as an accelerator variable, changes in demand which acquire new vintage capital (equal to investment) net of depreciation, are used. Catinat *et al.* (1987), Driver and Moreton (1992), and

Kaskarelis (1993) all take new capacity as a linear function of the change in actual output Y_t; i.e. $YY_t = [Y_t - (1-\delta)Y_{t-1}]$ where δ is the rate of depreciation. Then

$$\ln K_t^* = \gamma_0 + \gamma_1 \ln YY_t - \gamma_2 \ln(C/W)_t + \gamma_3 t \tag{11}$$

where γ_0, γ_1 and γ_2 are positive functions of coefficients in (10). Having taken the logarithm of equation (9), the investment equation under the "*putty-clay*" technology assumption can, therefore, be obtained as

$$\ln I_t = \gamma_0 + (1-\lambda)\ln I_{t-1} + \mathbf{P}(L)\ln YY_t + \mathbf{Q}(L)\ln\left(\frac{c}{w}\right)_t + \gamma_3 t \tag{12}$$

where **P**(L) and **Q**(L) are lag polynomials.

These two models, equation (6) and equation (12), are quite similar to the ones developed for industrialised economies. However, the theory of private investment in LDCs suggests that the applicability of these equations may be very limited due to some institutional and structural differences as well as data availability. A model, proposing to explain private investment in LDCs, must be flexible enough to allow for these characteristics. In this respect, an important characteristic of the Turkish corporate sector is the extensive dependence on external funds for financing investment expenditures [see Ersel and Öztürk (1993)]. If Turkish firms are constrained in the level of internally generated funds available, investment expenditures in the private sector will also be dependent on the availability of external funds, and will exhibit fluctuations according to changes in the level of the borrowing constraint. The theoretical modelling of external borrowing constraints in this chapter is less sound, and is modelled, rather *in an eclectic way*, by the inclusion of a variable on credit inflows to the private sector. In what follows, a variable capturing borrowing constraints is included as an argument to test whether, among others, the quantity or price variable is more important in investment decisions in Turkey. The final reduced forms of investment models under putty-putty and putty-clay technology assumptions can therefore be written as follows:

i.) Putty-putty technology assumption

$$\left(I_t^p/K_{-1}^T\right)_t = a_0 + a_1(L)\dot{Y}_t + a_2(L)\left(\dot{C}/\dot{W}\right)_t + a_3(L)C\dot{R}D_t^p + a_4\left(I_t^p/K_{-1}^T\right)_{t-1} \tag{6a}$$

$$\left(i_t - k_{t-1}\right) = a_0 + a_1(L)\Delta y_t + a_2(L)\Delta(c/w)_t + a_3(L)\Delta crd_t^p + a_4\left(i_t - k_{t-1}\right)_{t-1} \tag{6b}$$

$a_1, a_3 > 0,\ a_2 < 0$. Equation (6a) is the original specification of the model that has been given by the theory. Note that in equation (6a), all variables on the right-hand side (except the rate of capital accumulation) correspond to the changing rate of the relevant variable. Equation (6b), on the other hand, stands for the double log-linear form of equation (6a) including the rate of capital accumulation term. The estimation results of both models are presented in Section 4.2.

ii.) Putty-clay technology assumption

$$i_t = b_0 + b_1(L)yy_y + b_2(L)(c/w)_t + b_3(L)crd_t^p + b_4 i_{t-1} \tag{12a}$$

$b_1, b_3 > 0,\ b_2 < 0$

where $YY_t = [Y_t - (1-\delta)Y_{t-1}]$; crd_t^p: credit inflows to the private sector. Note that all lower case letters indicate the logarithm of the respective variable.

<u>A Note on the Relationship of Equation (14) with a Model that has mostly been applied for LDCs:</u>

A variant of this flexible accelerator model with putty-clay technology, which enables us to modify (12a), was developed by Blejer and Khan (1982), and has been used by Voridis (1993), Morriset (1994), van Wijnbergen (1992). The main advantage of Blejer and Khan (1982) is that through the varying partial adjustment coefficient assumption -borrowed from Coen (1971)- the model can be reduced to one including some features of developing countries such as the credit availability to the private sector.

Following Blejer and Khan (1982), now assume that the flow of investment is away from its steady state level (i.e. desired level), but itself adjusts towards equilibrium in the long-run according to the partial adjustment mechanism:

$$\ln I_t = \theta \ln I_t^* + (1-\theta)\ln I_{t-1} \tag{9}$$

where I_t^*: the desired level of investment, θ_t: the adjustment coefficient assumed to be varying as a function of some macroeconomic variables. There are two modelling strategies to incorporate some features of LDCs. Some authors, such as Ramirez (1994), adapt a rather *ad hoc* approach, and assume I_t^* as a linear function of some macroeconomic variables. The final reduced form equation is not the same as the putty-clay accelerator model above. Others (i.e. Driver and Moreton, 1992 and Blejer and Khan 1982), on the other hand, may relate I_t^*, for example, to new capacity and relative factor cost, and substitute this into the partial adjustment equation. They may then derive a reduced form which is entirely the same equation as equation (12a). In an effective demand model such as the one above, the desired level of capital stock can be written as a function of output (determined by a given level of demand in the output market), and the relative user cost of capital. Adapting the specification of King (1972), the desired investment is a log-linear function of change in the actual output and relative capital-labour cost,

$$\ln I_t^* = g_0 + g_1 \ln[Y_t - (1-\delta)Y_{t-1}] + g_2 \ln(c/w)_t \qquad (13)$$

where $g_1 > 0, g_2 < 0$.

The adjustment coefficient here has crucial importance, in the sense that the speed of adjustment, measured by that coefficient, is assumed to be affected by some other macroeconomic factors, which are supposed to reflect relevant features of the economy, such as public investment, the cost of the factor of production, or credit availability. Driver and Moreton (1992) use a similar formulation of the adjustment coefficient in order to incorporate the impact of profitability into the investment equation. However, in Blejer and Khan's framework, if one assumes that the speed of the adjustment process is influenced by the user cost of capital, credit available for the use of the private sector and public investment, then

$$\theta_t = \theta_0 + \theta_1 \frac{f[\Delta CrP_t, I_t^g, \ldots]}{(I_t^* - I_{t-1})} \qquad (14)$$

where I_t^g= public investment; the function $f(.)$ is assumed to be *linear* in all variables. Finally, substituting the expression for the desired investment and the adjustment coefficient into the partial adjustment equation gives rise to the following, relatively more general, investment equation,

$$i_t^p = b_0 + b_1(L)yy_t + b_2(L)(c/w)_t + b_3 crp_t + b_4 i_t^g + b_5 i_{t-1}^p \qquad (15)$$

where lower case letters indicate the logarithm of the respective variable. The modified Blejer and Khan model is reduced to the one quite similar to the above putty-clay investment model. Unlike the putty-clay models developed by Catinat *et. al.* and Artus and Muet (1990), Blejer and Khan's (1982) model is more general since different definitions of the function of the adjustment coefficient may yield different reduced forms of investment functions. Note that with the specification of the adjustment coefficient in (14), I implicitly assume that credit availability is <u>not</u>

strictly binding, but influences the speed of adjustment towards steady-state equilibrium.

3. Some Key Variables in The Model

The many econometric studies of investment have consistently shown the importance of the adjustment of capital to demand -i.e. accelerator variable-, and the length of this adjustment. Anand *et al.* (1990), Conway (1990), and Chhibber and van Wijnbergen (1991) found a similar result for the Turkish economy, leading to the conclusion that the expansion of real gross domestic product, which was used as a proxy of demand, increases real private investment with an elasticity significantly *greater than unity*.

If Turkish firms are constrained by internally generated funds, investment decisions in the private sector will be dependent on the external availability of funds. In the Turkish experience, the findings of various studies suggest that the availability of credit to the private sector is important (see Chhibber and van Wijnbergen, 1992, Anand *et al.* 1990, Rittenberg, 1990); and it is expected to have a positive sign in the equation. In the present study, the availability of external borrowing, as such, will be proxied by the real credit volume of the Turkish banking system to the private sector. In what follows, private investment is related to changes in real bank credit to the private sector, along with the inclusion of interest rates in the formulation of the cost of capital.

Two variables have been used to measure the cost of capital. The first one is similar to Jorgenson's definition of the implicit cost of capital, which comprises interest rates, the price of capital goods, the constant rate of depreciation, and inflation in the price of capital goods [see Jorgenson (1963)]. Depending on the availability of data, a more complicated form may also include some additional fiscal variables such as the corporate tax rate, depreciation allowances, investment grants, investment tax credits [see Dailami (1992), Auerbach (1990), and Hall and Jorgenson (1971)]. In this present study only the simple definition of the cost of capital variable has been used because of the shortage of a sufficiently long historical data on the fiscal variables described above. This specification of the relative cost variable allows for testing the theoretical model derived, and is calculated as (c_t/w_t) where $c_t = q_t \times (r_t + \delta - \Delta q_t/q_t)$, where c_t stands for the cost of capital, r_t, δ, Δq_t being the interest rate, depreciation rate and changes in the price of capital prices respectively; w_t stands for wages.

Given the fact that the Turkish financial system is still repressed by various forms of price and non-price rationing arising from informational imperfections [see Atiyas *et. al.* (1993)], and that demand for the capital stock demand would be more responsive to changes in the availability of credit to the private sector than to changes in the interest rate, I have also defined the relative price of capital goods as the second cost of capital variable. In such an economy, the Keynesian equilibrium relationship between the marginal efficiency of capital and the rate of interest, as we discussed in Chapter 3, may not hold, and the former may become more responsive to the supply conditions of capital goods, which may be reflected by the supply price of capital goods. In a developing country where capital goods imports take up a major share in total imports, the changes in the supply price, say as a result of nominal devaluations, would raise the cost of private investment expenditure. Their effects on the investment decision are expected to be negative.

The following acronyms are used in the presentation of the empirical results:

I_t^p = private investment,
I_t^g = public investment,
YY_t = net changes in capacity, $YY_t = (GDP_t - 0.95GDP_{t-1})$,
c_t = the relative user cost of capital, $c_t = q_t(r_t + \delta - \Delta q_t / q_t)$,
w_t = index of wages,
q_t = price deflator of private investment goods,
CRD_t^p = the availability of credit to the private sector,
r_t = nominal interest rates,
δ = the rate of depreciation, constant (assumed to be 5 percent) [see Maraslioglu and Tiktik (1991)],
Δ = difference operator indicating the first difference of a variable,

4. The Estimation and Results

In this section, the estimation results of equations (6a) and (12a), namely putty-putty model in accumulation-rate form and the log-linearised putty-clay model, are presented. In addition to these models, a naive accelerator model under the clay-clay technology assumption is also estimated. Unlike (6a) and (12a), the naive accelerator model allows for no factor substitution between capital and labour, therefore the relative prices do not appear in the model. However, the naive accelerator model is appropriate to see the response of the capital and adjustment to demand shocks (i.e. to the accelerator effects). For this purpose, the naive accelerator model of private investment is specified both in accumulation-rate form and in log-linearised form respectively. The estimations in this section are based on the data that are described in Chapter 5.

4.1. Naive Accelerator Models with a Clay-Clay Production Function:

The response of the capital adjustment to the accelerator effect is investigated in this section, using a clay-clay production function. Two forms of investment models, namely accumulation-rate form and the log-linearised form, are employed, and are presented by using a distributed lag polynomial function. This gives us a familiar partial adjustment model in the end. Since there exist insufficient observations, the length of the polynomial lags is restricted to one which can be represented by the following first-order distribution,

$$\Phi(L)=\frac{A_1+A_2L}{1-A_3L} \tag{16}$$

where A's are coefficients to be estimated; L is the lag operator indicating that $LI_t^p=I_{t-1}^p$. Using this first-order distribution (16), the unrestricted specifications for accumulation-rate form and log-linearised form of private investment respectively are derived as follows

$$\left(i_t^p-k_{-1}^T\right)_t=a_0+\Phi(L)\Delta y_t \tag{17}$$

$$i_t^p=b_0+\Phi(L)yy_t \tag{18}$$

(all lower case letters indicate the logarithm of the relevant variable) where y_t is the logarithm of GDP; yy_t is the logarithm of $(GDP_t-0.95GDP_{t-1})$; k_t^T is the logarithm of total capital stock including public and private capital stocks.[3] The ordinary least square (OLS) estimation has been used for estimations. The OLS estimation of the capital-accumulation-rate form (eq. 17) displays a first-order autocorrelation in error terms, and the possible upward bias of coefficients due to autocorrelation is eliminated by using Cochrane-Orcutt estimation method. This final estimation is reported as follows.

$$\left(i^p-k_{-1}^T\right)_t=\underset{(-2.026)}{-0.587}+\underset{(1.213)}{0.263}\Delta y_t+\underset{(2.309)}{0.502}\Delta y_{t-1}+\underset{(9.390)}{0.826}\left(i^p-k_{-1}^T\right)_{t-1}$$

$\overline{R}^2=0.902,$ $\qquad u_t=\underset{(2.854)}{0.475}u_{t-1}+e_t$

---

[3] The capital stock series is available at the aggregate level comprising the public and the private sector [see Maraslioglu and Tiktik (1991)].

where $\bar{R}^2$ is the adjusted R^2. Figures in parenthesis indicate t-statistics. The explanatory power of the model is quite high, around 0.92. The coefficient of the current changes in GDP is not significantly different from zero. The rest, however, confirms the existence of the accelerator relation between the rate of capital accumulation and changes in demand (proxied by GDP).

The second specification for the log-linearised form of private investment, on the other hand, fits the data relatively very well. There is no indication of autocorrelation, functional misspecification, or heteroscedasticity (see test statistics reported below the estimated equation).

$$i_t^p = \underset{(3.165)}{0.800} + \underset{(3.180)}{0.088}\, yy_t + \underset{(3.594)}{0.107}\, yy_{t-1} + \underset{(25.592)}{0.841}\, i_{t-1}^p$$

$\bar{R}^2 = 0.976,\ D.W(h) = 0.450$, SC = 0.170, FF = 0.0002, N = 0.970, H = 0.411.

where SC = Lagrange multiplier test for autocorrelation, FF = RESET test for function misspecification using the square of the fitted values, N = Normality test statistics based on a test of skewness and kurtosis of residuals, H = Test for heteroscedasticity base on the regression of squared residuals on squared fitted values. All reported test statistics are chi-square versions of the relevant tests.

According to both models, the adjustment of capital is responsive to accelerator variable, GDP. The length of the adjustment is given by mean lags of these models, which indicate the average time period that is required to adjust the actual capital stock to its desired level in response to changes in demand. They are about 5.4 years for equation (17) and 5.8 years for equation (18) (t-statistics of both of them are significantly high at 5 percent; 1.861 and 4.512 respectively). The long-run multiplier of (17) is not significant at any significance level, but that of (18) have been estimated 1.23 (t-statistics is 5.1). Consequently, in terms of R^2 and the diagnostic tests, the accelerator model (18) has performed very well with the Turkish data. The results have shown that the accelerator variable was important in the adjustment of capital in the long-run, but in the short-run its effects on investment were rather small. The adjustment overall takes almost 5.8 years according to the model in (18).

4.2. Accelerator Models with the Putty-Putty and Putty-Clay Production Function Assumptions

Unlike the models presented in Section 4.1, the so-called flexible-accelerator-relative cost model takes into account the effects of the relative price of capital. Following the theoretical discussion in Section 3, I define two separate empirical models under two different production technologies (namely putty-putty and putty-clay technologies). The results are presented in Table 6.1, Table 6.2, and Table 6.3. The estimates of the theory-based putty-putty and putty-clay models as well as their modified versions with alternative cost variables and the credit constraint variable are presented in these tables. Two different specifications of the putty-putty model have been estimated. The results in Table 6.1a belong to the original theoretical specification (6a) in which the dependent variable, the rate of capital accumulation, is regressed on the lagged value the rate of capital accumulation and the growth rates of output and the relative cost of capital. In Table 6.1b however, the same equation has been estimated in double-log form including the logarithm of the rate of capital accumulation (equation 6b) to see relative empirical performances in functional form specification and goodness of fit. Tables 6.2 and 6.3, on the other hand, report results on the estimations of the log-linearised investment demand equations under putty-clay technology, which correspond to equations (12a) and (15) respectively.

In the first two columns of Tables 6.1 and 6.2, the purely theoretical models without a variable reflecting the effects of credit availability, have been estimated in the light of discussion in earlier sections. Each model has been estimated with different definitions of cost variables (the relative user cost of capital, the relative price of capital goods, and the price index of capital goods) to test the robustness of the empirical findings to changes in the definition of the cost variable. And finally, in Table 6.3, the availability of credit has been included to capture the effects of financial factors on investment with the putty-clay technology assumption. Most importantly, aggregate public investment (comprising infrastructure investment and investment undertaken by state-owned enterprises)[4] has also been included in modified models, but the results in most cases have not improved. On the contrary, the inclusion of public investment has worsened the functional form specification (denoted by FF, RESET-test) of a large number of estimations.

The estimations, which were carried out for annual data, cover the period of 1963-1993. The results reported are estimates using ordinary least-squares (OLS). Microfit 3.0, developed by Pesaran and Pesaran, has been used for estimations [see Pesaran and Pesaran (1991)]. The possible simultaneity (or weak-exogeneity) between investment and the accelerator variable (investment being one of the components of GDP) was ignored in equations where the accelerator variable enters

[4] A sufficiently long disaggregate public investment data for the 1963-1993 period could not be found from official sources. Although the SPO published a official data on infrastructure investment and non-infrastructure, these data are available for the period starting from 1975.

Table 6.1a
Econometric Results for Putty-Putty model

$$\left(I_t^p/K_{-1}^T\right)_t = a_0 + a_1(L)\Delta\dot{Y}_t + a_2(L)\Delta\left(\dot{C}/\dot{W}\right)_t + a_3\Delta C\dot{R}D_t^p + \alpha_4\left(I_t^p/K_{-1}^T\right)_{t-1}$$

	Original Putty-Putty Model		Modified with Credit Constraint	
Variables	(1)	(2)	(3)	(4)
Constant	0.0053	0.0068	0.0042	0.0055
	(2.179)	(2.470)	(1.450)	(1.817)
$\Delta\dot{Y}_{t-1}$	0.0174	0.0178	0.0125	0.0128
	(1.976)	(1.825)	(2.334)	(2.027)
$\Delta\left(\dot{C}/\dot{W}\right)_t$	-0.0081	----	-0.007	----
	(-2.428)		(-2.754)	
$\Delta\left(\dot{q}/\dot{W}\right)_t$	----	-0.0270	----	-0.0240
		(-3.780)		(-3.988)
$\Delta C\dot{R}D_t^p$	----	----	**0.0120**	**0.0118**
			(1.821)	(1.933)
$\left(I^p/K_{-1}^T\right)_{t-1}$	0.880	0.819	0.898	0.8442
	(13.299)	(11.491)	(11.950)	(10.963)
$\overline{R}^2$	0.875	0.886	0.887	0.900
SE	0.0038	0.0037	0.0040	0.003
SC chi-sq. (1)	0.288	0.001	0.167	0.681
FF chi-sq. (1)	2.043	1.479	2.965	3.062
N chi-sq. (2)	1.181	0.841	0.927	0.595
H chi-sq. (1)	6.553	4.908	6.185	4.673

Note: The capital variable is taken as total capital including public and private capital stocks. SC = Lagrange Multiplier test for serial autocorelation, FF = Ramsey's RESET test for functional misspecification, N = Normality test, H = Heteroscedasticity test. Figures in parenthesis are t-statistics. Variables are

Y_t	= Gross Domestic Product,
C_t	= the user cost of capital; $c_t = q_t(r_t + \delta - \Delta q_t)$,
q_t	= the price deflator of capital goods,
W_t	= wages,
CRD_t^p	= credits to the private sector,
K_t^T	= total capital stock including public and private sectors.

Table 6.1b
Econometric Results for Putty-Putty model

$$\left(i_t^p - k_{-1}^T\right)_t = a_0 + a_1(L)\Delta y_t + a_2(L)\Delta(c-w)_t + a_3\Delta crd_t^p + a_4\left(i_t^p - k_{-1}^T\right)_{t-1}$$

	Original Putty-Putty Model		Modified with Credit Constraint	
Variables	(1)	(2)	(3)	(4)
Constant	-0.407 (-2.218)	-0.599 (-3.351)	-0.342 (-1.999)	-0.541 (-2.779)
Δy_{t-1}	0.495 (2.213)	0.515 (2.414)	0.369 (1.733)	0.448 (2.005)
$\Delta(c-w)_t$	-0.194 (-3.235)	----	-0.167 (-2.961)	---
$\Delta(\ln q - w)_t$	---	-0.625 (-3.614)	---	----
$\Delta(\ln q - w)_{t-1}$	---	----	---	-0.512 (-2.725)
Δcrd_t^p	---	----	---	**0.307** (2.214)
Δcrd_{t-1}^p	---	----	**0.309** (2.288)	---
$\left(i_t^p - k_{-1}^T\right)_{t-1}$	0.871 (15.697)	0.819 (15.103)	0.894 (17.200)	0.840 (14.013)
$\bar{R}^2$	0.907	0.914	0.922	0.908
SE	0.085	0.082	0.078	0.084
SC chi-sq.(1)	0.337	0.017	0.282	2.979
FF chi-sq.(1)	1.314	1.874	2.148	3.600
N chi-sq.(2)	1.423	1.704	0.687	2.311
H chi-sq.(1)	2.100	0.509	0.488	0.037

Note: The capital variable is taken as total capital including public and private capital stocks. SC = Lagrange Multiplier test for serial autocorrelation FF = Ramsey's RESET test for functional misspecification , N = Normality test, H = Heteroscedasticity test. Figures in parenthesis are t-statistics. Variables are

i_t^p = Logarithm of gross private investment

y_t = Logarithm of Gross Domestic Product,

c_t = Logarithm of the user cost of capital; $c_t = q_t(r_t + \delta - \Delta q_t)$,

$\ln q_t$ = Logarithm of the price deflator of capital goods,

w_t = Logarithm of wages,

crd_t^p = Logarithm of credits to the private sector,

k_t^T = Logarithm of total capital stock including public and private sectors.

as a first-lag form. t-statistics are presented in the parenthesis below each estimated coefficient. Along with estimated coefficients, some diagnostic test statistics to detect autocorrelation, functional form misspecification, non-normality, and heteroscedasticity have also been reported at the bottom part of tables. All reported diagnostic test statistics are *chi-square* versions. SC in tables stands for Lagrange Multiplier tests which are more general than a simple Durbin-Watson test in the sense that it is applicable to models with and without lagged dependent variables. They are also applicable to testing the hypothesis that the disturbances are not serially uncorrelated against the alternative that they are autocorrelated of order p. This test has been carried out for each equation by setting p equal to three to test for up to the third order autocorrelation in the error term.

Ramsey's RESET test for functional form misspecification, denoted by FF in tables, refers to the simple case where only the square of fitted values, $\hat{y}_t^2$, are included in the extended regression of $e_t = y_t - \mathbf{x}'\hat{\beta}_t$ on $\mathbf{x}'$ and $\hat{y}_t^2$. The test for heteroscedasticity provides an LM test of γ=0 in the model $E(u_t^2) = \sigma_t^2 = \sigma^2 + \gamma(\mathbf{x}'\hat{\beta}_t)^2$. All equations reported here show no indications of heteroscedasticity (except some in Table 6.1a), and functional misspecification. The normality test proposed by Bera and Jaque (1981) is valid irrespective of whether or not the regression includes an intercept. The normality test provides an indication that enables us to use normal distribution to evaluate any value of an estimated coefficient within an accurate confidence interval. Normality tests in all estimations confirm that we can accept the hypothesis that error terms are all normally distributed. Both specifications (putty-putty and putty-clay) of the investment equation seem to fit the Turkish data well. Around 90 per cent of the variation of the dependent variable is explained by these models. The signs of all variables are in accordance with theory. The t-statistics, presented in parentheses below estimated coefficients, are generally statistically significant.

Putty-Putty Technology:

The putty-putty model of investment fits reasonably well. In terms of t-statistics, the "double-log" specification in Table 6.1b resulted in slightly higher t-ratios and goodness of fit, indicating better fit to the data. The problem with the estimates in Table 6.1a is the presence of heteroscedasticity (see H). For all estimates in Table 6.1a, the estimated equations indicate heteroscedastic error terms. All reported t-values of heteroscedastic estimates are based on the White heteroscedasticity consistent standard error estimations.

Table 6.2
OLS Estimation Results of The Naive Flexible Accelerator Model with Putty-Clay Technology

$$i_t^P = b_0 + b_1(L)yy_t + b_2(L)(c-w)_t + b_3 i_{t-1}^P$$

	Theoretical Model	Modified Putty-Clay Model	
Variables	(1)	(2)	(3)
constant	0.695 (2.413)	-0.080 (-0.235)*	0.824 (3.050)
yy_{t-1}	0.097 (2.907)	0.103 (3.694)	0.109 (3.608)
$\Delta(c-w)_t$	-0.144 (-2.576)	----	----
$\Delta \ln q_t$	----	- 0.394 (-3.600)	----
$\Delta(\ln q - w)_t$	---	---	- 0.467 (-3.114)
i_{t-1}^P	0.892 (23.994)	0.988 (21.872)	0.871 (25.647)
$\overline{R}^2$	0.971	0.980	0.973
SE	0.0763	0.0675	0.0726
SC chi-sq.(1)	1.262	0.999	0.196
FF chi-sq.(1)	0.169	0.071	1.256
N chi-sq.(2)	1.361	0.858	1.586
H chi-sq.(1)	2.171	1.447	0.995

Notes: SC = Lagrange multiplier test for serial autocorrelation, FF = Ramsey's RESET test for functional misspecification, N = Normality test, H = Heteroscedasticity test. t-statistics are presented in parentheses. (a) indicates variables that are significant at a 10 percent significance level. On the other hand.

$$yy_t = \log(GDP_t - 0.95GDP_{t-1}); \quad c_t = \log[q_t(r_t + \delta - \dot{q}_t/q_t)]$$

where q = the price deflator of investment goods, r = nominal interest rate, w = the index of wages.

Table 6.3
OLS Estimation Results of The Flexible Accelerator Model with Putty-Clay Technology and The Credit Constraint

$$i_t^p = b_0 + b_1(L)yy_t + b_2(L)(c-w)_t + b_3(L)crd_t^p + b_4 i_{t-1}^p$$

Variables and Test Statistics	(1)	(2)	(3)	(4)	(5)
constant	0.724 (2.813)	0.673 (2.463)	0.502 (1.719)	0.046 (0.135*	0.044 (0.128)*
yy_{t-1}	0.092 (3.096)	0.083 (2.533)	0.082 (2.560)	0.109 (4.006)	0.111 (3.933)
$\Delta(c-w)_{t-1}$	-0.136 (-2.726)	---	---	----	----
$\Delta(\ln q - w)_t$	----	-0.432 (-2.970)	-0.336 (-2.141)	----	----
$\ln q_t$	----	----	----	-0.303 (-2.540)	-0.318 (-2.491)
Δi_t^g	----	----	0.195 (1.431)[a]	----	----
Δi_{t-1}^g	----	----	----	----	-0.0496 (-0.381)*
Δcrd_t^p	**0.356** **(3.480)**	----	----	**0.189** **(1.641)**[a]	**0.199** **(1.628)**[a]
Δcrd_{t-1}^p	----	**0.224** **(1.738)**	**0.251** **(1.969)**	----	----
i_{t-1}^p	0.889 (27.665)	0.897 (25.030)	0.916 (24.542)	0.968 (21.267)	0.967 (20.887)
$\overline{R}^2$	0.977	0.976	0.977	0.981	0.980
SE	0.064	0.070	0.061	0.065	0.066
SC chi-sq. (1)	0.091	0.018	0.211	0.008	0.002
FF chi-sq. (1)	0.069	1.209	0.697	0.006	0.011
N chi-sq. (2)	0.917	1.033	0.295	0.978	0.853
H chi-sq. (1)	1.267	0.462	1.261	1.052	1.048

Notes: SC = Lagrange multiplier test for serial autocorrelation, FF = Ramsey's RESET test for functional misspecification, N = Normality test, H = Heteroscedasticity test. The numbers in bracket are the critical values at a 5 percent significance level. t-statistics are presented in parentheses. For the definitions of variables, see notes in table 3. Δ stands for the first difference of a variable.

$$yy_t = \log(GDP_t - 0.95GDP_{t-1})\text{;} \quad c_t = \log\left[q_t\left(r_t + \delta - \dot{q}_t/q_t\right)\right]$$

where q = the price deflator of investment goods, r = nominal interest rate, w = the index of wages.

Putty-Clay Technology:

These models were estimated in level first. But the first-order lagged values of the cost variable consistently came up with opposite sign, although they were not different from their current values in magnitude. The Wald-test of a zero restriction on the sum of the lagged and current values of the cost variables was, therefore, applied to test the restriction that the coefficients of both current and lagged values of the cost variable are identical. The results of the test support the specification in which the relative cost variable enter the putty-clay model in differenced form, rather than in level as suggested by the theory. The same procedure was applied for the credit constraint variable, if required.

From the statistical point of view (higher measure of goodness of fit, higher t-values of variables and lower standard error), the putty-clay model seems to be more satisfactory although both models are acceptable. Also, with respect to the closeness to the theoretically derived models, the putty-clay model did not require any alteration while the putty-putty needed to take the logarithm of the dependent variable for the sake of better fit to the data.

The results pertaining to the variables deserve some explanation. The signs of all variables are in accordance with theoretical expectations. The accelerator variable is highly significant (always at 5 percent) in all equations irrespective of the technology assumption and the choice of cost variable. The accelerator variable was defined in two different forms depending on the technology assumption imposed on the form of the production function; namely changes in output (that is proxied by GDP) in the putty-putty model, and changes in output net of depreciation in the putty-clay model. While the accelerator model is significant in all equations, its impact on private investment was affected by the definition of the accelerator variable. The adjustment of the capital stock to changes in demand through the accelerator mechanism has also been found very significant by others [Conway (1990), Anand *et al.* (1990), Chhibber and van Wijnbergen (1992)]. In particular, Anand *et al.* (1992) and Chhibber and van Wijnbergen (1992) found that a variation in output demand increases the real private investment in Turkey with an elasticity significantly higher than *unity*. However, the same result was not supported by the estimation results in Table 6.1 and Table 6.2, resulting in a nearly 0.37 percent increase in investment as a result of a 1 percent change in output in the putty-putty technology case [see equation (3) in Table 6.1b], and a nearly 0.09 percent increase in response to change in output net of depreciation in the case of the putty-clay technology [see equation (1) in Table 6.3].

Table 6.4 Long-Run Multipliers

i.) For Table 6.1b

Variables	(1)	(2)	(3)	(4)
Accelerator	3.821	2.846	3.466	2.806
	(1.593)[a]	(1.889)	(1.346)[a]	(1.528)[a]
Cost	-1.502	-3.455	-1.573	-3.211
	(-1.825)	(-2.720)	(-1.657[a])	(-2.315)
Credit	----	----	**2.907**	**1.927**
			(1.397)[a]	(1.507)[a]

ii.) For Table 6.2

Variables	(1)	(3)	(4)
Accelerator	0.902	8.945	0.849
	(2.911)	(0.262)*	(3.525)
Cost	-1.341	-34.167	-3.629
	(-1.70)	(-0.240)*	(-2.337)

iii.) For Table 6.3

Variables	(1)	(2)	(3)	(4)	(5)
Accelerator	0.833	0.808	0.972	3.395	3.474
	(3.116)	(2.836)	(2.460)	(0.766)*	(0.747)*
Cost	-1.222	-4.202	-3.985	-9.424	-9.927
	(-1.934)	(2.066)	(-1.686)	(-0.576)*	(-0.567)*
Credit	**3.208**	**2.181**	**2.974**	**5.868**	**5.958**
	(2.274)	(1.269)*	(1.240)*	(0.725)*	(0.710)*
Public Inv.	----	----	2.318	----	-1.549
			(1.056)*		(-0.332)*

Notes: Figures in parentheses are t-statistics. * denotes insignificant long-run multipliers. [a] indicates coefficients which are significant at the 10 percent significance level. Long-run multipliers are calculated according to the following formula

$$\text{long-run multiplier} = \frac{\sum_{i=1} a_i}{1-b}$$

where $\sum_{i=1} a_i$ is the sum of coefficients of all lags and present values of a relevant variable b is the coefficient of the lag of the dependent variable.

High dependence of the Turkish corporate sector on external borrowing has been noted by Ersel and Öztürk (1993) and Atiyas (1990). This dependence affects the response of the Turkish corporate sector to a variation in the availability of financial funds. Our empirical findings from Table 6.1b and Table 6.3 confirm this conclusion with significant (at 5 percent) and positive coefficients of the credit variable in both models. In Table 6.3, for example, credit appears to have the most influential impact on private investment after the cost of capital. As noted earlier, the inclusion of the credit variable in both models improved the overall explanatory power of the models. The reduction in t-values of all variables after including the credit variable, could be interpreted as an indication of a possible omitted variable effect in the original specifications. This estimated effect on real private investment appears with a one-period lag according to our empirical results [except equation (5) in Table 6.1a, and equation (1) in Table 6.3]. Although other studies on Turkish private investment have also recognised the importance of the volume of credit to the private sector, only three out of six studies summarised earlier explicitly included a credit variable, and concluded that external funds availability is important (see Chapter 5).

The cost variables are also significant. In particular, the negative sign of the relative user cost of capital term in all estimations implies that increased cost of capital reduces investment while rises in wages increase capital accumulation and investment which indicates substitution of capital for labour. In both specifications of the investment model, the relative cost of capital is the most significant one at the 5 percent significance level. According to the estimated coefficient in Table 6.1b, a

1 percent increase in the cost of capital (say, as a result of an increase in the interest rate) decreases the rate of capital accumulation by almost 0.19 percent in the putty-putty model [eq, (1) in Table 6.1b]. The same elasticity has been estimated as -0.14 percent in the putty-clay model [eq. (1) in Table 6.3]. Introducing the price index of capital goods as a cost variable into the model magnifies the impact of the supply-side factors (such as devaluations and changes in the terms of trade) on private investment. In Table 6.2, the change in the estimated coefficient is drastic from 0.13 using the relative cost of capital variable in equation (1) to 0.43 using the relative price of capital variable in equation (2). The inclusion of the credit variable has improved the explanatory power of all models while decreasing the impacts of accelerator and cost variable on investment. This result remains robust for all equations irrespective of how differently the cost variable is defined. In Table 6.3,

for example, credit appears to have the most influential impact on private investment after the cost of capital.

Along with the credit variable, public investment was also included in Table 6.1b and Table 6.3. But in many cases, this variable either caused misspecification of the model with too high RESET test statistics, or became insignificant and reduced the significance of all other variables. However, the best results with the public investment variable are reported in Table 6.3 (eqs. 3, and 5). Among them, the effect of public investment estimates is negative but insignificant at any significance level in column (5); it is significant only at 10 percent in column (6), and positive (indicating the crowding-in effect of public investment). Note that no significant result including both the relative cost of capital and public investment could be obtained. One explanation for this poor performance of the public investment variable may be the choice of the aggregate public investment comprising infrastructure and non-infrastructure investment. Although this is not theoretically ideal, the availability of the relevant data determines the use of aggregate data on capital stock.

In Table 6.4, long-run elasticities of accelerator, cost, credit and public investment are presented for both putty-putty and putty-clay models. At the top of Table 6.4, long-run multipliers of putty-putty model in Table 6.1b are presented for the accelerator, the user cost of capital, and credit. The distinctive feature of these multipliers is their statistical significance at 10 percent. The long-run multiplier effect of credit in the putty-putty model comes second after the accelerator effect. The results in the middle of Table 6.4 belong to the putty-clay model in Table 6.2. All cost elasticities, which are significant at 5 percent (except those in the second column), reveal the relatively higher cost elasticity in the long-run for Turkish private investment. Output elasticities are also significant, but all of them less than unity.

I also estimated five elasticities of each variable for corresponding equations in Table 6.3. The bottom half of Table 6.4 reports these results. With the exceptions of equations 4 and 5, all long-run multipliers of the accelerator variable are significant, and their values vary between 0.81 and 0.97. All long-run multipliers of cost variables are also significantly different from zero, except those in 4 and 5. The distinctive characteristic here is that almost all of them indicate very high long-run cost elasticities. In the case of equation 2, this multiplier turn out even higher (about -4). The multipliers of credit are significant mostly at 10 percent in panel (i), and quite high compared to those of cost variables. It should be noted that according to the results in panel (iii), one long-run multiplier of credit out of five is insignificant. However, all multipliers of the first column, which belong to the theoretical putty-clay model (12a), are significant. With respect to these results in column (1) of panel (iii), the multiplier of the credit term is higher than those of the accelerator and the cost of capital variables. The cost, on the other hand, comes second, and is followed by the accelerator variable. The t-statistics also indicate that the effect of credit on investment is in fact significant at 5 percent level. However, the empirical results suggest that the long-run effects of public investment be insignificant in all three equations.

To sum up, amongst two specifications (putty-putty and putty-clay), the putty-clay specifications of the investment model appear more desirable in terms of R^2s. In both specifications, however, the inclusion of a credit variable has improved R^2s, and kept them around 0.90 and 0.95 percent of total variation in private investment. According to the putty-clay results, credit availability and cost of capital are the two major factors to which private investment is highly responsive in the short run as well as in the long run. The third influential factor is the accelerator variable. The long-run effects of mainly credit and then cost are high. Accelerator effects, on the other hand, are mostly less than unity (see panel (iii) in Table 6.4). The results of Table 6.1, Table 6.2 and Table 6.3, therefore, mirror the conclusion that the putty-clay model of investment demand is slightly more satisfactory on statistical grounds than that of putty-putty, and three determinants of the Turkish private investment are crucial for the future policy recommendations.

5. Sundurarajan and Thakur's Model: A Modified Flexible Accelerator Model

A model has been developed by Sundurarajan and Thakur who modified the neo-classical theory of investment in order to incorporate some of the channels through which public investment influences private investment [Sundurarajan and Thakur (1982)]. It is assumed that the private sector determines its desired level of capital stock by minimising total cost, defined as the discounted present value of future costs including both the costs of production and the cost of acquiring capital. Incorporating this desired level of capital stock into the partial adjustment of capital

$$\Delta K_t = \theta\left(K_t^* - K_{t-1}\right), \tag{14}$$

and recalling the capital account identity ($I_t = \Delta K_t + \delta K_{t-1}$), the investment demand equation can be derived as follows

$$I_t^p = \theta\left(K_t^* - K_{t-1}\right) + \delta K_{t-1} \tag{15}$$

Like Blejer and Khan (1984), they also relied on the definition of the adjustment coefficient in order to include public investment and saving.

In this section, I present the estimation results of Sundurarajan and Thakur's model with the Turkish data. I have adapted their model only with a small difference. Since the sufficiently long disaggregated capital stock of private and public sectors are not available in Turkey, I estimated the model by using total capital stock, including public and private. Following them, I first define the adjustment coefficient as

$$\theta_t = \theta_0 + \theta_1 \left[\frac{\left(S_t - I_t^g\right)/q_t}{\left(K_t^* - K_{t-1}\right)} \right] \tag{16}$$

This coefficient measures the effects of resource availability to the private sector on the speed of adjustment of the actual capital stock to the desired level of capital stock. Then, substituting θ in the partial adjustment mechanism yields the investment demand equation, which is

$$I_t^p = \alpha_0 + \alpha_1(L)Q_t + \alpha_2(L)\left(\frac{c}{w}\right)_t + \alpha_3(L)\left[\frac{\left(S_t - I_t^g\right)}{q_t}\right] + \alpha_4 K_{t-1}^T \tag{17}$$

where S_t= aggregate domestic savings, K_t^T=total capital stock, q_t= the price of capital goods. The expectations of the signs of the coefficients of output and the relative user cost of capital is the same as before. The last term, however, resource availability is expected to capture important channels through which crowding out of private investment occurs. As explained earlier, in developing countries two channels of crowding-out can be mentioned, one through an increase in prices and interest rates following an increase in public investment (which can be defined as rationing through price), and nonprice rationing such as licensing or other controls. This credit rationing effect, therefore, is taken into account by postulating a direct linkage between total resource availability and fixed private investment.

The estimated equations are presented in Table 6.5. Due to the simultaneity between private investment and saving, the instrumental variable estimation method has been used instead of the ordinary least square method. The time period of the estimation is 1963-1991. The model provides a good fit for private investment. The estimated t-ratios are generally very significant at the 5 percent level. The standard diagnostic tests show no indication of the violation of OLS assumptions. Sargan's over-identification test indicates the validity of the instruments chosen. The

Table 6.5
Instrumental Variable Estimates of Sundurarajan-Thakur Model (1963-1991)

$$\ln I_t^p = \underset{(-2.878)}{-4.742} + \underset{(3.558)}{0.406}\ln GDP_t + \underset{(2.746)}{0.319}\ln GDP_{t-1} - \underset{(-3.042)}{0.129}\ln\left(\frac{c}{w}\right)_t - \underset{(-3.065)}{0.104}\ln\left(\frac{c}{w}\right)_{t-1}$$

$$+\underset{(5.409)}{0.256}\ln\left[\frac{(S_t - I_t^g)}{q_t}\right] + \underset{(2.123)}{0.118}\ln\left[\frac{(S_{t-1} - I_{t-1}^g)}{q_{t-1}}\right] + \underset{(2.688)}{0.377}\ln K_{t-1}^T$$

$\overline{R}^2$=0.992, D.W.= 1.980, SE= 0.0396, MLL=53.613
SC= 0.002, FF= 1.976, N= 0.574, H= 0.760, Sargan's Over-identification Test: chi-sq.(3)=2.253

implicit assumption in this form is that the impacts of public investment and aggregate savings (as proxy for the availability of financial resources) on private investment are the same.

A test of the flexible accelerator model is given by the statistical significance of the accelerator variable and the user cost of capital; both significant at 5 percent. With respect to estimates in Table 6.5, accelerator variables have very high t-statistics. The relative cost of capital also has a significantly negative effect on private investment, and its effects occurred with a time lag of one year. Accordingly, an increase in interest rates -therefore the relative user cost of capital- tends to depress investment demand in Turkey.

The results suggest that net saving available to the private sector is a highly significant variable. This effect is measured by the coefficient of the variable on financial resources availability to the use of the private sector. The effects of aggregate savings and public investment can indeed be measured by this coefficient. For example, increased public investment would compete with the private sector for the financial sources in the economy, and reduce net saving and then private investment. However, the model can only capture this crowding-out effect of public investment, but the crowding-in effects through the externalities of public investment expenditure on infrastructure remain untouched by the model.

6. Sectoral Private Investment Models (Flexible Accelerator)

Due to the data availability, five different sectors here are considered; namely, agriculture, mining, energy, manufacturing, and services. Disaggregated data available on sectoral investment and output only for the period of 1968-1993 have been obtained from Marasliogiu and Tiktik (1991). Both putty-putty and putty-clay

Table 6.6
Putty-Putty Estimations for Manufacturing

	Semi-Log Specification			Double-Log Specification		
Variables[1]	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.002 (0.441)*	-0.014 (-1.546)[a]	-0.003 (-0.362)*	-0.629 (-4.048)	-0.598 (-4.025)	-0.790 (-4.719)
$\dot{Y}_t$	0.145 (4.680)	0.153 (5.233)	0.148 (5.709)	2.068 (4.212)	2.193 (4.653)	2.109 (4.801)
$(\dot{C}/\dot{W})_t$	-0.014 (-3.071)	-0.015 (-3.552)	-0.016 (-4.040)	-0.293 (-4.016)	-0.314 (-4.468)	-0.315 (-4.834)
$C\dot{R}D_t^p$	----	0.027 (1.937)	0.017 (1.274)*	----	0.370 (1.732)	0.242 (1.161)*
$\dot{I}_t^g$	----	----	0.014 (2.375)	----	---	0.198 (1.940)
$(I_t^p/K_{-1}^T)_t$	0.825 (15.448)	0.905 (14.001)	0.813 (11.760)	----	----	----
$(i_t^p - k_{-1}^T)_t$	----	----	----	0.821 (15.522)	0.886 (14.199)	0.807 (11.415)
$\overline{R}^2$	0.942	0.950	0.961	0.942	0.948	0.955
SE	0.007	0.006	0.005	0.104	0.100	0.092
SC chi-sq. (1)	0.161	1.146	0.196	0.234	0.467	0.048
FF chi-sq. (1)	0.740	1.746	6.052*	0.251	0.967	2.594
N chi-sq. (2)	1.301	1.075	0.851	0.335	2.013	0.496
H chi-sq. (1)	0.210	0.192	1.107	0.417	0.109	3.112

Note: 1) $\dot{X}$ for any variable indicates the rate of growth in that variable.

models have been tried for each sector, but only the data from manufacturing have provided significant results for the putty-putty model. These results are also reported in Table 6.6. The functional specification chosen for all sectors is the putty-clay model of equation (12a). Table 6.7 reports the results for the putty-clay model. Two main different models are reported for each putty-clay model. One of them is the pure flexible accelerator model linking private investment to both the accelerator variable -which is output of the relevant sector- and the relative user cost of capital (comprising sector specific rate of depreciation, and the price of capital goods). The second one is the generalised version of the flexible accelerator model including credit availability to the private sector and public investment. Since no time series on sectoral credit are available, aggregate credit to the private sector has, instead, been used as a proxy. A similar difficulty arises for the data on sectoral wage levels, and instead, general wage index derived from the data on total non-agricultural wage and salaries has been substituted. However, since this wage index does not cover wage and salaries in the agricultural sector, the price index of fixed capital goods has been used for this sector.

Two putty-putty models have been estimated for manufacturing, semi-log which is consistent with the theoretically derived model (6a), and its double-log version [equation (6b)]. Both results are presented in Table 6.6. The estimations have started with the flexible accelerator without any additional term apart from the accelerator and cost variables, and then successively credit and public investment variables have also been included. Although all variables seem to be significant (except for credit in (3) and (6)), the inclusion of public investment caused functional form misspecification in the theoretical putty-putty model (see eq.3). However, by changing the functional form to the double log, the problem has been overcome. According to the results in the table, the accelerator and cost variables are the two strongly significant variables at the 5 percent level. Despite the fact that credit is significant when it is included alone, once public investment is included, it becomes insignificant.

The putty-clay models of manufacturing along with those of other sectors are reported in Table 6.7a and Table 6.7b. The first columns of each sectoral estimations in the table represent the results of the *pure* accelerator model without credit and public investment. The next columns are, on the other hand, the estimation results of the generalised accelerator model. There is no unexpected sign in any of the estimations in Table 6.7.

The pure accelerator model fits the data well with high adjusted R^2 (0.85 % of total variation), and shows no indication of the violation of the standard OLS assumptions. The putty-clay model performs better than the putty-putty in the sense that the inclusion of credit and public investment does not lead to any functional form misspecification problem. The results in column 2 mirror the fact that private investment in manufacturing is highly sensitive to credit availability, public investment in manufacturing, and the relative cost of capital, but is not responsive to shocks caused by demand. This, together with the negative impacts of high interest policies and the shortage of credit, may however, explain the drastic fall in the share of private investment in manufacturing in the period 1985-1990 in an environment where the share of public investment declined from 19.4 % on average between 1980-1984 to 7.3 % in the period 1985-1990 (see Table 5.17 in Chapter 5).

Table 6.7a
Sectoral Investment Equations (all variables are in logarithm)

	Manufacturing		Agriculture		Services		
Variables	(1)	(2)	(1)	(2)	(1)	(2)	(3)[1]
Constant	1.391 (1.624)	3.196 (3.893)	2.517 (2.619)	2.850 (3.121)	-4.311 (-2.556)	-1.611 (-2.022)	-1.404 (-1.011)
yy_t	0.050 (3.050)	----	----	----	0.969 (5.595)	0.466 (3.658)	0.496 (2.346)
yy_{t-1}	----	0.022 (1.168)	----	----	----	----	----
yy_{t-2}	----	----	0.072 (1.985)	0.049 (1.386)	----	----	----
$(c-w)_t$	----	----	----	----	-0.116 (-2.206)	----	-0.284 (-3.762)
$\Delta(c-w)_t$	----	----	----	----	----	-0.358 (-3.660)	----
$\Delta(c-w)_{t-1}$	-0.269 (-3.666)	-0.384 (-4.544)	----	----	----	----	----
$\Delta \ln q_t$	----	----	-0.495 (-2.350)	-0.635 (-3.034)	----	----	----
crd_t^p	----	----	----	----	----	----	**0.151** (2.895)
Δcrd_t^p	----	**0.433** (2.374)	----	----	----	----	----
Δcrd_{t-1}^p	----	----	----	**0.456** (1.950)	----	----	----
Δi_t^g	----	----	----	0.242 (1.523)	----	----	----
Δi_{t-1}^g	----	0.253 (2.423)	----	----	----	----	----
Dummy	----	----	----	----	--0.826 (-4.545)	-0.941 (-6.202)	-0.692 (-6.651)
i_{t-1}^p	0.782 (7.923)	0.589 (5.542)	0.562 (4.115)	0.569 (4.398)	0.263 (1.864)	0.652 (4.285)	0.195 (1.395)
$\bar{R}^2$	0.850	0.838	0.520	0.611	0.856	0.888	0.910
SE	0.098	0.102	0.167	0.150	0.154	0.132	0.121
SC chi-sq.(1)	0.024	0.000	0.007	0.057	0.147	0.882	2.514
FF chi-sq.(1)	0.038	0.144	0.085	1.737	2.114	0.545	0.736
N chi-sq.(2)	0.826	0.552	0.298	0.247	0.172	0.071	0.984
H chi-sq.(1)	0.626	0.237	0.593	1.574	1.714	0.139	5.203

Note: Dummy in the service sector is for 1989.
1) t-ratios are based on the White's heteroscedasticity consistent standard errors

Table 6.7b
Sectoral Investment Equations (cont)

Variables	Mining			Energy		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	-3.064 (-2.232)	-3.071 (-1.558)[a]	-3.915 (-3.654)	-0.814 (-2.077)	-0.485 (-0.859)*	-0.558 (-1.195)*
yy_t	----	0.795 (2.318)	0.955 (4.411)	----	----	----
yy_{t-1}	0.721 (2.510)	----	----	0.113 (2.229)	0.103 (1.743)	0.107 (1.869)
$(c-w)_{t-1}$	----	----	----	----	----	-0.104 (-1.641)[a]
$\Delta(c-w)_t$	-0.277 (-2.471)	----	-0.289 (-3.059)	-0.008 (-0.095)*	----	----
$\Delta(c-w)_{t-1}$	----	-0.319 (-2.580)	----	----	----	----
crd^p_{t-1}	----	**0.023** (0.690)*	----	----	**0.007** (0.182)*	----
Δi^g_{t-1}	----	----	-0.225 (-1.686)[a]	----	-0.104 (-2.245)	----
Dummy	----	----	----	-0.794 (-5.681)	-0.792 (-4.454)	-0.806 (-21.439)
i^p_{t-1}	0.584 (3.548)	0.424 (3.216)	0.401 (3.224)	1.045 (22.813)	0.965 (7.169)	0.988 (19.658)
$\bar{R}^2$	0.900	0.943	0.938	0.964	0.958	0.961
SE	0.166	0.143	0.134	0.135	0.153	0.149
SC chi-sq.(1)	0.113	0.620	0.717	3.160	0.219	0.308
FF chi-sq.(1)	0.468	0.760	0.483	2.948	0.036	0.001
N chi-sq.(2)	0.200	1.571	0.848	3.820	1.564	1.621
H chi-sq.(1)	0.501	0.692	1.296	1.105	4.051	4.180

Note: Dummy in Energy is for 1986. a) significant at the 10 percent level.

Table 6.8
Sectoral Long-Run Multipliers

	Manuf	Agri.	Services		Mining		Energy	
Variables	(2)	(2)	(2)	(3)	(1)	(3)	(1)	(2)
Accelerator	0.050 (1.153)	0.102 (1.249)	1.341 (3.661)	0.293 (2.530)	1.734 (5.509)	1.595 (8.566)	2.511 (0.966)	2.927 (0.247)
Cost	-0.891 (-3.754)	-1.316 (-2.459)	-1.028 (-1.567)	-0.353 (-4.186)	-0.667 (-1.910)	-0.483 (-2.967)	-0.178 (-0.093)	----
Credit	**1.003** (2.257)	**0.945** (1.867)	----	**0.188** (3.356)	----	----	----	**0.185** (0.441)
Public Inv.	0.587 (2.512)	----	----	----	----	-0.375 (-1.686)	----	-2.938 (-0.259)

The putty-clay model performs reasonably well for the agricultural sector. Despite the fact that the inclusion of credit improves the goodness of fit slightly, the adjusted R^2 is the lowest of five sectors. The distinctive feature of the results is the high responsiveness to the price of capital goods in agriculture. This effect becomes even higher when credit and public investment are both included.

The model for the service sector has first been estimated without any dummy variable. However, the normality test of the estimation was too high. Using the visual inspection in residuals, it has been decided to smooth the outlier in 1986 by a dummy. In Table 6.7, only the results with the dummy variable are reported. The accelerator model appears to work better for services. Unlike manufacturing and agriculture, the accelerator variable has the highest impact on investment. This is followed by cost and credit variables in column 3. Note that due to the existence of the heteroscedastic disturbance term, all t-ratios in the column 3 of the service sector are based on the White's heteroscedasticity consistent standard errors.

The accelerator model provides the best fit to the data from the mining sector (see column 3 of Table 6.7b). The adjusted R^2s in all three estimations are about 0.90 percent of total variation. The accelerator effect comes up significantly very high, and not different from unity (the Wald test was calculated 0.941 for equation 1 in Table 6.7) . While the cost variable is significant and, as expected, has a negative sign, the credit variable seems not to have any significant effect on the determination of private investment in the mining sector. Instead, public investment in the mining sector appears to have significant and negative effects on investment at 10 percent.

The estimation result in the energy sector has also been improved by using a dummy variable for the outlier in the disturbance term in 1986. The explanatory power of the model is quite impressive, although significance of the cost variable in (1) and the credit term in (2) are not significant at all. As noted in the second column of the energy sector, the accelerator model has been estimated without any cost variable, but with credit and public investment in the energy sector. In eq. 3, the cost variable in level has become significant. Overall, the only consistently significant variable in all three equations is the accelerator variable. Although public investment seems significant in the second estimate, its significance totally depends on the presence of credit term in the equation.

In Table 6.8, the long-run multipliers of some selected equations of each sector are presented. The long-run multipliers for manufacturing and agriculture show a great similarity regarding the significance of accelerator, cost and credit effects. For manufacturing, the credit availability in the long run is the main factor that constrains firms (it is almost unity in magnitude). According to the long-run multipliers in magnitude, the cost factor of capital investment is, on the other hand, slightly more important factor in agriculture (whose long-run multiplier of cost is -1.3) than credit (its multiplier's value is 0.95). However, the accelerator factor in the long-run is not an influential determinant of private investment in both sectors.

It appears that there are three highly significant constraints determining private investment expenditures in the services sector in the long run. Their long-run elasticities are however small. The cost variable whose long-run multiplier is -0.353 is the most influential and followed by accelerator (0.29 is the value of the multiplier), and by credit (whose value of the multiplier is about 0.19). These three sectors (manufacturing, agriculture, and services) are the only sectors that are sensitive to the availability of credit . Among the rest, the energy sector's investment decisions in the long term seem not to be affected by any of these factors at all. Mining, on the other hand, has responded mostly to the accelerator (whose value of the multiplier is about 1. and 1.6 for each corresponding equation), and to cost (-0.67 and -0.483 respectively). Also, public investment seems significant in mining in the long run at 10 percent.

7. Conclusion

This chapter initially has three main aims. The first one is to find out to what extent a theory-based neoclassical flexible-accelerator type of investment models can be successfully applied to a developing country, namely Turkey. In this respect, I have

Table 6.9
What Determines Private Investment In Turkey:
General Summary of the Estimations of the Putty-Clay Model

Variables	Aggregate	Manufac.	Agricultural	Services	Mining	Energy
Accelerator	at 1 %	not significant	at 10 %	at 5 %	at 1 %	at 5 %
Cost	at 5 %	at 1 %	at 1 %	at 1 %	at 1 %	not significant
Credit	at 1 % and 5 %	at 5 %	at 5 %	at 1 %	not significant	not significant
Public Inv.	not significant	at 5 %	at 10 %	not significant	at 10 %	at 5 %

Note: Figures in each cell indicate the significance levels of the variables in the first column

provided a microeconomic foundation for a so-called flexible-accelerator-relative price model by borrowing to a great extent from Catinat *et al.* (1987) and Artus and Muet (1990). Two versions of the model have been derived and estimated under two alternative production technology assumptions, namely the putty-putty and the putty-clay technologies. Assuming that factor-substitution between capital and labour is variable ex post and ex ante, the putty-putty version of the model has been derived in an accumulation-rate form in which the rate of capital accumulation is a positive function of the rate of growth in output and a negative function of the rate of changes in the relative cost of capital. Empirical results, however, required some modification in the specification of the model, and then the double-log form of the putty-putty model has performed well with the Turkish data.

Alternatively, the putty-clay version of the model (assuming that the rate of capital-labour substitution is variable ex post but fixed ex ante) has been derived, in a double-log-linearised form, as a function of the net change in output and the relative cost of capital. As being a more realistic assumption, the model with the putty-clay technology has performed relatively better than the putty-putty model in terms of better fit to the data. However, the data have also required a modification in the specifications of the explanatory variables in the putty-clay model. The econometric tests carried out with this model have revealed that the cost of capital and the credit variables should enter the putty-clay model in the first-differenced form, rather than in levels as suggested by the theory.

The second purpose of the chapter is to find out what determines Turkish private investment expenditures. Theoretical model allows for the effects of two main neo-classical variables in the determination of investment demand of a firm. These are the accelerator (the rate of growth in output in the putty-putty case, the net change in output in the putty-clay case), and the relative cost of capital comprising the rate of interest and the price of capital goods. Expected effects of these two variables are positive for the accelerator, and negative for the cost variable.

Apart from the functional modifications of the investment model on the statistical ground, two additional variables, namely the availability of credit to the private sector (in line with the third purpose of the paper to test the effects of dependence of the Turkish corporate sector on external funding), and public investment (to find out the crowding-in and crowding-out effects of the public sector). The inclusion of these variables are, however, theoretically less sound, and an eclectic approach has been adapted to do so.

Empirical results have not provided any significant evidence to support the important impact of public investment on private fixed capital accumulation at the aggregate level. I must, on the other hand, note that the public investment data used in the estimations are aggregate data including both infrastructure and non-infrastructure public investment. Any further investigation on the effects of the public sector's investment requires disaggregate data on public sector infrastructure and non-infrastructure investment, that are available only for a shorter time period between 1975 and 1993 in the Turkish case.

Importantly, despite the fact that the original theoretical model does not include the credit variable, its inclusion into both specifications improved the explanatory power of the model, and reduced the previous value of t-statistics estimated without the credit variable. This may empirically be interpreted as the misspecification of the original model without the credit term.

The empirical results, that have been obtained in the earlier sections, belong to the estimations that are based on a relatively larger sample size (including 31 observations) than those previous models applied to Turkey. In Table 6.9, the general summary results of the putty-clay models are presented. The table reports the significance level of each variable for aggregate and sectoral private investment equations. At aggregate level, all three variables -the accelerator, the relative capital-labour cost, and the credit availability to the private sector- appear significant. Given the results in Table 6.9, the significance level of the impacts of the accelerator consistently is higher than those of the relative prices and the credit constraint. However, in the long-run, credit and the cost of capital variables become more influential than the accelerator. According to the result from Table 6.4, the long-run elasticities of credit and cost are reported to be 3.2 and -1.2 respectively -both are significant at 5 percent- (see panel (iii) in Table 6.4). The long-run elasticity of the accelerator, however, comes last with 0.8 (less than unity), and significant at the 5 percent significance level.

At the sectoral level, the estimates on private investment in manufacturing have revealed that changes in credit availability to the private sector, the cost of capital and public investment in manufacturing are important factors (all significant at 5 percent). In particular, public investment is very sensitive to changes in credit availability; a unit increase in credit to the private sector in general increases private investment by 0.43 percent. In the long run, this effect is unity and significant at 5 percent level. Cost of capital's effect is -0.36 percent as a result of a unit change in the cost of capital, -0.89 percent in the long-run. Public investment also positively affects private investment both in the short and long run. Given the high volatility of interest rates (that is one elements of the composite definition of the cost of capital) and a continuous decline in the share of public investment in the manufacturing sector, the estimates of the model give some suggestive evidence on the likely factors that might play an important role.

Agriculture shows some similarities to manufacturing. While the share of agricultural private investment declined (along with successive drops in production levels), the capital cost and decreasing agricultural public investment might contribute to this poor performance in the agriculture sector. However, in the long run the cost term and credit availability are two important factors affecting investment behaviour in agriculture with -1.3 percent and 0.95 percent elasticities respectively (both significant at 5 percent).

Services, on the other hand, have enjoyed increases in credit, and stimulated demand, although they were adversely influenced by the cost of capital. But the first two factors as a whole seem to have overcome the negative effect of the last. The last two sectors, mining and energy, have very little share in aggregate investment and in total production. The mining sector has emerged positively sensitive to the accelerator and negatively to cost and public investment. Overall the empirical performance of the energy sector has been very poor, but the accelerator and public investment have come up very significantly.

How robust are these results to the specifications of a particular model (such as the one presented in this chapter)? In the next chapter, the neoclassical determinants of the private Turkish investment (at both aggregate and sectoral levels) are analysed, using a different (data-oriented) econometric methodology.

Appendix-A

Panel Data Estimation of The Putty-Clay Model of Private Investment Demand

Finding an adequately long time series for a specific variable is rather difficult task in developing countries. In addition to a comparatively better econometric explanation, my main purpose here is to make the optimal use of all available data on investment. For this purpose, I adopt a rather different econometric approach in the present appendix. This new approach accounts for the combination of cross-sectional and time series components of the available data. As defined earlier, the data set consists of five different sectors (agriculture, manufacturing, services, and energy) over a ten-year-time period between 1968 and 1993. A relatively short time-period of my data-set may shed some doubt upon the reliability of the results in the text. But the panel data set, which combines observations on different individual cross-section units over several time period, on the other hand, contains more information for each time period unit. However, the approach adopted in this appendix is not totally free of problems. The dynamic nature of investment decisions has not been taken into account because of the insufficient number of cross sectional units in the sample which was required for the dynamic estimation.

The new econometric methodology possesses several major advantages to deal with some economic and econometric questions; see Baltagi (1995) for a detailed account of these advantages. First of all, the panel data econometrics give a relatively large number of observations for each corresponding time period, and increase the degree of freedom, making use of more information available from data. From the econometric point of view, panel data estimation techniques reduce the risk of multicollinearity among variables introducing the effects of all omitted (or excluded) variables into the intercept term, and increase the efficiency of estimations. Secondly, they control the individual *heterogeneity* across cross-sectional units.

In this respect, the theory of panel data has defined three sorts of omitted variables [see Hsiao (1986)]: i.) individual time-invariant variables, which are the same for a given cross-sectional unit through time, but vary across cross-section unit, ii.) period individual-invariant, that are the same for all cross-sectional units at a given period in time, but vary through time, ii.) individual time -varying variables, that vary across cross-sectional units at a given point in time, and also exhibit variation over time. When we pool the data, the assumption we usually maintain is that the effects of all omitted variables are reflected into the intercept term. In most of the panel data applications in economics, these unobservable, or omitted, variables are assumed to be time-invariant or individual specific factors. The estimation strategies of a panel data regression differ from each other according to how to treat the omitted individual-specific factors in the regression. The theory has so far suggested two different methods for this; the first one assumes that individual-specific effects are fixed, whereas the second one treats them as random. In this appendix, however, the model is kept as simple as possible in the sense that the time effects are ignored, as in many similar economic applications, and only the one which is known as the fixed-effects model, is covered.

Following most economic studies in the applied panel data literature [see Cardellichio (1990), Fazzari and Mott (1986) for example], I have employed a pooled data estimation strategy relying mainly on a priori assumption that intercepts vary across over cross-sectional units, but not through time. In the present appendix, two models are considered, and the decision of which one is appropriate is determined by the sample data on the ground of some statistical testing. The most simple model considers that all individual cross-sectional units are identical imposing the same slope and intercept coefficient on each cross-sectional unit, and the OLS has been applied to the entire pooled data. The second one, known as the fixed-effect model, recognises the differences among cross sectional units, and attempts to capture these differences by specifying a different intercept coefficient for each cross-sectional unit. In doing this, the crucial assumption is that the effects of all omitted variables are to be reflected in the variable-intercept term, and that all these effects are independent of explanatory variables on the right hand side (that is known as the orthogonality condition).

Fixed Effects Models:

When several individual units are observed over time, the problem of specifying the stochastic nature of the disturbances becomes conceptually more difficult. In the one-way error-component model, the effects of the numerous omitted individuals varying variables may be individually unimportant, but may be collectively significant. To see this, assume that we have $i = 1,...,N$ cross-sectional observations and $t = 1,...,T$ time-series observations, and consider the following pooled data regression of the investment model

$$I_{it}^{P} = X_{it}'\beta + u_{it} \tag{A-A1}$$

where i denotes five cross-sectional units (manufacturing, agriculture, services, mining, and energy), t denoting time. X is a matrix of four explanatory variables (accelerator, the cost of capital, credit and public investment), and its individual elements are denoted as $X_{it,k}$ where k=1,...,4. The u_{it} are independent and identically distributed random variables with $E[u_{it}] = 0$ and $E[u_{it}^2] = \sigma_u^2$. When cross-section and time-series data are combined in the estimation of the regression above, certain unobservable, omitted factors may be present in the data. Without considering those factors, the pooled OLS estimates of the slope coefficients may be *biased* and *inefficient*. To introduce these omitted factors into the regression, the most of the error component models decompose the error term u_{it} into three components as follows,

$$u_{it} = \mu_i + \lambda_t + \varepsilon_{it} \tag{A-A2}$$

where μ_i represents all the omitted factors affecting the error term that are time-invariant and specific to each cross-sectional unit. λ_t reflects time-specific factors that affect all cross-sectional units equally over time. And finally ε_{it} represents the remaining factors which are assumed to vary over both cross-sectional units and time. This is called the two-way error components model since the disturbance term u_{it} is broken into both individual-specific and time specific error components (μ_i and λ_t respectively). Following common practice in the economic applications of the pooled data estimation, we simplify the model by assuming that only the individual time-invariant component of the error term is included, then reduce the previous regression equation into what we called the one-way error component model as follows,

$$I_{it}^{P} = X_{it}'\beta + \mu_i + \varepsilon_{it} \tag{A-A3}$$

It is assumed that the slope coefficients are the same for all cross-section units, but the intercept term may differ over cross-sectional units, and remain constant over time. This is called fixed effects model (also known as the dummy-variable model, covariance model, and within-groups estimator).

The Estimation and Results:

The primary purpose of this appendix is to see whether or not the results obtained in the text change when the cross-section pooled data is used. Investment decisions are dynamics in character, and the dynamics is represented in investment equations by including lagged dependent variables such as one in eq. 12. But the estimation of such an equation is complex, and requires a large number of cross-section units to achieve the consistency property of the estimation. Instead, I changed the functional specification of equation 12 by excluding the lagged investment, and making the equation static. Estimation results are presented in Tables A-1, A-2, A-3, and A-4. The results in Tables A-1 and A-2 are those of equation 12, excluding the agricultural sector since the time series on wages does not cover this sector. Given the poor performance of the energy sector in the previous time series analysis, it is also excluded from the sample in Table A-2. Tables A-3 and A-4 are the results from the pooled data covering all sectors. The specification in these tables are, in a sense, Keynesian because the price index of capital goods (that is supposed to capture the supply side effects) is used to utilise all data available. Particularly in Table A-4, the energy sector is excluded again. Each table reports two estimation results for the same specification. OLS in these columns stands for the ordinary least square estimator results of pooling all sectors, but not considering sector-specific effects. On the other hand, in the second column of each specification, sector-specific but time-invariant effects have been included by defining a dummy variable for each sector in the sample. The estimation method used is noted by DVLS (which stands for dummy variable least square estimator).

The credit variable and public investment have subsequently been included starting from a simple accelerator relationship between private investment, the capital-labour cost, and the accelerator. Dummy variables in all estimates are both individually and jointly significant (F tests in tables are the joint test). With respect to DVLS results in the third columns of Table A-1 and Table A-2, all variables are significant (including public investment). Unlike the time series analysis, the effects of the cost variable have come up lowest, followed by that of the accelerator. The credit variable and particularly public investment have become the most influential factors according to the panel data estimations. However, according to the results in Table A-3 and Table A-4, the price of capital goods emerges insignificant.

Table A-1
The Panel Data Estimations of The Accelerator-relative-Cost Model
(Without Agriculture)

	(1)		(2)		(3)	
Variables	OLS	DVLS	OLS	DVLS	OLS	DVLS
qq_t	0.489 (7.275)	0.181 (4.712)	0.482 (6.784)	0.078 (2.220)	0.426 (5.870)	0.058 (1.736)
qq_{t-1}	0.530 (6.605)	0.148 (3.004)	0.531 (6.582)	0.094 (2.274)	0.487 (6.076)	0.084 (2.162)
Δcw_t	-0.276 (-3.615)	-0.031 (-0.726)*	-0.284 (-3.529)	-0.060 (-1.711)	-0.273 (-3.483)	-0.060 (1.821)
crp_t	----	----	0.018 (0.341)*	0.146 (6.694)	0.028 (0.556)*	0.145 (7.124)
ig_t	----	----	----	----	0.376 (2.528)	0.258 (3.752)
Constant	-1.577 (-2.560)	----	-1.650 (-2.518)	----	-3.727 (-3.584)	----
D1	----	5.356 (10.123)	----	5.587 (12.768)	----	3.963 (6.650)
D2	----	5.205 (8.480)	----	5.693 (11.135)	----	3.858 (5.540)
D3	----	2.301 (5.032)	----	2.353 (6.239)	----	0.888 (1.686)
D4	----	2.029 (5.026)	----	1.966 (5.906)	----	0.256 (0.463)
SSE	153.07	34.734	152.88	23.358	143.15	20.229
log-likelihood	-163.179	-89.022	-163.118	-69.183	-159.829	-61.992
F	----	79.2	----	127.5	----	138.2
DF	96	93	95	92	94	91

Notes: OLS = Ordinary Least Square; DVLS = Dummy Variable Least Square; F = The joint significance test of dummy variables; DF = Degree of Freedom.

Table A-2
The Panel Data Estimations of The Accelerator-relative-Cost Model
(Without Agriculture and Energy)

	(1)		(2)		(3)	
Variable	OLS	DVLS	OLS	DVLS	OLS	DVLS
qq_t	0.450	0.185	0.460	0.194	0.307	0.164
	(5.645)	(4.572)	(5.681)	(5.340)	(3.963)	(5.068)
qq_{t-1}	0.433	0.170	0.410	0.100	0.244	0.089
	(4.485)	(3.358)	(4.035)	(2.059)	(2.557)	(2.105)
Δcw_t	-0.231	-0.065	-0.236	-0.064	-0.179	-0.077
	(-2.413)	(-1.394)	(-2.455)	(-1.546)	(-2.107)	(-2.213)
crp_{t-1}	----	----	0.047	0.104	0.089	0.112
			(0.774)*	(4.230)	(1.675)	(5.239)
ig_t	----	----	----	----	0.801	0.376
					(4.773)	(4.748)
Constant	-0.269	----	-0.482	----	-4.056	----
	(-0.318)		(-0.540)		(-3.754)	
D1	----	5.144	----	4.915	----	2.452
		(9.663)		(10.237		(3.680)
D2	----	4.955	----	4.819	----	2.043
		(8.021)		(8.688)		(2.695)
D3	----	2.111	----	1.815	----	-0.417
		(4.591)		(4.341		(-0.701)
SSE	119.50	23.381	118.49	18.511	89.075	13.850
log-likelihood	-123.889	-62.712	-123.570	-53.953	-112.870	-43.075
F	----	70.9	----	91.8	----	92.2
DF	71	69	70	68	69	67

Notes: OLS = Ordinary Least Square; DVLS = Dummy Variable Least Square; F = The joint significance test of dummy variables; DF = Degree of Freedom.

Table A-3
The Panel Data Estimations of The Accelerator-relative-Cost Model with The Price of Capital Goods
(all Sectors)

Variables	(1) OLS	(1) DVLS	(2) OLS	(2) DVLS	(3) OLS	(3) DVLS
qq_t	0.430 (6.963)	0.175 (5.187)	0.443 (7.151)	0.201 (6.548)	0.616 (8.836)	0.204 (5.432)
qq_{t-1}	0.382 (6.041)	0.163 (4.762)	0.371 (5.512)	0.084 (2.479)	0.261 (4.138)	0.058 (1.886)
p_t	----	----	----	----	-0.107 (-4.333)	-0.011 (-0.953)*
p_{t-1}	----	----	-0.083 (--3.041)	-0.015 (-1.206)*	----	----
Δp_t	-0.035 (-1.914)	-0.012 (-1.370)	----	----	----	----
crp_{t-1}	----	----	0.124 (2.480)	0.122 (5.448)	0.124 (2.680)	0.111 (5.289)
ig_t	----	----	----	----	-0.021 (-0.288)*	0.190 (2.763)
constant	0.149 (0.269)	----	-0.982 (-1.464)	----	-1.385 (-1.900)	----
D1	----	4.034 (11.075)	----	3.519 (9.337)	----	2.997 (6.881)
D2	----	5.318 (13.624)	----	4.816 (11.698)	----	3.709 (6.301)
D3	----	5.110 (11.201)	----	4.722 (10.456)	----	3.484 (5.376)
D4	----	2.356 (6.788)	----	1.838 (5.066)	----	0.834 (1.595)
D5	----	1.938 (6.195)	----	1.375 (4.105)	----	0.226 (0.417)
SSE	21.044	47.682	198.670	38.219	184.82	35.993
log-likelihood	-209.923	-117.132	-206.326	-103.306	-201.808	-99.556
F	----	36.0	----	97.4	----	95.1
DF	121	117	120	116	119	115

Notes: OLS = Ordinary Least Square; DVLS = Dummy Variable Least Square; F = The joint significance test of dummy variables; DF = Degree of Freedom.

Table A-4
The Panel Data Estimations of The Accelerator-relative-Cost Model with The Price of Capital Goods (without energy)

	(1)		(2)		(3)	
Variables	OLS	DVLS	OLS	DVLS	OLS	DVLS
qq_t	0.351	0.176	0.365	0.194	0.324	0.164
	(5.342)	(4.760)	(5.419)	(5.536)	(4.730)	(4.739)
qq_{t-1}	0.296	0.149	0.267	0.087	0.217	0.073
	(4.522)	(4.077)	(3.689)	(2.263)	(2.933)	(1.985)
Δp_{t-1}	-0.025	-0.011	-0.023	-0.066	-0.019	-0.059
	(-1.454)	(-1.215)*	(-1.334)	(-0.772)*	(-1.079)*	(-0.727)*
crp_{t-1}	----	----	0.047	0.089	0.047	0.075
			(0.950)*	(3.663)	(0.956)*	(3.184)
ig_t	----	----	----	----	0.188	0.270
					(2.266)	(3.283)
constant	1.748	----	1.542	----	1.039	----
	(2.766)		(2.306)		(1.503)	
D1	----	4.129	----	3.828	----	3.138
		(10.654)		(10.256)		(7.611)
D2	----	5.424	----	5.157	----	3.628
		(13.053)		(12.990)		(6.053)
D3	----	5.235	----	5.033	----	3.347
		(10.765)		(10.938)		(4.962)
D4	----	2.450	----	2.143	----	0.757
		(6.642)		(6.012)		(1.400)
SSE	151.520	38.839	150.090	33.896	142.320	30.306
Log-likelihood	-162.670	-94.606	-162.197	-87.800	-159.538	-82.203
F	----	67.5	----	78.8	----	84.1
DF	96	93	95	92	94	91

Notes: OLS = Ordinary Least Square; DVLS = Dummy Variable Least Square; F = The joint significance test of dummy variables; DF = Degree of Freedom.

Appendix-B

Derivation of the Optimal Demand for Capital in an Effective Demand Model

Assume that a representative firm minimises the cost of production subject to a given demand in the output market. The production cost consists of the costs of labour and capital;

Minimise $$C = wL + cK$$

Subject to $$\overline{Y} = F\left(e^{\alpha t}K, e^{\beta t}L\right)$$

where w is the unit cost of labour, c being the unit cost of capital. In the production function technological progress is assumed to exist. And the production function is assumed to be a homogeneous degree of v. A simple Lagrange function can be written for this cost minimisation problem as follows,

$$L = (wL + cK) + \mu\left(\overline{Y} - F\left(e^{\alpha t}K, e^{\beta t}L\right)\right)$$

where μ is a Lagrange multiplier. The first-order conditions with respect to capital and labour respectively are

$$\mu e^{\alpha t}F_K = c, \quad \mu e^{\beta t}F_L = w$$

Then the optimality condition becomes

$$\frac{e^{\beta t}F_L}{e^{\alpha t}F_K} = \frac{w}{c}$$

<u>Some essentials of the model:</u>

In addition to the optimality condition derived above, the share of wage costs, b, as a proportion of production costs is the second fundamental of the model,

$$b = \frac{wL}{wL + cK}$$

The elasticity of substitution between capital and labour is also

$$\sigma = -\frac{\partial(K/L)/(K/L)}{\partial(c/w)/(c/w)} = -\frac{\partial \ln(K/L)}{\partial \ln(c/w)}$$

(see Varian 1992 for detailed explanation). Lastly using the Euler theorem and the homogeneity of the production function degree of v, the following can also be written

$$F_K e^{\alpha t} K + F_L e^{\beta t} L = vY$$

Having shown the essentials of the model, let me write the following total differential of the production function which is itself a function of three variables, capital, labour, and time:

$$dY = \alpha e^{\alpha t} F_K K dt + \beta e^{\beta t} F_L L dt + e^{\alpha t} F_K dK + e^{\beta t} F_L dL$$

$$\frac{dY}{Y} = \frac{1}{Y}\left(\alpha e^{\alpha t} F_K K + \beta e^{\beta t} F_L L\right)dt + e^{\alpha t} F_K \left(\frac{K}{Y}\right)\frac{dK}{K} + e^{\beta t} F_L \left(\frac{L}{Y}\right)\frac{dL}{L}$$

$$d\ln Y = \frac{1}{Y}\left(\alpha e^{\alpha t} F_K K + \beta e^{\beta t} F_L L\right)dt + e^{\alpha t} F_K \left(\frac{K}{Y}\right)d\ln K + e^{\beta t} F_L \left(\frac{L}{Y}\right)d\ln L$$

Further arrangement yields

$$d\ln Y = \frac{1}{Y}\left(\alpha e^{\alpha t} F_K K + \beta e^{\beta t} F_L L\right)dt + \frac{1}{Y}\left(F_K e^{\alpha t} K d\ln K + F_L e^{\beta t} L d\ln L\right)$$

$$d\ln Y = \frac{1}{Y}(.)dt + \frac{1}{Y}\left[F_K e^{\alpha t} K d\ln K + \left(F_L e^{\beta t} L d\ln K - F_L e^{\beta t} L d\ln K\right) + F_L e^{\beta t} L d\ln L\right]$$

$$d\ln Y = \frac{1}{Y}(.)dt + \frac{1}{Y}\left(F_K e^{\alpha t} K + F_L e^{\beta t} L\right)d\ln K + \frac{1}{Y} F_L e^{\beta t} L(d\ln L - d\ln K)$$

Using the Euler theorem,

$$d\ln Y = \frac{1}{Y}(.)dt + v d\ln K - \frac{1}{Y} F_L e^{\beta t} L \ln\left(\frac{K}{L}\right)$$

From the formula of the elasticity of substitution, we have

$$d\ln(K/L) = -\sigma d\ln(c/w)$$

Substitute this into the last version of total differential,

$$d\ln Y = \frac{1}{Y}(.)dt + vd\ln K + \frac{1}{Y}F_L e^{\beta t} L\sigma \ln\left(\frac{c}{w}\right)$$

Make use of the relative share of the labour cost,

$$F_L e^{\beta t} L = bvY, \qquad F_K K = \frac{1}{b}(1-b)F_L e^{\beta t} L$$

Having substituted these in the equation before, we obtain

$$d\ln Y = v[\alpha(1-b) + \beta b]dt + vd\ln K + bv\sigma \ln\left(\frac{c}{w}\right)$$

where

$$\dot{Y} = d\ln Y/dt, \quad \dot{K} = d\ln K/dt, \text{ and } (\dot{c} - \dot{w}) = d\ln(c/w)/dt$$

Therefore

$$\dot{Y} = v[\alpha(1-b) + \beta b] + v\dot{K} + bv\sigma(\dot{c} - \dot{w})$$

This finally leads us to the expression for the optimal capital stock

$$\dot{K}^* = \frac{1}{v}\dot{Y} - bv\sigma(\dot{c} - \dot{w}) - [\alpha(1-b) + \beta b]$$

The Integration of $\dot{K}^*$ with Respect to Time

Given $\dot{K}^* = \dfrac{dK^*/dt}{K^*}$, now integrate $\dot{K}^*$ over time as follows

$$\int \frac{dK^*/dt}{K^*}dt = \frac{1}{\upsilon}\int \frac{dY/dt}{Y}dt - b\upsilon\sigma\int \frac{d(c-w)/dt}{(c-w)}dt - [\alpha(1-b)+\beta b]\int dt$$

$$\int \frac{dK}{K^*} = \frac{1}{\upsilon}\int \frac{dY}{Y} - b\upsilon\sigma\int \frac{d(c-w)}{(c-w)} - [\alpha(1-b)+\beta b]\int dt$$

$$\ln K^* = \frac{1}{\upsilon}\ln Y - b\upsilon\sigma\ln(c-w) + [(\alpha-\beta)b - \alpha]t$$

Koyck Geometric Distribution Function in terms of The Rate of Capital Accumulation

Given that

$$\dot{K} = \lambda \dot{K}^{*} + (1-\lambda)\dot{K}_{-1} \text{ and } \dot{K} = I - \delta K \text{ in continuous time,}$$

also

$$\frac{\Delta K}{K_{-1}} = \lambda \frac{\Delta K^{*}}{K^{*}_{-1}} + (1-\lambda)\frac{\Delta K_{-1}}{K_{-2}}, \text{ and } \Delta K = I - \delta K_{-1} \text{ in discrete time,}$$

the following can easily be written

$$\frac{I}{K_{-1}} = \lambda \frac{I}{K^{*}_{-1}} + (1-\lambda)\left(\frac{I}{K_{-1}}\right)_{-1}.$$

Chapter 7

An Alternative Econometric Analysis

1. Introduction

Estimating investment equations is difficult because economic theory provides only the relationship between the determinants of the capital stock in the long-run steady state equilibrium, but does not say anything about the short-run disequilibrium behaviour. Theory defines equilibrium as a state in which there is no tendency to change. Economists generally consider a stable equilibrium to be one to which an economic system always tends to return in the long-run. Although economic theory is useful to formulate the long-run equilibrium relationship, this equilibrium may never hold in the short-run, if persistent shocks continuously keep the system away from its steady state level. Consequently, the problem of formulating the short-run relationships in addition to the long-run determinants of, say, investment, becomes crucial. This chapter presents an alternative of the accelerator model to private investment, particularly taking into account the short-run behaviour of investment within a self-contained theoretical model, and provides additional evidence for the robustness of the findings of the earlier chapter using a different econometric methodology.

Time series analysis stresses the difficulties associated with traditional econometric model building (as the one used in Chapter 6), mainly because of the fact that many macroeconometric time series are in fact not stationary (indicating time dependent mean and variance), and using non-stationary variables in a regression equation results in so-called spurious correlation [Granger and Newbold (1974)]. The new econometric methodology has basically been built upon this fact.

The application of this innovative method in the modelling of investment is quite new, and there already exists a growing literature [e.g. Fielding (1993), Kaskarelis

(1993), Driver and Moreton (1992), Shafik (1992), and Bean (1981)]. The most popular approach to modelling investment in developing countries links investment to variables that determine the optimal level of capital stock, and includes the dynamics using an *ad hoc* partial capital adjustment mechanism (e.g. see Chapter 6). The new econometric method that I have suggested here considers a more general adjustment process in the sense that the partial adjustment mechanism is nested by it. This general model of adjustment is known as the error-correction model. According to the model here, the adjustment towards the long-run involves some costs, and a representative firm is assumed to reach the long-run optimal level of investment by minimising the costs of adjustment, and determines the short-run investment behaviour subject to these adjustment costs. The model in section 3 develops the short-run adjustment mechanism of investment decisions, and combines the long-run determinants of investment with the short-run adjustment process. The problem of determining which adjustment process is more appropriate is the challenging one, because the initial purpose of using the error-correction model is statistical (rather than theoretical) in order to avoid the spurious correlation associated with trended time series. However, the theoretical model in section 3 allows for such testing of the error-correction mechanism against the partial adjustment process.

The following sections develop arguments relating to the determinants and the functional representation of private investment with the data from Turkey. In section 2, the main elements of the *new* econometric methodology are discussed. Section 3 develops the model, and in section 4, estimation strategies available to estimate such a dynamic model are presented. Section 6 reports the empirical findings for aggregate and sectoral investment from the Turkish data. The comparison of the model with the one used in Chapter 6 is briefly summarised in section 7. Finally section 8 is devoted to some concluding remarks.

2. Concepts of The New Econometric Methodology

2.1 Cointegration

Equilibrium relationships are quite important in the new econometric model building methodology. The idea is that the variables connected to each other in equilibrium in accordance with a certain economic theory, should not diverge from each other in the long run. The existence of this long-run relationship indicates that these variables are cointegrated. Such variables may drift away in the short run, but show a tendency to return to a particular equilibrium state in the long run. The concept of cointegration may therefore be used to test the presence of a steady-state long-run relationship between economic variables as suggested by economic theory. The formal definition of cointegration of the set of variables, $\mathbf{x}_t$, can be adapted from the seminal paper of Engle and Granger (1987) as follows:

Definition: The components of the vector $\mathbf{x}_t$ are said to be co-integrated of order d, b, denoted $\mathbf{x}_t \sim CI(d-b)$, if (i) $\mathbf{x}_t$ is $I(d)$ and (ii) there exists a vector α such $\alpha'\mathbf{x}_t \sim I(d-b)$, d≥b>0. The vector α is called the co-integrating vector. (Engle and Granger, 1987: 253)

In the previous chapter, the dynamics of investment were assumed to follow the Koyck distributed lag specification. Accordingly, actual investment demand was assumed to adjust to its steady-state level by the partial adjustment mechanism in which changes in investment are proportional to the discrepancy between the desired (in steady state) and actual investment (in the short-run) levels. The determinants of the desired investment derived in the long run are simply substituted into the partial adjustment model to give a dynamic representation of the short-run investment model. In the new econometric methodology, the equilibrium relationship also plays an important role in the specification of the short-run dynamics. Suppose that there exists a long-run relationship between the desired level of investment and its long-run determinants, X_t such as

$$I_t^d = \beta X_t \tag{1}$$

(assuming that there are no stochastic components of the relationship), where β is the cointegrating vector. This relationship between I_t^d and X_t holds in the long-run, but the short-run investment level may diverge from this desired level, that is

$$I_t - \beta X_t \neq 0 \tag{2}$$

where I_t is the short-run level of investment which $I_t \neq I_t^d$. This discrepancy ($I_t^d - I_t$) is taken as an error made by agents, and becomes important information in the next decision period of agents in the sense that they correct their actual investment demand depending upon whether $I_t < I_t^d$ or $I_t > I_t^d$. If this error, for example, is positive ($I_t > I_t^d$), then actual I_t is expected to fall in the next period in order to satisfy the equality between the actual (short-run) investment and its long-run level. The term, ($I_t^d - I_t$), is known as an error-correction term. Unlike the partial adjustment model, the explicit long-run relationship between the desired level of investment and its determinant is included in the short-run specification of the model through the error-correction term.

According to the cointegration analysis, if I_t and X_t are both non-stationary (indicating that their movements over time are towards steady state equilibrium), the existence of the linear long-run relationship between I_t and X_t, as mentioned above, confirms the cointegation between these variables. The problem with co-integration relationship (1) is that the vector of βs is in general not known, and should be estimated separately using either OLS or Maximum Likelihood (ML) estimators, which are discussed in section (4).

The most important implementation of cointegration analysis is the *Granger Representation Theorem* [Engle and Granger, (1987)]. This theorem implies that if a set of variables is cointegrated of order (1, 1), denoted $CI(1,1)$, then there exists a valid error-correction representation between these variables. The inclusion of the error term into the equation guarantees that the errors eventually becomes smaller and smaller, and finally zero in the long-run. Error-correction models are currently so popular because they incorporate both long-run relationships between variables as suggested by the economic theory, and short-run disequilibrium behaviour.

In statistical theory, the concept of equilibrium indicates stationarity of time series, that are not tending to grow over time and eventually converge to its deterministic mean value. The difficulty with the traditional econometric model building arises from the fact that many macroeconomic time series are in fact non-stationary and may yield so-called spurious results if they are regressed on each other. The theory suggests that a convenient way of making a non-stationary time series stationary is to take first difference [Granger and Newbold, (1974)] rather than using variables in levels. Sometimes it is necessary to difference a series more than once in order to accomplish stationarity. This sort of series is defined by the concept of integration. Engle and Granger (1987) define this as follows:

<u>Definition:</u> A series with no deterministic component which has a stationary, invertible, ARMA representation after differencing d times, is said to be integrated of order d, denoted $x_t \sim I(d)$ (Engle and Granger, 1987: 252).

Before carrying out any regression analysis, it is necessary first to determine the order of integration of all variables in question (given that the order of integration is also the number of times the variables needed to be differenced in order to achieved their stationarity). This is known as testing for a unit root. Methods of testing for unit roots are described in the next section.

2.2. Stationarity, Non-Stationarity and Unit Roots

The application of the ordinary least squares method (OLS) assumes that a random process generating a time series, say x_t, is invariant with respect to time. This is simply known as a stationarity property of the time series. The stationarity requires that the random process be in a particular statistical equilibrium, and not affected by time. If we characterise this equilibrium by the first and the second moments of the random process, the statistical equilibrium, known as stationarity, yields

$$E(x_t) = E(x_{t-1}) = E(x_{t-2}) = ... = E(x_{t-n}) = m$$

$$V(x_t) = V(x_{t-1}) = V(x_{t-2}) = ... = V(x_{t-n}) = s^2$$

where m is the constant mean of the stochastic process x_t; s^2 is the constant variance of the series. For any lag k, the covariance of the series,

$$\gamma_k = Cov(x_t, x_{t-k}) = E[(x_t - m)(x_{t-k} - m)]$$

must also be independent of time. But these properties of a time series are hardly applicable to any economic time series, whose means and variances sometimes show radical changes over time, indicating non-stationarity. The application of the OLS technique to these non-stationary series becomes inappropriate because a regression of one non-stationary economic variable against another may cause spurious results in which conventional significance tests could indicate a strong relationship between these variables when in fact there is no such a relationship. And OLS would not yield a consistent parameter estimation at all.

Many economic time series, however, follow a non-stationary *random walk* , such that

$$x_t = x_{t-1} + \varepsilon_t \tag{3}$$

where $E(\varepsilon_t) = 0$, $E(\varepsilon_t \varepsilon_s) = 0$ for $t \neq s$; i.e. ε_t is *white noise*. Using a simple backward lag operator, (3) can be written as

$$x_t = \sum_{j=1}^{t} \varepsilon_j \quad \text{where } x_0 = 0 \tag{3a}$$

The variance of x_t can then be derived from (3a) as a function of time;

$$Var(x_t) = \sum_{j=1}^{t} Var(\varepsilon_j) = t\sigma_\varepsilon^2 \tag{4}$$

This means that the variance of x_t becomes infinitively large as t approaches infinity. So, the stochastic process cannot be in a particular statistical equilibrium as required by the stationary of a variable. Instead, it converges to such an equilibrium only in infinity.

Although many economic time series are non-stationary, they can generate stationary series if they are differenced one or more times. The order of differencing is a matter of statistical testing as will be explained shortly. Take the above random walk representation of x_t, for example. Its first-difference, Δx_t, will be

$$\Delta x_t = \varepsilon_t \tag{3b}$$

which is stationary, since ε_t is a white noise stationary disturbance term. This means that x_t, which follows a random walk, is integrated of order one, I(1), but Δx_t is integrated of order zero, I(0) (the number in the parenthesis shows the order of differencing the series required before having stationarity). Before starting any time series analysis, the determination of the order of differencing, that converts the series into a stationary one, is crucial. Testing the order of differencing is usually known as a *unit root test.* Many economic time series are however first-order differencing series, so that if they are differenced once, the resulting series become stationary.

This random walk representation of the stochastic variable x_t is, in fact, an AR(1) model where the coefficient of x_{t-1} is unity. One likely simple test which x_t is a random walk is to fit a regression of x_t against x_{t-1}, and test whether or not, the AR(1) coefficient is unity. The OLS estimation of the coefficient of x_{t-1}, however, will be biased downward, particularly in a small sample, and leads falsely to the conclusion that the series is stationary. Dickey and Fuller, on the other hand, showed that the distribution of the AR(1) coefficient is not a standard Student's t distribution [Dickey and Fuller, (1979)]. They then produced a number of statistics to test the null hypothesis that the time series in question is stationary [Dickey and Fuller, (1979) and (1981)]. The distribution of the statistics to test AR(1) data generation process is denoted by τ_μ in order to distinguish it from the standard t-distribution.

It is important to note that tables of critical values depend on the data-generation process. The simplest data-generation process is

$$x_t = \rho x_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim IID\left(0, \sigma_\varepsilon^2\right) \tag{5}$$

The null hypothesis is that ρ = 1, against the alternative $|\rho| < 1$. If the error term in this equation is a white noise process, then this equation represents a random walk process when $\rho=1$. Such a data generation process is nonstationary. But if $|\rho|<1$, then the process is integrated of order zero, and is stationary. The critical value τ is given by the top part of table (8.5.2) of Fuller (1976). The test can also be applied to the following more general AR(1) data-generating process where x follows a random walk with drift,

$$x_t = \alpha + \rho x_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim IID(0, \sigma_\varepsilon^2) \tag{6}$$

where α is a drift parameter. The null hypothesis is that $\rho=1$ against $|\rho|<1$. The qualitative interpretation of this process is similar to the previous one. However the distribution of τ_μ for ρ is different and consequently a different table of critical values should be used. The τ_μ statistic to be calculated from the above AR(1) process is compared with the critical value of τ_μ given in the middle part of the table (8.5.2) of Fuller 1976. If the calculated τ_μ does not exceed the critical value from the table at a chosen significance level, then we cannot reject the null hypothesis of a unit root.

A stochastic trend is often combined with a deterministic trend. The last data-generation process also accounts for both drift and a linear deterministic trend as follows,

$$x_t = \alpha + \gamma t + \rho x_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim IID(0, \sigma_\varepsilon^2) \tag{7}$$

With this equation, it is possible to test simultaneously for the absence of a stochastic trend ($\rho=1$) and the absence of a deterministic trend ($\gamma=0$). The test is the Lagrange multiplier test whose critical values are reported in Dickey and Fuller (1981).

A weakness of the Dickey-Fuller test (DF) is the possibility of autocorrelation in the error-term. Since the OLS estimator with autocorrelated error term is not efficient, Dickey and Fuller suggest the inclusion of lags of the left-hand side variable as additional explanatory variables [Dickey and Fuller (1981)]. This is described as the Augmented Dickey and Fuller test, ADF, and widely used data-generation process among others. The representation of the process is

$$x_t = \alpha + \rho x_{t-1} + \sum_{j=1}^{p} \delta_j \Delta x_{t-j} + \varepsilon_t, \qquad \varepsilon_t \sim IID(0, \sigma_\varepsilon^2) \tag{8}$$

(8) is called the augmented regression. The determination of the order of lag, p, is subject to the number of observations used in the analysis, and should be relatively small in order to save degrees of freedom, but large enough to allow for the existence of autocorrelation in the residuals. The test is exactly the same as before, but the critical values are presented in Dickey and Fuller (1981).

3. Error-Correction Representation of The Investment Model:

The model suggested here aims to explain the short-run dynamics of investment decisions. I assume a representative firm that maximises its intertemporal profit. Such an optimisation problem involves the direct cost of production and highly complex costs of capital adjustment. The full solution of the problem, particularly the one including a non-linear cost of capital adjustment, is rather difficult, and may yield a non-linear decision rule. To cope with this complexity, I divide the problem into two parts [e.g. see Cuthbertson and Gasparro (1992), Ireland and Wren-Lewis (1989), and Moran (1989)]. The first part considers a static optimisation problem which gives the so-called long-run (or steady-state) solution of the model. The second part introduces the dynamics into the model using an optimisation of a quadratic cost function in the adjustment process of investment towards its steady-state target value.

The model is a version of the well-known accelerator models. I begin with a simple, but fairly general, maximisation problem of the firm by assuming that the firm's profit maximisation is restricted to the current and the next period. This is a simplified and discrete-time version of Jorgenson's cash flow maximisation, and has been used by various authors in different contexts [e.g. see Rama (1993) and Artus and Muet (1990)]. The firm's total cash flows are assumed to consist of the cash flows of each period. In the present period, current profit from production plus the discounted capital gain from the capital installed earlier, and expected profit plus expected discounted capital gain in the next period will be the elements of the optimisation problem. The model can finally be written as

Maximise
$$\Delta V_t = (p_t Y_t - w_t L_t) + [q_t K_t - q_{t-1}(1+r_{t-1})K_{t-1}] - q_t I_t$$
$$+\left(\frac{1}{1+r_t}\right)(p_{t+1}Y_{t+1} - w_{t+1}L_{t+1}) + \left(\frac{q_{t+1}K_{t+1}}{1+r_t}\right) - q_t K_t \tag{9}$$

subject to
$$\Delta K_{t+1} = I_t - \delta K_{t+1} \tag{10}$$
$$\bar{Y}_t = F(K_t, L_t) \tag{11}$$
$$\bar{Y}_{t+1} = F(K_{t+1}, L_{t+1}) \tag{12}$$

where V_t: the value of the firm, p_t : the price of output, Y_t : output, q_t: the price of capital goods, K_t: capital stock, δ: depreciation rate, r_t: discount rate, I_t: investment w_t: nominal wage, L_t: labour. The first term in the objective function (9) represents current profits in period t. The second one is the discounted capital gains (or losses) during the first period that arise from changes in the price of capital goods. The third term shows investment expenditure in period t. The fourth term is the discounted expected profit in period (t+1) and the fifth term measures the discounted expected capital gains (or losses) during the period (t+1). The objective function is maximised subject to a set of technological and economic constraints. The first constraint is the law of motion of the capital stock [equation (10)]. The second and the third ones [equations (11) and 12)] are technological constraints given by production functions for periods t and (t+1). By assumption, the firm faces a strictly binding constraint in the output market [see Precious (1987)].

The firm is assumed to choose the optimal level of output, capital, and labour to maximise its profit in the current period. The optimisation of (9) subject to (10), (11) and (12) then produces the supply of output and labour for period t and output supply, demand for capital and labour in period (t+1). As seen from (9), demand decisions for production factors of the firm in both periods are independent of each other, and the investment is the only variable connecting these two periods through constraint (10). This separability of periods and the constraint (10) allows us to write the objective function (9) as follows, substituting (10) for investment in the objective function using equation (10),

$$\Delta V_t = (p_t Y_t - w_t L_t) + \left[q_t K_t - q_{t-1}(1+r_{t-1})K_{t-1}\right] + \left(\frac{1}{1+r_t}\right)(p_{t+1}Y_{t+1} - w_{t+1}L_{t+1} - c_{t+1}K_{t+1}) \qquad (9a)$$

where $c_{t+1} = q_t\left[\delta + r_t - (q_{t+1} - q_t)/q_t\right]$ is the user cost of capital. The maximisation in period t [in (9a)] determines output and demand for labour in t subject to prices and output constraint (11) in the first period, and the initial capital stock K_{t-1}. The optimisation for period (t+1) determines demand for labour and capital together in (t+1) on the basis of expected prices and the demand constraint in the output market. In this case, the decisions are independent of those in period t, so the overall problem become a maximisation of the profit function in period (t+1); that is

$$\text{Maximise} \qquad (p_{t+1}Y_{t+1} - w_{t+1}L_{t+1} - c_{t+1}K_{t+1}) \qquad (13)$$

$$\text{subject to} \qquad \bar{Y}_{t+1} = F(K_{t+1}, L_{t+1}) \qquad (12)$$

This is the static optimisation problem that leads us to the desired level of capital. In this case, I am interested only in demand for capital K_{t+1}, which sets the demand for investment decided in period t [see equation (10)]. Note that in this so-called Keynesian situation, where the supply of output is determined by demand for output, and is assumed to be strictly binding, then demand for labour for a given level of output will be a function of output and capital stock,

$$\overline{Y}_{t+1} = F(K_{t+1}, L_{t+1}) \quad \Rightarrow \quad \overline{L}_{t+1} = G(K_{t+1}, \overline{Y}_{t+1}) \tag{12a}$$

where $\overline{L}_{t+1}$ is the constrained demand for labour. Therefore, after substituting (12a) into (13), the first-order condition with respect to K_{t+1} will give the optimal level of capital stock depending on the constrained demand for output, and the relative user cost of capital,

$$K^*_{t+1} = H\left(\overline{Y}_{t+1}, \left(\frac{c}{w}\right)_{t+1}\right) \tag{14}$$

Demand for investment can finally be determined using (10). However, in the long-run steady-state equilibrium, changes in the capital stock will be zero (i.e. $I^*_t = \delta K^*_t$ or $\Delta I^*_t = \delta \Delta K^*_t$ if the target variable, either I^*_t or K^*_t moves), and the long-run-steady state demand for investment will be

$$I^*_{t+1} = f\left(\overline{Y}_{t+1}, \left(\frac{c}{w}\right)_{t+1}, \delta\right) \tag{15}$$

where δ is the constant rate of depreciation, $\overline{Q}_{t+1}$ the given level of demand in the output market, $(c/w)_{t+1}$ the relative user cost of capital. Having obtained the long-run determinants of investment, suppose that the next problem the economic agent faces is to decide on how much to invest in the short run to achieve this target value in (15). Assume that in the process of moving towards the target level of investment, the economic agent wishes to minimise the costs arising from adjustment of the capital stock. Following Nickell (1985), consider the case where the adjustment cost functions are quadratic for simplicity and easy tractability. This optimisation problem facing the agent can then be written as

$$\text{Minimise} \qquad E\left\{\sum_{s=0}^{\infty} \beta^s \left[\theta_1 (I_{t+s} - I^*_{t+s})^2 + \Delta I^2_{t+s} - 2\theta_2 \Delta I_{t+s} \Delta I^*_{t+s}\right] \middle| \Omega_t \right\}, \tag{16}$$

where $\Omega_t = (I_t, I_{t-1}, \ldots; X_t, X_{t-1}, \ldots; u_t, u_{t-1}, \ldots)$ is the information set of the economic agent at time t, $0 \leq \beta \leq 1$ is the discount factor, I^*_{t+s} is the target value of the desired investment derived in equation (15). Equation (16) is a fairly general adjustment cost function which encompasses simpler specifications as special cases. The first term in the square bracket represents the cost of being away from the long-run equilibrium level of investment. The second one is the cost of changing the speed of adjustment towards the target. The last one implies that the loss is attenuated if the agent moves in the right direction; this last term will go to zero if the target level of investment remains constant. The optimal strategy with the last term in (16) is to close the gap between the choice variable I_t and the target as the latter grows. This adjustment cost term ensures that the gap, which arises from being in disequilibrium, is asymptotically closed; see, for example, Hendry and von Ungern-Sternberg (1981) in the context of consumption analysis. It is also worth noting that in earlier investment studies, the partial adjustment mechanism, in which $\theta_2 = 0$ (i.e. the target is constant), has extensively been used to introduce the dynamic nature of investment into the modelling [Griliches (1967) and Nickell (1978)]. This might be true if the target variable is constant, and can be tested here by imposing the restriction $\theta_2 = 0$ on (16).[1] The objective function (16), therefore, is a simple but fairly general dynamic form of adjustment including the partial adjustment model as one of special cases.

The complete solution of the problem can be found in Nickell (1985) in more detail. To minimise the total adjustment cost function, we differentiate the function with respect to investment, I_{t+s}, to obtain the first-order condition. This produces a linear decision rule for s=0 given by

$$\beta E(I_{t+1}|\Omega_t) - (1+\beta+\theta_1)I_t + I_{t-1} = \beta\theta_2 E(I^*_{t+1}|\Omega_t) - (\beta\theta_2 + \theta_2 + \theta_1)I^*_t + \theta_2 I^*_{t-1} \qquad (17)$$

The solution of this second-order difference equation yields the following unrestricted equation for I_t

$$\Delta I_t = \theta_2 \Delta I^*_{t-1} + (1-\lambda)\left\{\left[\theta_2 I^*_{t-1} + (1-\theta_2)(1-\beta\lambda)\sum\nolimits_{j=0}^{\infty}(\beta\lambda)^j E(I^*_{t+j}|\Omega_t)\right] - I_{t-1}\right\} \qquad (18)$$

If we assume that $\theta_2 = 0$, then the forward-looking solution of the difference equation (17) generates the following alternative short-run investment demand equation

$$\Delta I_t = (1-\lambda)\left\{\left[(1-\beta\lambda)\sum_{j=0}^{\infty}(\beta\lambda)^j E(I^*_{t+j}|\Omega_t)\right] - I_{t-1}\right\} \qquad (18a)$$

In (18) and (18a), $E(I^*_{t+j}|\Omega_t)$s are not observable, but it is assumed that its actual values are determined by a random variable $\tilde{I}_{t+j}$ for j > 0. The sequences of I^*_{t+j} can then be defined by

$$I^*_{t+j} = E(\tilde{I}_{t+j}), \quad j > 0 \qquad (19a)$$

$$I^*_{t+j} = \tilde{I}_{t+j}, \quad j \le 0 \qquad (19b)$$

[1] Chhibber and Shafik (1992) defined a quadratic cost function similar to (16), but neglect the importance of the restriction that $\theta_2 > 0$ to derive the error-correction representation of the investment model. As noted in the text, assuming that $\theta_2 = 0$ only leads us to the conventional partial adjustment model, not the error-correction mechanism.

If we follow Nickell (1985) and assume that $\tilde{I}_{t+j}$ follows a random walk *with* drift,

$$\tilde{I}_{t+j} = \mu + \tilde{I}_{t+j-1} + \varepsilon_{t+j} \tag{20}$$

where ε_{t+j} is white noise, μ the drift term. Given (19a) for j > 0 and (20),

$$I^*_{t+j} = \mu + E\left(\tilde{I}_{t+j-1}\right) \tag{21}$$

By recursive substitution for $\tilde{I}_{t+j-1}$ defined in (20), the following can be obtained

$$I^*_{t+j} = \mu j + E\left(\tilde{I}_t\right) \tag{22}$$

Therefore, using $I^*_{t+j} = \tilde{I}_{t+j}$ for j ≤ 0,

$$I^*_{t+j} = \mu j + I^*_t \tag{23}$$

If the random variable $\tilde{I}_{t+j}$, however, follows a random walk *without* drift, a similar version of (23) can be derived as

$$I^*_{t+j} = I^*_t \tag{23a}$$

Substituting first (23) into (18) yields a familiar error-correction representation of the dynamic investment demand model

$$\Delta I_t = b_0 + b_1 \Delta I^*_t + b_2\left(I^*_{t-1} - I_{t-1}\right) \tag{24}$$

This is a more general version of the partial adjustment model which contains the simple partial adjustment mechanism as a special case under restriction $\theta_2 = 0$. Substituting (23a) into (18) and assuming that the restriction $\theta_2 = 0$ holds, the familiar partial adjustment mechanism can thus be derived

$$\Delta I_t = (1-\lambda)\left(I^*_t - I_{t-1}\right) \tag{24a}$$

We can then test the validity of the error-correction model (24) against the partial adjustment model (24a) by testing the restriction $b_1 = b_2$ in (24). The full test is presented in the appendix in more detail.

In equations (9)-(15), the long-run equilibrium level of investment has been derived. Assuming the functional relationship between long-run investment level and its determinants are linear, the following equation can be written

$$I^*_t = a_0 + a_1 Y_t + a_2 (c/w)_t + e_t \tag{25}$$

Replacing (25) in (24) yields an estimateable error-correction model, such as.

$$\Delta I_t = b_0 + b_1(L)\Delta Y_t + b_2(L)\Delta(c/w)_t - b_3(I_{t-1} - I^*_{t-1}) + u_t \tag{26}$$

where $(I_t - I^*_t)$ is so-called error-correction term which is supposed to capture the adjustment of prediction error made by agents. This is an error-correction representation of the accelerator model. In the following section, the issue of estimating (26) is considered.

4. Estimation Strategy:

There are a number of strategies that one can apply to the estimation of equation (24). Cointegration analysis, which is one of them, particularly deals with the estimation issues that arise when the variables of interest are integrated of order 1. Using the concept of cointegration, one can easily establish whether or not there exists a long-run relationship given by economic theory. If investment and its determinants are all integrated of order 1, then a simple test of cointegration is to test the stationarity of the error-term from the long-run regression of investment on its long-run determinants. Stationarity requires that the error term will be integrated of order zero.

There are two methods of estimating dynamic relationship between cointegrated variables. In this section, I have summarised two different estimation approaches. The first one is the simple two-stage Engle and Granger method, and the Johansen maximum likelihood approach. The insufficient number of observations however (covering the periods of 1963-93 and 1968-93 for aggregate private investment and sectoral investment respectively) limits the usage of the second econometric technique. I therefore choose to use the Engle and Granger two-step method to estimate equation (25) and (26) in this case.

4.1. The Two-Step Engle and Granger Method:

Specifically, the method first explores the long-run equilibrium levels relationship before estimating a short-run dynamic equation. At the first stage, the hypothesised long-run relationship in levels is estimated by using the simple OLS estimator. The significance of the result (high R^2 and significant t-ratios) confirms the existence of cointegration between the variables. In particular, if private investment I^p_t and one set of determining variables, say X_t, are integrated of order 1, then the formal test for cointegration involves testing whether or not the error term, e_t, from a regression of I^p_t on X_t is stationary. For this test procedure, the DF and ADF tests can be applied to the residuals. If the hypothesised long-run relationship between investment and other exogenous variables are given as in equation (25), the disturbance term from this regression will be

$$e_t = I_t^* - \left[a_0 + a_1 Q_t + a_2 (c/w)_t\right]$$

The DF or ADF test is applied to these residuals to test its stationarity. If it is stationary, the long-run relationship written in equation (25) actually exists, and the estimates of the coefficients of this equation can be interpreted as the cointegration coefficients or the long-run multiplier.

The second stage consists of using the lagged error terms from the levels regression to pick up the process by which economic agents correct for expectational error in previous periods. These error terms, together with differences of other variables, reflect the short-run dynamics. For the simple economic interpretation I have included only the first lag of the error term. The residuals from that long-run equation are then used as the error-correction term in the following short-run dynamic equation,

$$\Delta I_t = b_0 + b_1(L)\Delta GDP_t + b_2(L)\Delta(c/w)_t - b_3 e_{t-1} + u_t \qquad (26')$$

4.2. The Johansen Maximum Likelihood Approach

This is a multivariate generalisation of a model in differences with an error-correction mechanism. The Engle and Granger method cannot guarantee a unique cointegrating vector if there exist more than one variable that is suspected to be cointegrated. The Johansen procedure however allows for the presence of more than one cointegrated vector, although there is always one in the Engle-Granger. The main reason for this may be the econometric methodologies on which both methods are grounded. Unlike the Johansen, the Engle-Granger method made a clear exogenous-endogenous division of variables assuming that a unique cointegration relation between these variables is as a result of that division. In contrast, the Johansen is grounded upon the vector autoregression representation of all possible relationships between variables, that does not hold any priori exogenous-endogenous distinction between variables. If one suspects that there exist more than one cointegrating vector, then the Engle-Granger method is not appropriate.

The application of the method is quite straightforward [see Johansen (1988), and Johansen and Juselius (1990)]. Regardless of the exogenous-endogenous division of variables, consider now the following general vector autoregressive regression (VAR)

$$\mathbf{y}_t = \sum_{i=1}^{k} \mathbf{A}_i \mathbf{y}_{t-i} + \mu + \mathbf{e}_t \tag{28}$$

where $\mathbf{y}_t = [I_t \quad X_t]'$ assuming that $\mathbf{y}_t \sim I(1)$ and a linear combination $\beta' \mathbf{y}_t \sim I(0)$ where β' is a vector of cointegrating coefficient; $\mathbf{y}_t$ is a $(n \times 1)$ vector of endogenous variables, μ is an $(n \times 1)$ vector of constants as $\mathbf{e}_t$ is an $(n \times 1)$ vector of random disturbances of zero mean and variance matrix Ω, *i.e.* $\mathbf{e}_t \sim$ n.i.d.$(\mathbf{0}, \Omega)$. The cointegration transformation of the same VAR model (28) can also be written similar to ECM of the Engle-Granger,

$$\Delta \mathbf{y}_t = \sum_{i=1}^{k} \Gamma_i \Delta \mathbf{y}_{t-i} + \Pi \mathbf{y}_{t-k} + \mathbf{e}_t \tag{29}$$

where $\Gamma_i = -\mathbf{I} + \mathbf{A}_1 + \mathbf{A}_2 + \ldots + \mathbf{A}_i$ ($\mathbf{I}$ is a unit matrix)

$\Pi = -(\mathbf{I} - \mathbf{A}_1 - \mathbf{A}_2 - \ldots - \mathbf{A}_k)$

For the purpose of cointegration analysis, the attention is on the matrix Π, and, in particular, on its rank. Since N is the number of variables, the rank must be at most equal to N. If the rank is equal to N, all elements of $\mathbf{y}_t$ are stationary, and there is not such a matrix as Π. However, if the rank is R which is less than N, then this time

$$\Pi = \alpha \beta' \tag{30}$$

where β and α are both $N \times R$ matrices, and β is called the cointegrating vector which has the property that $\beta' \mathbf{y}_t \sim I(0)$ while $\mathbf{y}_t \sim I(1)$. On the other hand, the rank of matrix Π also gives the number of co-integrating vector. α is regarded as the adjustment matrix, indicating that the speed of adjustment of particular variables with respect to a particular disturbance in the equilibrium relation.

5. Empirical Results:

5.1. Unit Root Tests:

The annual data for aggregate private investment from 1963 to 1993 and the data for agriculture, manufacturing, mining, and services from 1968 to 1993 are used for estimation. All variables are at constant prices. Following the above discussion, time series properties of each individual series are tested to determine the order of differencing, if any, required to attain stationarity. Provided that all variables are I(1), the Granger Representation theorem can be applied to the data. Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests are applied to test whether variables are stationary or needed to be first-order differenced. The results are presented in Table 7.1. The cointegrating regression Durbin-Watson (CRDW) statistics [Sargan and

Table 7.1a.
Unit Root Tests

Variables	CRDW	With Trend DF	With Trend ADF	Without Trend DF	Without Trend ADF	Results
Aggregate						
i_t^p	1.011	-1.317	-2.761	-0.814	-1.697	I(1)
i_t^g	1.378	-1.080	-1.708	-2.637	-2.506	I(1)
y_t	1.865	-2.076	-3.234	-1.217	-1.710	I(1)
crd_t^p	1.649	-2.776	-3.499	-0.866	-0.661	I(1)
cw_t	1.465	-1.793	-2.109	-0.386	-0.696	I(1)
Agriculture						
i_t^p	1.809	-2.330	-2.484	-2.476	-2.762	I(1)
i_t^g	1.568	-2.679	-4.257	-1.057	-1.282	I(1)
y_t	2.885	-2.281	-3.102	-1.387	-3.397	I(1)
q_t^a	0.149	-2.553	-1.955	3.135	1.054	I(1)
Manufacturing						
i_t^p	1.566	-1.510	-2.020	-1.490	-1.855	I(1)
i_t^g	1.349	-1.737	-1.743	-0.081	-0.292	I(1)
y_t	1.383	-1.817	-3.428	-1.614	-1.657	I(1)
cw_t	1.440	-1.678	-1.887	-0.733	-1.016	I(1)
Services						
i_t^p	2.924	-3.682	-1.641	-1.757	-0.336	I(1)
i_t^g	1.243	-1.958	-3.157	-0.683	-0.995	I(1)
y_t	2.393	-2.395	-1.519	-0.411	0.140	I(1)
cw_t	1.751	-1.706	-2.096	-0.902	-0.535	I(1)
Mining						
i_t^p	1.471	-1558	-2.568	-0.726	-0.894	I(1)
i_t^g	1.708	-0.688	-0.783	-1.255	-1.212	I(1)
y_t	1.455	-1.608	-1.909	-0.315	-0.503	I(1)
cw_t	1.688	-1.633	-2.136	-0.655	-0.909	I(1)

Note: i_t^p: logarithm of private investment, i_t^g: the logarithm of public investment, y_t: the logarithm either of gross domestic product for the aggregate model, or of output level in sectoral models, crd_t^p: the logarithm of credit to the private sector, cw_t: the logarithm of the relative user cost of capital, p_t: the logarithm of the price of capital goods. At 5 percent, the upper and lower values of small sample test for 25 observations are -2.00 and -2.11 respectively. They are -2.26 and -2.05 for the sample size 30 at the same significance level. At 1 percent, however, they are -3.43 and -2.81 for the sample size 25, and -3.33 and -2.72 for 30 observations.

Table 7.1b. (cont.)

	Φ_2		Φ_3		
Variables	1	2	1	2	Results[a]
Aggregate					
i_t^p	3.674	----	4.009	----	RW, no drift
i_t^g	2.793	----	3.221	----	RW, no drift
y_t	7.088	----	5.977	----	RW with a drift
crd_t^p	6.303	----	6.124	----	RW with a drift
cw_t	1.994	----	2.243	----	RW, no drift
Agriculture					
i_t^p	2.595	----	3.713	----	RW, no drift
i_t^g	6.466	5.174*	9.095	7.405	RW, no drift
y_t	11.032	9.074*	9.408	3.665*	RW with a drift
q_t^a	0.115	----	0.162	----	RW, no drift
Manufacturing					
i_t^p	1.556	----	2.088	----	RW, no drift
i_t^g	2.572	----	3.502	----	RW, no drift
y_t	7.440	5.327*	6.994	3.405*	RW, no drift
cw_t	1.671	----	1.836	----	RW, no drift
Services					
i_t^p	2.094	----	1.473	----	RW, no drift
i_t^g	4.424	----	4.994	----	RW, no drift
y_t	5.104	----	1.231	----	RW, no drift
cw_t	2.150	----	2.215	----	RW, no drift
Mining					
i_t^p	2.540	----	3.402	----	RW, no drift
i_t^g	1.652	----	2.454	----	RW, no drift
y_t	3.126	---	1.826	----	RW, no drift
cw_t	1.968	----	2.295	----	RW, no drift

Note: The first column is the results of the regression in which first-order differenced dependent variable is regressed on intercept, a time trend, lagged dependent variable, and one-period lagged value of first-order differenced dependent variable. In the second column, some results are reported for the regression equation in which two-period lagged value of first-order differenced dependent variable is also included along with those in the first column.

[a] RW indicates random walk. The 95 % point distribution of Φ_2 for the sample size between 25 and 50 is between 5.68 and 5.13. The 95 % point distribution of Φ_3 for the same sample sizes is between 7.24 and 6.73.

Bhagrave (1983)], DF and ADF tests were applied to test whether or not variables were stationary or needed to be first-order differenced to attain stationarity. The number of times that a series needs to be differenced is given by the order of integration; i.e. if the variable is integrated order of 1, it will be differenced once. These results are reported in Table 7.1a separately for regressions with intercept and trend, and those without a time trend. The empirical reliability of standard tests for unit roots is related to their performance with small-samples. The critical values of the standard tests have already developed for large samples. The usual practice in unit root testing with small samples has been to choose the test that requires relatively small degree of freedom such as the DF test. Bearing this in mind, two different tables for critical values for the null hypothesis that the variable is I(1) are used for testing unit roots. The first one is the standard tables of Fuller (1976) and Dickey and Fuller (1981). The second one is the critical values for a small sample developed by Blangiewicz and Charemza (1990) and reported for different small sample sizes and significance levels in Charemza and Deadman (1992). In the latter, they report an upper and a lower critical value for each sample size at a given significance level. Those values differ with respect to the number of explanatory variables in the cointegration relationship (two in equation (25), and zero for a simple unit root test of a variable). If the estimated t-statistic, for instance, is smaller than the lower critical value for a particular number of observations, the null hypothesis (that the variable has unit root) is to be rejected. If it is greater than the upper critical value, then the null hypothesis cannot be rejected. The upper and lower critical values for 25 observations at the 1 % significance level, for example, are respectively -2.81 and -3.43 [see Charemza and Deadman (1992): p.]. For 30 observations they are-2.72 and -3.33 respectively. However Charemza and Deadman (1992) have developed the critical values for the regressions, either with intercept or without intercept, which exclude a time trend. In this case, the standard table for critical values in Fuller (1976) has been used. For some inconclusive results (such as the price of capital goods in agriculture), the appropriateness of the ADF test has been checked by estimating the augmented regression that $\Delta x_t = c_0 + c_1 x_{t-1} + c_2 \Delta x_{t-1}$ where x is a variable to be tested. Due to the data availability just one lag of the first-order difference term has been included, and checked whether c_2 is significantly different from zero; if it is not, I only use the results of the simple DF test. In Table 7.1b, the statistical significance of stochastic and deterministic trends are also tested. Since the null hypothesis involves more than one parameter, the appropriate test is the Lagrange Multiplier test as suggested in Dickey and Fuller (1981). The results of each test in Table 7.1a and Table 7.1b are reported in the last column of each table.

Table 7.2
Co-integration Relationships
(the dependent variable is i_t^p)

	Constat	y_t	cw_t	ns_t	$\overline{R}^2$	SE	CRDW	DF	ADF
Model I	0.251 (0.434)	1.302 (19.12)	-0.192 (-6.384)	----	0.953	0.105	2.78	-3.332	-2.333
Model II	-0.382 (-0.97)	0.987 (14.07)	-0.179 (-8.999)	0.283 (5.838)	0.980	0.069	3.02	-4.669	-3.031

Note: y_t = log of gross domestic product, cw_t = log of the relative price of capital to wages, ns_t = log of domestic saving net of public investment deflated by the deflator of private investment.

With respect to the critical values in Charemza and Deadman (1992), the last two columns of Table 7 indicate that we can accept the hypothesis that all variables are indeed I(1) at 1 and 5 percent significance levels. The DF test statistics with a time trend, in general, also confirm this conclusion at the 5 percent significance level with the only exceptions being the ADF statistics of price of agricultural capital goods and the DF test of private investment in services. However, these two variables also comply with the general conclusion of the non-stationarity of all variables at the 1 % significance level. Since the lag of the first-differenced term in the augmented regression described above was insignificant, the conclusions of the DF test have been used in the results columns. Additional supports are also provided by Table 7.1b.

5.2 Aggregate Private Investment

The Engle and Granger two-step procedure has been applied to the Turkish data. The first step is the estimation of a long-run cointegration relationship [equation (25)] using the levels of the variables. Evidence of cointegration includes high R^2, significant t-statistics of the coefficients, and significant DF and ADF tests on the residuals. The long-run equations in Table 7.2 enable us to decide whether or not the variables in the levels equation are cointegrated. The theory indicates that two variables are important in accelerator type of models; the accelerator variable (which might be proxies such as demand, output etc.), and the relative capital-labour cost. Before estimating the long-run equation (25), public investment and the volume of credit available to the private sector have also been included in this long-run equation to investigate the significance of their influences on the long-run investment, but were not found to be significant in the long run. However, a new financial variable, domestic saving net of public

Table 7.3
Dynamic Equations for Private Investment
(All variables are in logarithm)

Model I

$$\Delta ip_t = \underset{(1.656)}{0.034} + \underset{(1.754)}{0.351}\,\Delta gdp_t - \underset{(-3.089)}{0.173}\,\Delta cw_t + \underset{(2.061)}{0.262}\,\Delta crp_{t-1}$$

$$+ \underset{(0.984)^{*}}{0.144}\,\Delta ip_{t-1} - \underset{(-2.319)}{0.367}\,RES_{t-1}$$

$\overline{R}^2 = 0.561$, SE =0.071,
SC=0.0002, FF=2.609, N=0.912, H=1.807, DF = -4.978, ADF = -2.965, t-statistics in parenthesis.

Model II

$$\Delta ip_t = \underset{(2.166)}{0.036} + \underset{(3.179)}{0.428}\,\Delta gdp_t - \underset{(-3.244)}{0.119}\,\Delta cw_t - \underset{(-1.799)}{0.071}\,\Delta cw_{t-1} + \underset{(4.213)}{0.194}\,\Delta ns_t - \underset{(-4.752)}{0.758}\,RES_{t-1}$$

$\overline{R}^2 = 0.828$, SE = 0.045,
SC = 0.201, FF = 0.003, N =1.126, H = 1.385, DF = -4.657, ADF = -4.373

investment, has been tried, and found significant estimates of all coefficients.[2] Two different versions of accelerator models of equation (25), therefore, were estimated. The model I is the one in which the logarithm of private investment is regressed on constant, the log of gross domestic product, and the log of relative cost of capital goods (as the theory in Section 3 suggests). The second, modified version of the accelerator model is, in fact, in the line of the Sundurarajan - Thakur model which, unlike the true accelerator model, includes domestic savings net of public investment, which has been thought to capture the possible effects of the availability of financial funds.

In the first-step estimations, (25) was estimated by ordinary least square estimators, and the results are reported in Table 7.2. The results enable us to accept a presence of the cointegration relationship between private investment, output and relative prices in the long run. Like the tests of variables for unit roots in the earlier section, the DF and ADF tests have been applied to residuals. Although the ADF value of the first model seems small compared with the critical value -3.84 of Fuller (1976), the lag of the first-order difference variable of the disturbance term in the augmented regression was insignificant, and the DF indicates a stationary disturbance term. The second model indicates a very high computed DF value, -4.67, that achieves the stationarity of residuals with respect to the critical value (-3.60, -3.50) at 5 percent

[2] In incorporating the financial variable, particularly the presence of a credit constraint, the justification can be provided by assuming that the share of firms facing credit constraints is constant over time, and the long-run investment function is the sum of constraint and unconstrained firms altogether [e.g. see Catinat et al. (1987) and Tybout (1983)].

significance level for the sample size between 25 and 50. But the critical values for small samples in Charemza and Deadman (1992), which are -2.96, and -2.80 for the sample size 30 at the 10 % significance level, display the stationarity of all residuals from both equations except for the ADF of the model I.

The coefficients in Table 7.2 can be regarded as long-run multipliers. Accordingly, the accelerator effects of GDP on private investment in both models are around unity. The long-run cost elasticities are statistically significant and, about 0.2 in both models as a consequence of a unit increase in relative cost of capital goods. In the long-run, private investment has been, as expected, positively related to the level of output -proxied by GDP-, and negatively to the relative cost of capital goods as the estimation in Table 7.2 indicates. The residuals from these long-run equations have been used to capture the short-run dynamics of the investment process in the second step.

Having sequentially dropped higher-order lags in both models, the two equations have been reported in Table 7.3 as preferred specifications. The results are encouraging. Signs of all variables are in accordance with the theory. According to the Lagrange multiplier test, which has been performed for up to a third-order autocorrelation in the residuals, there is no indication of serial autocorrelation. The functional form of the model is correctly specified due to the supporting evidence from the RESET test (noted by FF). The model also exhibits a normal distribution of residuals (noted by N), and appears to be free of heteroscedasticity (see H). The DF and ADF statistics are high enough to display the stationarity of the residuals of the second model.[3] The ADF value for the true accelerator model, however, is significant with respect to the critical values in Charemza and Deadman (1992). The results of the short-run dynamics of aggregate private investment reveals that the accelerator variable, GDP, has the highest effects, followed by credit to the private sector and the relative price of capital goods. t-statistics appeared to be significant at 5 percent, except for the first-differenced term of private investment in the model I. The coefficient of the net saving term in the second equation is also highly significant. Although public investment has not emerged so significantly in the first model, its impact on private investment can be captured through the significant net saving term in the second model, so that public investment displays negative crowding-out effects. The lagged residual

[3] For a small sample, the results of the DF and ADF tests from the short-run regression are more reliable than those from cointegration regression.

Table 7.4
Co-Integration Relations for Agriculture, Manufacturing, Services, and Mining
(the dependent variable is the logarithm of private investment)

Variables	Agriculture	Manufacturing	Services	Mining
Constant	-10.959	-5.072	-8.095	-13.729
	(-2.601)	(-3.538)	(-3.166)	(-5.437)
y_t	1.728	0.961	1.364	2.186
	(4.157)	(9.752)	(7.022)	(8.197)
q_t^a	-0.139	----	----	----
	(-3.416)			
cw_t	----	-0.342	-0.240	-0.147
		(-9.164)	(-3.404)	(-2.114)
$\overline{R}^2$	0.394	0.817	0.763	0.843
DF	-3.143	-4.976	-4.721	-2.394
ADF	-4.220	-2.426	-4.123	-2.480

variables capture the adjustment of prediction errors made by agents, and they are highly significant in both equations. Results also show strong evidence of the appropriateness of an error-correction framework, implying that agents always adjust their desired level of investment to unexpected changes according to the error-correction mechanism.

5.3. Sectoral Private Investment

I now turn to the determinants of private investment in these five sectors. The Engle-Granger estimation procedure has been applied to each sectoral data set. The sectors, as described in the earlier chapter, consist of agriculture, manufacturing, services, and mining. Although the data are available for energy, the empirical results are not statistically satisfactory, and have not been reported here. Only the true accelerator model has been estimated, and the results of the long-run equilibrium equations are presented in Table 7.4. The agricultural sector displays a difference from the rest with the inclusion of the price deflator of agricultural capital goods instead of the relative cost of capital.

The presence of the long-run cointegration relationship between output and the relative-cost variable was tested at the first stage of the Engle-Granger methodology. The residuals from the long-run equations display mixed results in terms of stationarity of disturbance terms. In particular, the mining sector's residuals fail the DF and ADF tests. The ADF test for manufacturing also indicates that we cannot accept that residuals are stationary. Therefore the presence of a cointegration relationship is

Table 7.5
Short-run Sectoral Private Investment

	Agriculture		Manufacturing		Services		Mining	
	(1)	(2)	(1)[b]	(2)	(1)	(2)	(1)[b]	(2)[b]
Constant	-0.0189 (-0.182)*	-0.035 (-0.340)*	-0.106 (-2.115)	-0.223 (-3.113)	-0.076 (-0.608)*	-0.046 (-0.646)*	0.012 (0.280)*	0.025 (0.544)*
Δy_t	1.218 (2.071)	1.356 (2.324)	1.579 (3.239)	2.305 (5.237)	1.913 (2.777)	1.933 (2.901)	1.679 (1.940)	1.981 (2.670)
Δq_t^a	-0.722 (-3.109)	-0.741 (-3.161)	----	----	----	----	----	----
Δcw_t	----	----	-0.247 (-3.942)	----	-0.305 (-1.859)	-0.308 (-1.933)	-0.318 (-2.483)	-0.321 (-2.218)
Δcw_{t-1}	----	----	----	-0.245 (-3.824)	----	----	----	----
Δcrd_t^p	0.558 (2.132)	0.617 (2.371)	----	0.347 (2.224)	----	----	----	----
Δcrd_{t-1}^p	----	----	0.129 (1.240)*	----	0.086 (0.293)*	----	----	----
Δi_t^g	----	----	0.168 (2.128)	0.109 (1.340)[a]	----	----	----	----
Δi_{t-1}^g	0.263 (1.199)*	----	----	----	----	----	-0.324 (-2.387)	-0.346 (-2.280)
Δi_{t-1}^p	0.280 (1.488)[a]	0.341 (1.853)	0.381 (3.479)	----	0.154 (0.782)*	0.155 (0.807)*	0.329 (1.427)[a]	----
RES_{t-1}	-0.773 (-4.048)	-0.699 (-3.821)	-1.461 (-4.448)	-0.432 (-2.041)	-1.196 (-2.737)	-1.201 (-2.827)	-0.662 (-2.183)	-0.502 (-1.832)
$\overline{R}^2$	0.580	0.569	0.745	0.688	0.613	0.634	0.467	0.418
SE	0.145	0.147	0.081	0.089	0.210	0.205	0.144	0.150
SC	0.508	0.818	0.924	0.071	1.377	0.980	0.444	0.895
FF	0.181	0.087	0.001	0.532	0.046	0.010	0.915	0.142
N	0.811	1.183	1.033	0.365	3.343	2.850	1.499	3.599
H	0.632	0.339	4.813	2.739	0.060	0.073	8.791	9.689
DF	-5.098	-5.286	-3.945	-4.734	-4.260	-4.262	-5.318	-4.247
ADF	-5.333	-4.693	-2.432	-3.912	-3.827	-3.826	-2.845	-3.106

Note: * indicates insignificant coefficients at 5 % and 10%. [a] stands for significant variables at 10 percent. [b] indicates heteroscedasticity corrected results. SC = Lagrange multiplier test for serial correlation; FF = Functional misspecification test; N = Normality test; H = Heteroscedasticity test.

confirmed only for agriculture, manufacturing and services, but not for mining. Despite the fact that the mining sector does not show the existence of the cointegration relationship, the short-run dynamic equation has also been estimated and reported in Table 7.5 by employing the disturbance term from the cointegration regression in the short-run ECM regression. All cointegration relationships appeared to be significant; R^2s are, in general, very high with the only exception being the agricultural sector. The t-statistics are all significantly high, and different from zero. The government's sectoral investment and the availability of credit to overall private sector have not been significant in the long-run relationship.

The results from the estimations of sectoral dynamic equations appear in Table 7.5. All estimates are of the expected signs, and the majority of them are statistically significant. The error-correction terms in all estimates are significant, and have the expected negative signs. The DF and ADF test statistics also show stationary residuals from all short-run estimates. In particular, the results for mining indicate no cointegration relationship between the variables on the basis of calculated DF and ADF statistics. However, we must be cautious to accept this conclusion from the results of the long-run estimation because the estimations with a small sample might reveal such a misleading conclusion. Therefore, I estimated the short-run dynamic models for all sectors, including mining, in the next step. The results (presented in Table 7.5) support the choice of the error-correction representation of the data. Despite the opposite conclusion of the long-run estimates, the error-correction term in the estimates for mining has emerged highly significantly at the 5 percent significance level confirming the error-correction model. The overall goodness of fit of the error-correction specification to the sectoral data is satisfactory in terms of R^2 and the statistical tests reported in Table 7.5. The general conclusions of these empirical results are the high and significant effects of accelerator variables in the short-run, that are greater than unity in all sectoral estimates. This is followed by the relative cost of capital (the price deflator of agricultural capital goods in agricultural sector). The credit variable appears significant in only agricultural and manufacturing sectors. In services, the true accelerator without any additional variable, apart from accelerator and the relative cost variable, has not emerged significantly. In mining, however, although credit has not come out significantly, public investment exhibited negative, crowding-out effects on private investment.

6. The Comparison of the Result of the ECM with those of Earlier Chapter

Although the functional specifications of models are quite different, the results in this chapter show strong similarities to those in the earlier chapter. In this section, I focus

Table 7.6
The Comparison of The results of the ECM with those in Chapter 6

	Aggregate Investment	
Variables	The Putty-Clay	The ECM
Accelerator	* significant at 1 %	* significant at 5%
Cost	* significant at 1 %	* significant at 1%
Credit	*significant at 1 % with the capita- labour cost	* significant at 5%
Public Investment	* not significant with the capital- labour cost	* not significant
	Manufacturing	
Variables	The Putty-Clay	The ECM
Accelerator	* not significant with credit and public investment variables	* significant at 5%
Cost	* significant at 1%	* significant at 1%
Credit	* significant at 5%	* significant at 5%
Public Investment	* significant at 5%	* significant only at 10 %
	Agriculture	
Variables	The Putty-Clay	The ECM
Accelerator	* significant only at 10 %	* significant at 5%t
Cost	* significant at1%	* significant at 5%
Credit	* significant at 5%	* significant at 5%
Public Investment	* significant only at 10 %	* not significant
	Services	
Variables	The Putty-Clay	The ECM
Accelerator	* significant at 1%	* significant at 1%
Cost	* significant at 1%	* significant at 5%
Credit	* not significant	* not significant
Public Investment	* not significant	* not significant

Table 7.6 (cont.)

	Mining	
Variables	The Putty-Clay Model	The ECM
Accelerator	* significant at 1%	* significant at 1%
Cost	* significant at 1%	* significant at 1%
Credit	* not significant	* not significant
Public Investment	* significant only at 10 %	* significant at 5%

on these similarities. The comparison has been done on the basis of the qualitative importance of each variable. Despite the different functional specification of functional form and some variables (e.g. accelerator variable in both models, and the dependent variable), the same kind of variables appear almost the same in terms of significance among the determinants of investment.

Table 7.6 summarises these similarities. The significance of each variable has been evaluated according to the value of t-ratios. The variables are evaluated as significant if the t-ratio just passes the test at 10 percent. It might be a significant variable if its t-value rejects the zero coefficient at 5 percent. Finally, the variables whose coefficients were different from zero at 1 percent have been regarded as highly significant. The common feature of two models is the evidence of the significant effects of the accelerator (except for manufacturing), the cost of capital, and the availability of credit to the private sector. Services and mining sectors support the true accelerator model where accelerator and the capital-labour cost variables are significant without referring to the presence of credit and public investment among the determinants of private investment.

7. Conclusion:

The general model developed in this chapter has allowed us to take simultaneous account of the influence of accelerator, relative capital-labour cost and credit constraints. The model has been built upon a combination of the accelerator and financial theories of investment. Unlike the previous chapter, here I employed a different econometric methodology in order to take into account the non-stationarity of the data used. The aim of the chapter, as in the previous one, was to define the role of the main determinants of private investment for the Turkish economy, and to measure their relative importance. The econometric technique used was the recently developed error-correction method.

Bearing the statistical problems associated with small sample size in mind, the results of the chapter ought to be taken as suggestive. The estimations and the comparison of the error-correction model with those in the earlier chapter revealed that the accelerator effect remained a determining factor in investment decisions. The adjustment process of investment to its optimal level, captured by the lagged residual term in the dynamic specification of the model, appeared to be fairly fast; one percent correction in previous mistakes of previous periods affects the current period's private investment almost 0.4 percent in the model I, 0.8 percent in the model II. This confirms the conclusion of Chhibber and van Wijnbergen (1992), although they assumed a partial adjustment mechanism. Private investment was influenced in the short run by credit constraints, which are proxied by the variable of the credit availability to the private sector. The credit variable did not emerge as a long-run determinant of private investment, but appears to influence only the short-run fluctuation in private investment. The same effects of the financial factors were also proxied by the domestic saving net of public investment. This last specification of the credit constraint in the model enabled us to define the influence of public investment, that was insignificant in the so-called true accelerator model.

The relative cost of capital variable is another significant variable (always at 5 percent level). According to the results of the model I, a unit increase in the relative cost of capital (say because of a rise in lending rates) would decrease private investment by 0.17 percent. This effect, however, comes as the lowest after those of the accelerator and the credit variables.

The sectoral estimations show great similarities to those of aggregate estimations. The credit variable appears not to affect the long-run level of private investment, but only short-run fluctuations in the estimations of agriculture and manufacturing. Unlike aggregate results, the effect of the credit variable is high, 0.6 point, in agriculture. Two sectors, namely services and mining, showed no evidence of significant impact of the credit variable. The sectoral results also suggest a strong accelerator effect for all sectors (higher than unity). Regarding the impact of public sector, the so-called Sundurarajan-Takur model revealed the highly significant crowding-out effect of public investment, which was indeed indirect through the net domestic saving term. In mining, public investment reveals a significant negative effect.

For sectoral estimations, it seems that the true accelerator model, without any proxy for credit rationing, fits the data from mining and energy very well. Once the credit variable is included, the results displayed relative fragility. Particularly, the credit variable has been found significant only in agriculture and manufacturing. Therefore, the main conclusion of the chapter is that credit constraint is an important determinant of short-run fluctuations in private investment at the aggregate level, and at the sectoral level, it is important only for manufacturing and agriculture sector. The accelerator variable and the cost variable are significant in all estimations at the aggregate and sectoral levels.

Appendix

A Hypothesis Test of the Error-Correction Process Against the Partial Adjustment Mechanism

Using the assumption that the future level of investment in equation (18) is rational and follows a random walk without a drift term, the error-correction model of investment (26) can be written

$$\Delta I_t = b_1 \Delta I_t^* + b_2 \left(I_{t-1}^* - I_{t-1}\right) \tag{A-1}$$

where

$$I_t^* = a_0 + a_1 gdp_t + a_2 cw_t \tag{A-2}$$

$$\Delta I_t^* = a_1 \Delta gdp_t + a_2 \Delta cw_t \tag{A-3}$$

Substituting (A-2) and (A-3) into (A-1) yields the following

$$I_t = b_1 a_0 + b_1 a_1 gdp_t - a_1 \left(b_2 - b_1\right) gdp_{t-1} + b_1 a_2 cw_t - a_2 \left(b_2 - b_1\right) cw_t - \left(1 - b_2\right) I_{t-1} \tag{A-4}$$

Which is the unrestricted regression equation. When the restriction that $b_1 = b_2$, the restricted equation becomes

$$I_t = b_1 a_0 + b_1 a_1 gdp_t + b_1 a_2 cw - \left(1 - b_2\right) I_{t-1} \tag{A-5}$$

The test I have carried out is a simple F-test in the form of

$$F = \frac{(RSS - URSS)/n}{URSS/(N - k - 1)} \tag{A-6}$$

where RSS = restricted sum of square of error, URSS = unrestricted sum of square of error term, n = the number of restrictions, N = the number of observations, k = the number of parameters to be estimated in the unrestricted regression. The F statistics from the models described above for the degree of freedom (1, 21) have been calculated 6.45, which was larger than the critical value 4.32 at 5 percent, implying the rejection of the restriction.

Chapter 8

The Intertemporal Investment Decision of a Firm Borrowing in the Imperfect Credit market Subject to a Liquidity Constraint

1. Introduction:

The importance of financial factors is a subject with a long history in the course of literature. It is assumed in the neo-classical theory that cash flows and external borrowing do not play any direct role in investment decisions. Although earlier literature has drawn some attention to the importance of financial variables, Jorgenson, in his well-known survey, argued that accelerator type models were superior to those including financial variables [Jorgenson (1971)]. Using a relatively larger sample, on the other hand, Elliott (1973) found supportive evidence in favour of profit models by reversing the ranking of Jorgenson (1971). From the econometric point of view, both studies used aggregate data, and the comparisons were based on statistical prediction error or goodness of fit.

The neoclassical theory of investment and Tobin-q theory are both based on the assumption of a "representative firm", and do not distinguish firms according to their sizes and access to external financial opportunities. This is basically a consequence of the assumption of perfect capital markets. According to Fazzari *et al* (1988), the representative firm assumption is the reason that limits the significance of the financial variable in empirical investment models. Once the perfect capital market assumption is relaxed, the aggregation problem appears because small firms with relatively less access to external financing would be more vulnerable to the availability of financial funds than those with great access. Therefore, the application of the same empirical investment model to all firms would be inappropriate. Fazzari *et al* (1988) studied the effects of financial variables on investment behaviour by introducing capital market imperfections and applying an investment model to different groups of firms with different financial characteristics. Unlike earlier researches, their empirical investment models with financial variables were applied to panel data rather than aggregate time series data.

Much of the accelerator type of researches have been based on the assumptions that financial markets were perfect, and that complete information was available to all participants in those markets. The consequence of this assumption was the perfect substitutability of internal and external sources of financial funds, which is widely known as the Modigliani and Miller theorem. The Modigliani and Miller theorem provided the theoretical basis for the neoclassical theory by demonstrating the irrelevance of financial structure and financial policy for real investment [Modigliani and Miller (1958)]. By this theorem, it has been assumed that there was no wedge between the opportunity cost of internally generated funds and the costs of external funds (such as issuing equity and/or borrowing). The demand for external financing was exogenously determined by the difference between the value of investment expenditure and internal funds. The supply of financial funds was ignored in empirical neoclassical models to a great extent because of the irrelevance theorem.

Recent empirical studies, however, have explored the violation of the irrelevance theorem, and described financial factors as one of the determinants of real investment expenditures [e.g. Fazzari and Athey (1987), Fazzari *et al* (1988), Bond and Meghir (1994), Estrada and Vallés (1995)]. This also brought a new dimension into investment modelling. The availability doctrine and the irrelevance of the irrelevance theorem have begun to occupy an important place in theoretical discussions. At the macroeconomic level, a wide empirical consensus on the real effects of financial policies on investment spending has led economists to question the relevance of the Modigliani and Miller theorem [see Blinder and Stiglitz (1983)], and to revise the judgement of Jorgenson about the role of financial factors in the determination of real investment expenditures. The question of whether internally generated funds and external funds are, in fact, the perfect substitute has gained a central importance in the new empirical and theoretical researches. It has also been suggested that internal funds are actually less costly than external financial resources to a great extent because of the presence of transaction costs, tax advantages, agency problems, costs of financial distress, and asymmetric information.

In many studies, however, the most prominent explanation of the high cost of external funds is the existence of asymmetric information. This generates a significant cost disadvantage of external finance for some firms. The theoretical reasoning behind this disadvantage is supported by the "lemons" problem of Akerlof (1970). For example, in the case of fixed capital information, the lemons problem can be applied to a situation where the firm's managers are assumed to have full information about the quality and the real value of a project, but the lenders do not. The implication of the Lemons problem for some firms is credit rationing in the form of restriction on loan size. The reason for this is that good borrowers may prefer the restriction because small loan sizes may lower the market default risk, reducing the *lemon premium*; bad borrowers , on the other hand, must follow along in order not to reveal themselves. Asymmetric information on a project's quality and the high cost of getting information about borrowers' riskiness could create this lemon problem and then *credit rationing* . Jaffee and Russel (1976) first drew attention to the result that as the interest rate rises, lenders cannot distinguish borrowers' quality and riskiness of the project and can limit the amount of credit. Latter, Stiglitz and Weiss (1981) theoretically showed that credit rationing in equilibrium is perfectly consistent with the rational behaviour of economic agents. In such a situation, borrowers who wish to borrow at ongoing effective rates of interest could not obtain financing because of asymmetric information on the quality of the project.

In earlier chapters, the significance of financial variables together with some standard neoclassical determinants of investment (such as the accelerator and the relative user cost) has been investigated by using a completely neoclassical investment model. Modelling the effects of financial factors in the previous two chapters remained rather eclectic. The present chapter in this respect rules out this defect of previous chapters, and aims to endogenise the impacts of imperfections in financial capital markets. Relying on the empirical results of these chapters, financial factors are brought into closer examination in the present chapter. For this purpose, a more comprehensive theoretical model, in which financial market imperfections and a liquidity constraint are empirically taken into account, is suggested. The chapter consists of the following seven sections. In section 2, credit market imperfections and credit rationing are discussed in general. Section 3 provides a discussion on financial market failures and financial liberalisation in developing countries. The experience with financial liberalisation and the structure of financial markets in Turkey are described in section 4. Section 5 presents the assumptions and the derivation of the investment model. After reporting the empirical results in section 6, some conclusions drawn from the empirical results are discussed in section 7.

2. Credit Market Imperfections and Credit Rationing:

The recent literature of investment builds upon the theory of imperfect information. According to this literature, when financial markets intermediate between borrowers and lenders, they must cope with some informational imperfections about borrowers. Not only do these imperfections determine the allocations of financial funds among projects with different returns and risks, but they also determine the efficiency of those markets [see e.g. Blinder and Stiglitz (1983), Greenwald *et al.* (1984) and Blinder (1986)]. This literature also attempts to develop consistent microeconomic foundations of investment behaviour, considering linear quadratic capital adjustment costs and imperfect information in the capital market. It is generally argued that in contrast to the neoclassical theory, financial markets are not flexible enough to generate a sufficient amount of increase in interest rates after a certain point. The inflexibility of interest rates can be explained by the imperfect structure of financial markets which may occur for one reason or another (such as interest rate ceiling imposed by usury law or the presence of the default risk). Keynes, for example, discussed the failure of the interest rate to fall sufficiently to restore investment to a normal level by putting forward the concept of *liquidity trap*. In the new literature, the reason for the inflexibility is based on informational imperfections.

The explanation is briefly as follows: As shown in Stiglitz and Weiss (1981), due to asymmetric information between lenders and borrower, lenders' supply of credit to an individual borrower becomes perfectly inelastic at some rate of interest because of diminishing expected return on loans to bad-quality borrowers (those with high default risks). Therefore, no increase in the loan rate induces the lender to raise the amount of credit. Lenders perceive that the interest rate is no longer a good indicator in the presence of default risks; therefore credit rationing on the amount of loan sizes, rather then an increase in interest rates, becomes a rational response of lenders.

Two Kinds of Credit Rationing:

Credit rationing can broadly be defined as a disequilibrium situation where the demand for loans exceeds the supply at the ruling price level. One can clearly distinguish two types of credit rationing, which are widely known as *temporary* and *permanent* [Baltensperger (1978)]. The difference between them arises due to the roles of price and non-price adjustments. Non-instantaneous adjustment of markets to disequilibrium (mainly because of sluggish price adjustment) forms a cause of temporary credit rationing. For example, high cost of adjustment such as administrative cost, from the banks' point of view, could be one possible reason for this type of rationing.

Permanent rationing, also known as rationing in equilibrium, occurs via non-price elements of adjustments, and refers to situations where borrowers' demands for loans are unfulfilled, even though they are willing to pay the ruling price. The recent credit rationing literature has been dominantly concerned with the permanent rationing and its rationality within the profit maximising behaviour of lenders [Jaffee and Russel (1976), and Stiglitz and Weiss (1981)]. The hypothesis about the supply of loan has essentially been based on the existence of default risk. In essence, the argument is that, after a certain amount of loan, no increase in interest rates could compensate lenders for the default risk of the borrower associated with further increases in loan, and those borrowers within the high default risk group cannot obtain more than a certain amount of credit, regardless of the interest rate he is willing to pay.

This theory has been built upon informational imperfections. Many informational problems arise from asymmetric information about the investment projects between borrowers and lenders. Banks do usually not know how the credit they lend is being invested. As the interest rate charged to any class of borrowers increases, so does the probability of default on loan contracts. Following Stiglitz and Weiss (1981), it is usually assumed that the contract between borrower and lender is a debt contract that allows for bankruptcy. Due to the nature of debt contracts, the borrower keeps any extraordinary profit while the lender simply gets paid the interest charge if the project turns out fruitful. When the project fails, the borrower can default and leaves the bank with all losses. Under imperfect information about the quality of the project, expected profit to the borrower then increases, and expected returns on loan to the lender falls as the riskiness of the project rises. According to Stiglitz and Weiss (1981), if there are a discrete number of potential borrowers, each with a different risk, then the bank's expected return from lending to a specific group of borrowers will not be a monotonically increasing function of the interest rate [see Stiglitz and Weiss (1981) for a formal derivation]. They showed that, given certain assumptions, the loan curve may bend backwards so that credit rationing can emerge. From the banks' point of view, reacting to excess demand for loans by increasing the rate of interest may lower the banks' expected return because of *moral hazard* and *adverse selection* problems. *Moral hazard* (or incentive effect) in such a situation occurs where borrowers become more risk takers at higher rates of interest, and eventually a higher proportion of riskier borrowers would accept the loan offer as the lender increases the interest rate, but the increased risk of bankruptcy would actually decrease the lender's expected return. This would not be a problem if the lender could observe and control the nature of the project undertaken by the borrower. *Adverse selection*, on the other hand, is a situation where as the interest rate increases, safer borrowers drop out of the application pool, and more and more riskier borrowers come forward to accept the loan offer at a high interest rate. As a result, the lender may prefer to ration credit rather than to raise the interest rate in order to protect himself from the increased probability of bankruptcy.

3. Financial Market Failures and Financial Liberalisation in Developing Countries:

The most predominant assumption of the neoclassical literature is that markets work very well in the allocation of economic resources if there are no distortions caused by government interventions to markets. The financial liberalisation literature implicitly accepts this role of markets, and supports policy implications aiming to remove all distortions. However, this concept of the market economies may be subject to a broad criticism that markets do, in fact, not necessarily operate well even without distortions. This would not be more evident than financial markets in developing countries. Excessive reliance on debt finance of the corporate sector, and the domination of credit markets, mostly by banks, make firms in developing countries even more vulnerable to such problems as asymmetric information and credit rationing than those in developed market economies.

Financial markets in developing countries are, in general, imperfect and financially repressed by various government interventions. According to the neoclassical view, these distortions are the reasons preventing financial markets from working efficiently. These distortions may include interest ceilings on deposit and loan rates, high reserve requirements, and preferential credit policies to certain sectors etc. [see McKinnon (1991): 43-46]. The consequences of the financial repression are to reduce the supply of financial funds to formal financial markets and to set a limitation on the quantity of real investment expenditures. Liberalising financial markets, meaning the removal of such distortions caused by government and Central Bank regulations, is considered to be a necessary condition for efficient markets and faster economic growth. The theoretical back-up for this argument has been provided by the McKinnon and Shaw hypothesis which provides a rationale for financial liberalisation as a means to promote growth and financial development.

The formal theoretical model of the McKinnon-Shaw hypothesis focuses particularly on interest ceiling on deposit and/or lending rates. Briefly, this hypothesis argues that regulated interest rates at a constant level create non-price rationing in credit markets. Since banks are not allowed to charge risk premium over fixed interest rates, riskier but potentially more productive investment projects cannot be undertaken [Fry (1982)]. McKinnon and Shaw argue that interest rate ceiling discourages economic agents from depositing their money in the banking sector, and promoting current consumption, then reduces the quantity of investment. As a result, the removal of interest rate ceilings and all types of government regulations that cause distortions in financial markets, will be a recommended policy implication. Once liberalisation is achieved, additional savings are expected to be forthcoming in financial system. Investment, as they suggest, also rises automatically since an increase in savings and bank deposits creates more loanable funds for investment.

The presumption of the McKinnon-Shaw hypothesis is based on the fact that the liberalised interest policy eliminates non-price rationing which is defined as temporary earlier, but overlooks the possibility of permanent rationing which may occur due to imperfections in financial markets even when the financial market is liberalised. Given informational imperfections and adverse selection problems in financial markets, banks in developing countries cannot charge an interest rate high enough (even though interest rates are freed from government interventions) to cover the default risk of riskier projects. In fact, limited bank-based credit markets, which are severely affected by the adverse selection problem, cannot finance these riskier project, and skew the allocation of credit leaving some demand for loan unsatisfied.

Following Stiglitz and Weiss (1981), Cho (1986) analysed the potential limitation of financial liberalisation in developing countries. He basically argued that full-scale liberalisation of the banking sector would not necessarily achieve efficient capital allocation in the absence of well-functioning equity markets. Financial liberalisation aims to eliminate non-price rationing, but to ignore the second type of rationing arising from the adverse selection and moral hazard effects. He suggests that the need for developing well-functioning equity markets should be a part of a comprehensive financial liberalisation. Since equity financing, as he discussed, is free from adverse selection and moral hazard problems of debt financing, equity capital can also finance those risky but productive projects which are rationed in debt markets due to asymmetric information.

In addition to Cho (1986), Fazzari *et al.* (1988) argued that equity financing is, in general, not enough to solve credit rationing problems raised from asymmetric information associated with debt financing. If firms face asymmetric information problem in credit markets, they probably also need to pay a risk premium to obtain new equity because of agency problems in equity markets. The conflicting interests of firms' managers and creditors cause this problem. Managers usually have the incentive to forego some desirable investment opportunities, particularly in the case of high debt-equity ratio, acting in the interest of the equity owner and against the interest of creditors. They also have the incentive to issue new debt that raises riskiness and increase the existing debt stock. Since creditors realise this conflict, they request a premium to restrict the behaviour of managers as the debt stock increases.

McKinnon (1991) developed a version of Stiglitz and Weiss' s model including macroeconomic instability. Instability in this sense may come out in the forms of unexpected inflation, real exchange rate variability and so on. The inclusion of macroeconomic instability is characterised by strong positive covariance in project yields. Stiglitz and Weiss (1981) assume that banks in their model are risk-neutral, and the bank's optimal strategy is independent of its own risk characteristics. In other words, the expected profit of the bank is not stochastic. However, in a risky environment, banks cannot diversify away risks they themselves face, so that the expected profit to banks becomes stochastic. McKinnon (1991) distinguished two different risk situations from the bank's point of view. First he assumes the case of no moral hazard. In such a situation, the effect of increased macroeconomic instability on a risk-averse bank's lending policy would generate lower expected profit to the bank and more severe credit rationing. Increased macroeconomic instability is likely to lower the a risk-averse bank's optimal real loan rate and expected profits. Second, he assumes a situation with moral hazard, in which an increase in instability leads banks to extend their customer bases including relatively riskier projects that they would not otherwise lend. Unless the government imposes some measures on banks (such as increasing reserve requirement and forcing banks to choose lower interest rates to minimise the bankruptcy risk in the banking sector) banks would continue to expand credit to riskier projects to maximise their expected profits. In the case where banks are likely to have undue incentives to make a high-interest loan and the lack of government control on banks is missing, the interaction between instability and moral hazard may cause non-performing loans to increase. McKinnon (1991) also drew attention to the consequences of lack of governmental supervision in the banking sectors and the practice of deposit insurance. In particular, the existence of moral hazard in the banking system induced by deposit insurance and macroeconomic instability leads the monetary authority to impose a ceiling on the loan rate to minimise the losses that are covered by deposit insurance. The general response of banks to such measures would be to introduce even more stringent credit rationing.

4. The Turkish Experience:

Like many other developing countries, Turkey undertook a comprehensive financial liberalisation effort to eliminate exogenous constraints - which were mostly created by intensive government interventions - in the beginning of the 1980s. Before the financial liberalisation reforms, the financial markets in Turkey were severely repressed. The main features of this repression were the ceiling on interest rates for deposit and credit - real interest was often negative because of high inflation -, high reserve and liquidity requirement, the practice of preferential credit allocation subject to subsidies, the monetarisation of high public deficit, restricted entry to the banking sector, and finally constrained foreign exchange operations.

The financial liberalisation took place in July 1980. The reform strategy was to promote financial market development through the deregulation and inducing competition by easing entry into the banking sector. The liberalisation was implemented into three different phases. In the first phase, the liberalisation was rather premature, and relied mostly on the measures increasing competition in the banking sector in order to improve the allocation of financial resources, and on the removal of interest ceilings on borrowing and lending rates. The financial reform was also expected to improve the balance sheet of the Turkish corporate sector by inducing firms to reduce their reliance on the bank credit. The important aspect of this financial deregulation attempt was the stabilisation programme that was undertaken simultaneously with the financial deregulation as a part of a more comprehensive reform programme. The stabilisation and liberalisation of the economy was accompanied by some measures that aimed at reducing high inflation, and solving the twin deficit problem by encouraging domestic financial savings and activities which were supposed to provide a rapid expansion in foreign earnings. This period, however, ended with a financial crisis, so-called Banker's crisis, and the liberalisation process was partly reversed.

The failure of this first deregulation attempt was related closely to the responses of Turkish banking and the corporate sectors to reform and stabilisation policies. On the one hand changing macroeconomic environment adversely affected the profitability and the cost of borrowing of the corporate sector that was highly leveraged, and consequently caused insolvency of some firms, leaving the financial system with a huge amount of non-performing loans (which was expected to be 10-30 % of the total asset in the banking system in the period 1980-1982) [see Atiyas (1990)]. Two major factors of the worsening macroeconomic situation were drastic increases in the cost of borrowing and a decline in gross earnings of the corporate sector because of tight income management policies. On the other hand, the behaviour of the banking sector was initially to fulfil the objective of deregulation by attracting more deposits through a higher interest rate policy. However, the poor earning performance of the corporate sector and non-performing loans eventually led to excessive increases in interest rates. To solve the cash problem, some small banks and brokerage houses tried to attract new deposits by increasing interest rates, and refinanced non-performing loans. This Ponzi game lasted almost two and half years, and ended with a financial crisis. According to Atiyas (1990), "financial liberalisation may not generate desired responses if it is carried out when there are changes in the macroeconomic environment that adversely affect the profitability of and cause financial distress in the corporate sector, and consequently the banking sector.." [Atiyas (1990): 133].

The influence on the corporate sector of the initial deregulation attempts of the financial market was drastic. Increases in interest rates on time deposits resulted in a rapid increase of the average cost of bank loans. This was the major influence on the corporate sector that had already been vulnerable to the cost of borrowing. As bleak economic conditions persisted, drops in retained earnings in the Turkish corporate sector caused liquidity constraints, and reduced the ability of firms to finance even the service payment of outstanding debt stock. Therefore, firms relied heavily on bank credits. As a result, excess demand for bank credit eventually pushed the lending rate further up.

The Turkish experience with the deregulation in the early 80s fits very well to the McKinnon (1991)'s story mentioned earlier. The Turkish banks and brokerage subject to moral hazard set their loan rate at higher and riskier levels knowing (or guessing) ex ante that favourable macroeconomic conditions would lead to high profits, and that they could walk away from heavy losses under the government guarantee. Although there did not exist such an explicit guarantee by the government, the loosely regulated banks were foreseeing ex ante that the government would have to intervene in order to maintain the stability and confidence of the banking sector.

Following the democratic election in 1983, the financial reforms in Turkey gained a new momentum, proposing structural changes in the Turkish financial system and introducing new financial institutions. This second phase covered the period of 1983-1987, and witnessed a number of legislative and institutional measures such as the establishments of the Capital Market Board and an interbank money market, reopening the Istanbul stock Exchange market, enactment of a new banking law, allowing the holding of a foreign-currency-deposit. The third phase is the period between 1988 and 1990 when the government devoted itself to development of advance financial markets by taking further actions to establish a foreign exchange and banknote markets to ease exchange rate operation and international capital movement (i.e. convertibility of the Turkish Lira).

Regarding the endogenous constraints of the Turkish financial system, the Turkish financial liberalisation has not been successful in eliminating informational imperfections in financial markets [see Atiyas and Ersel (1994)]. Despite the removal of government control on interest rates, financial markets in Turkey are still imperfect, and the allocation of credit is still skewed. Atiyas *et al.* (1993) implemented a survey designed to examine banks' lending behaviour in Turkey. The survey was conducted in summer of 1991 and consisted of 16 banks, a mixture of large, medium-size, and small banks. According to the findings of Atiyas *et al.* (1993), banks in Turkey typically distinguish their customers amongst three risk groups in the Stiglitz-Weiss sense; namely the blue chip companies, the relatively risky but creditworthy companies, and the companies that are not eligible for loan. The presence of the last group of companies proves the fact that the banking system in Turkey still rations some companies by nonprice measures. The risk attributed to this last group of companies is related to firm-specific features rather than macroeconomic conditions. The majority of small and mid-sized banks concentrated their activities on predominantly blue chip companies in big cities. Besides, bigger banks had a much wider customer base.

Another well-known fact arising from the survey was that bank lending rates show a wide variation in Turkey. In contrast to the general belief of developed financial markets that banks announce a prime rate and then increase it according to the riskiness of borrowers, many banks in Turkey first announce a minimum rate and then negotiate it downward. The basic idea for this was that negotiating lending rates with riskier borrowers in that way is much easier than asking for a premium over a prime rate. However, small firms preferred to work over a prime rate, but were less reluctant to announce it to the general public. In terms of the type of debt contracts, small number of banks and companies were willing to agree on a loan without collateral. In general, roughly 80-90 percent of all banks required collateral in Turkey.

The Turkish private and public banking sectors have gone through a considerable amount of adjustment during the financial liberalisation starting in 1981. One of the aims of the Turkish financial reform was to increase the efficiency and competition in the banking sector which was dominated mainly by commercial banks.

Table 8.1. The Finance Structure of The Turkish Corporate Sector.

	1984	1985	1986	1987	1988	1989
Debt/ Equity	1.41	1.55	1.82	1.66	1.72	1.25
Short Term Debt	(0.74)	(0.78)	(0.80)	(0.78)	(0.79)	(0.73)
The Share of Bank Loan	0.47	0.46	0.47	0.39	0.42	0.36
Direct Financing	0.03	0.03	0.03	0.06	0.03	0.04
Other Liabilities	0.50	0.49	0.48	0.54	0.54	0.55

Source: Ersel and Ozturk (1993).

Zaim (1995) evaluated the improvement in the technical and allocative efficiency (or inefficiency) of the Turkish banking sector by estimating the nonparametric production frontiers of the sector. Regarding inducement in the technical efficiency of the financial liberalisation, the banking sector has increased the technical efficiency by 10 percent from 1981 to 1990. Also the differences in technical efficiencies between banks has decreased over time.

Another characteristic of the Turkish banking sector is the public dominance. Zaim indicated that inefficiency in public banks is due to irrational credit allocation. Technically state-owned banks appear to be more efficient compared to the private banking sector. However the gap between private and public sector has been decreased due to stimulation to the banking sector (such as easing entry to the banking sector and allowing more competition, and achieving optimum scale) given by liberalisation.

Aydogan (1993) assessed the competitiveness in the Turkish banking sector by testing the operational efficiency of the system. The operational efficiency, measured by the difference between deposit and loan rates, requires a narrow spread between these two rates. The empirical findings of Aydogan (1993) pointed out that the Turkish banks still have market power in the deposit market, and financial liberalisation could not be successful to achieve a competitive banking sector. Aydogan reached this conclusion through the positive effects of inflation and excess demand for loan in the determination of the spread. Due to the market power of the banks, they easily control the cost of deposits as they increase the lending rate. Moreover in an inflationary environment, banks require an additional risk premium over the lending rate that increases the spread. Aydogan also noted the role of the capital market in collecting deposit as a main competitor for the banks. However, the size of the Turkish capital market and the involvement of the banks in the capital market transaction limits the capital market to perform its competitive role in the economy.

What were the effects of financial liberalisation on the financial structure of the Turkish corporate sector? To see this, the debt composition of firms registered at the Capital Market Board of Turkey is reported in Table 1. Three important conclusions emerge from these figures. First, the strong dependence of the Turkish firms on bank credit is more evident when its share is taken into account. The share of bank loans is about one fifth of total finance although it dropped to 36 % in 1989. Second, the share of direct finance options, such as bonds and financial bills, are quite negligible, around 3 % over the period 1984-1989 (the only exceptions are 1987 and 1989 with the 6% and 4% shares respectively). Third, other liabilities including reserves, allowances, revaluation funds, retained profit etc. take up almost half of total finance. The vulnerability of the Turkish firm to the implications of any imperfections in financial markets becomes clearer when the share of the short-term debt is considered. Almost three quarters of total debt are recorded as short-run commitments.

Overall, banks in the Turkish financial system still ration some companies by non-price measures. Despite increases in the technical efficiency and competition (due to stimulation brought about by the liberalisation), the operational efficiency of the banking sector, measured by the spread between deposit and loan rates, is still low because of the high inflation premium and excess demand for bank credit. The corporate sector, on the other hand, consistently remained heavily dependent on bank loans even after financial liberalisation. Direct finance options, including issuing equity, still take a very small component of total finance although financial liberalisation brought new institutions (such as the Istanbul Stock Exchange and Capital Market Board) and financial instruments. Given these characteristics of the Turkish financial markets and corporate sector, the following section develops an empirical model that takes into account the imperfect structure of the Turkish credit markets and the dependency of the corporate sector on bank loans.

5. Capital Market Imperfections and Empirical Investment Equations:

Imperfections in credit markets may have great effects on the volatility of fixed capital investment expenditures at times when there exist credit constraints and the firm is unable to smooth investment expenditure through borrowing or issuing new equity. The reliance on internally generated financial funds in such situations makes investment expenditures more vulnerable to fluctuations in cash flows and profit. The empirical models concerning the impacts of capital market imperfections on a firm's real decisions should concentrate particularly on the role of financial variables in investment. In this section, the impacts of financial constraints on investment expenditures in Turkey are to be investigated with an intertemporal model of a representative value maximising firm. Before the formal presentation of the model, the following section aims to provide a general survey of a more recent literature on the modelling of financial constraints in real decisions.

5. 1. General Overview of the Recent Literature:

The significance of cash flow, in particular financial variables in empirical investment models, is the subject of a long historical discussion. In the last decade, the economic theory concentrated on the imperfections in financial markets, and provided an explanation for the impacts of financial markets on real economic decisions. In relation to private investment behaviour, two crucial financial market imperfections have drawn significant attention in the literature. From the lenders' point of view, incentive effects and the moral hazard problem caused by asymmetric information in financial markets limit the lenders to extend credit to the firms within higher default risk groups. From the manager's point of view, another informational problem allows the manager to prefer more borrowing instead of issuing equity. While the managers find the borrowing option profitable, issuing new debt will not be to the benefits of equity holders since an increasing borrowing also increases the riskiness of the company. Therefore, these conflicting interests lead the equity owners to claim an extra risk premium which is called *agency cost.*

Although there has been a general theoretical agreement on the importance of financial variables in real decisions, the empirical findings had been rather mixed since the seminal paper of Jorgenson (1971). However, the most recent empirical studies have raised the question, and paved the way for a new insight into the question of what determines company investment. The innovation in these studies is the use of company level panel data over a limited time period instead of using aggregate time series. The principal data sources of these studies are published company accounts. They, however, deal not only with the theoretical modelling in association with how to model financial variables within a consistent optimisation framework of a representative firm, but also with some measurement problems and econometric estimation issues of panel data.

There have been three types of modelling of investment demand in the literature. The maximisation of the value of a firm's market value is at the centre of those kind of models. In the earlier research by Jorgenson and his associates [e.g. see Jorgenson and Stephenson (1967) and Jorgenson and Siebert (1968)] during the 1960s and 1970s, the aim was to derive the optimal capital stock from the firm's maximisation problem without explicitly considering the optimal path of adjustment, and to provide evidence to support the idea that price variables have superiority over quantity variables in the determination of investment expenditure. The dynamic nature of investment was incorporated into the model by delivery lags which were assumed to be a barrier to instantaneous adjustment. Given the formal elegance of the Modigliani-Miller theorem, they abstracted financial considerations from investment models. The Modigliani-Miller theorem was taken as a convenient justification for ignoring the effects of capital markets when they solved the intertemporal cash maximisation of the firm.

However, the methodological revolution in macroeconomics in the 70s and 80s, as discussed earlier in this chapter, has shifted attention towards financial matters [for example, very influential paper by Stiglitz and Weiss (1980) and Greenwald and Stiglitz (1988)]. Alternatively, two different models to study the effects of financial variables in investment decisions were developed in the 1980s. The basic idea in the first group of modelling was to add both a financial variable, usually based on the neoclassical technology assumption and a convex cost of capital adjustments, yielding the fundamental relationship between investment and the unobservable shadow value of capital, which is known as marginal-q. But in many empirical studies, the unobservable shadow price of capital is simply related to the observable market value of the firm relative to the replacement cost (which is known as average-q) under some specific assumptions [see Hayashi (1982) and Chirinko, (1987) for example]. The main advantage of the q approach is that with the inclusion of the convex cost of adjustments, the investment decision becomes forward-looking, and does not require any assumption on the formation of future expectations. The q variable controls future expectations using the stock market value of the firm by which expectation on future is reflected. But in the late 1980s, a question was raised regarding whether or not the stock market value, which is itself very sensitive to speculative attacks, is actually a good indicator for the value of a firm. Instead of relying on the unreliable market value of a firm, Abel and Blanchard (1986), however, developed another approach to incorporate the q value into the investment model. What they do is to define an auxiliary equation - along with the original investment demand equation - and then use it to forecast the future value of the marginal revenue product of capital (see chapter 2 for more explicit discussion). The empirical performance of the q model has not yet been very satisfactory on its own terms, and its explanatory power has not been favourably high in comparison with competitive models. Although the q variable has appeared very significant, empirical estimations have indicated the presence of misspecification error through autocorrelation. The attempts to improve the empirical performance of the q models cover a large range of theoretical effort including the allowance for the existence of multiple capital product [Hayashi and Inoue (1991)], the inclusion of financing options and taxation [Cuthberson and Gasporro (1995), Fazzari *et al.* (1988), Hayashi (1985), and Poterba and Lawrence (1983)], and violation of the perfect product market assumption [Schiatarelli and Georgoutsos (1990), and Galeotti and Schiatarelli (1991)].

The second group of empirical approaches also starts with the assumption of neoclassical technology and convex cost of adjustment. Like the previous one, this approach also uses the first-order condition of the firm's optimisation problem, and directly estimates the Euler equation for investment without requiring the q variable. Due to the lack of reliable data on the market value of the firm (not only in developing countries, but also in developed economies), the choice is usually in favour of this, so-called Euler equation approach. This approach was first developed in the investment literature by Abel (1980), and has been extensively used in public finance literature by others [e.g. Poterba and Summers (1983)]. Like the q-theory of investment, the new approach relates investment rates in successive periods by using the costs of capital adjustment. Although expected investment rates are not directly observable, the fact that the Euler equation approach requires only a one-period-ahead forecast value of investment rate, provides its major advantage. Instead of using an auxiliary equation to forecast the unobservable expectations of the marginal product of capital as in Abel and Blanchard (1986) and Abel (1980), the expected value can be replaced by the actual investment rate in the next period with a measurement error. In what follows, an empirical investment equation will be derived by using the Euler equation approach. Unlike the current literature, the empirical testing in this chapter will be carried out using aggregate time series data [the exception in the literature is Schiantarelli and Georgoutsos (1990)].

Why the Euler Equation Approach?:

As explained above, there have been various alternatives to investigate the impacts of imperfect capital markets on the rate of investment; apart from eclectic models, those studies would be divided into two basic groups, namely *q-models of investment* and *the Euler equation approaches*. My choice in this chapter is the latter one because of the following reasons: The Euler equation approach is particularly appealing for developing countries where the stock exchange, that provides the main variable (the market values of firms) of the q-model, is either not present or not well-developed. The Euler equation approach avoids this problem by simply not requiring the stock market values of firms.

Euler equations are also appealing because of their flexible structure to incorporate rich economic relationships into the empirical modelling such as imperfect output market [see Schiantarelli and Georgoutsos (1990)], imperfect credit markets and credit constraints [see e.g. Whited (1992), Hubbard and Kashyap (1992), Jaramillo, Schiantarelli and Weiss (1993), and Galeotti, Schiantarelli and Jaramillo (1994)], and multiple inputs [see Hayashi and Inoue (1991)]. Therefore, one is able to use all information from the firm's optimisation problem.

In relation to the previous paragraphs, the Euler equation approach is suitable when taking into account the intertemporal effects of all economic and technological constraints through Lagrange multipliers. For instance, the functional representation of the unobservable multiplier associated with an exogenous borrowing constraint, as in the present chapter, can be derived in terms of observable, and substituted in the first-order condition of the capital stock in order to reflect the effects of a binding constraint when the value of this multiplier is greater than zero. The parameterisation of the Lagrange multiplier in my model is based on the first-order condition of the outstanding debt stock; i.e. the derivation of the investment demand equation benefits from information that is already given by the optimisation. The omission of the effects on capital stock decisions of the unobservable multiplier, that indeed might be correlated with the other pre-determined variables of the model, would cause a misspecification of the estimated model. However, one also can parameterise the unobservable multiplier associated with the borrowing constraint in an eclectic way, and relate it to some observable variables which are exogenously included into the model [see Pesaran and Smith (1995), and Whited (1992)].

5. 2. Basic Fundamentals of the Model:

The aim of the model of this section is to find out the interactions between real and financial decisions on the basis of empirical evidence from the Turkish economy. In doing so, the model accounts for the impacts of capital market imperfections (e.g. asymmetric information) and liquidity constraints on investment decisions. For this, an Euler equation approach to modelling investment demand is used. A similar approach has been used by various authors very recently with some differences [Bond and Meghir (1994), Galeotti, Schiantarelli and Jaramillo (1994), Jaramillo, Schiantarelli and Weiss (1993) and Schiantarelli and Georgoutsos (1990)]. Unlike similar models, the present one uses all information associated with a binding borrowing constraint through an unobservable Lagrange multiplier. I define this multiplier in terms of observable variables given by the solution of the optimisation problem. With this feature, the model represents a new approach to modelling borrowing constraint in empirical investment literature.

One of the first applications of this approach was developed by Abel (1980). His Euler equation was used to investigate the relative elasticities of price and output variables in neoclassical tradition. However, some studies have reviewed the importance of quantity and cost variables (such as debt as a means of financing investment, and the risk premium being charged by lenders according to the riskiness of a borrower) other than output and the relative price of capital. Abel's model considered the forward-looking nature of investment through the relationship between the current rate of investment and the future profitability. His treatment of multi-period expectations involves a standard Koyck transformation applied to the investment function which is in the form of a distributed lead function. Unlike his approach, the Euler equation in the following sections does not require multi-period expectation formation. The future is included only through the one-period-ahead expected rate of investment.

In the present chapter, a theoretical intertemporal model is developed using the cash maximisation of a representative firm subject to imperfect financial markets - justified by a quadratic risk premium or agency cost function - and a credit constraint which was defined as a maximum limit on the outstanding debt stock of the firm. In the derivation of the investment function, a quadratic cost function of capital adjustment was assumed. Concerning capital market imperfections, it is assumed that asymmetric information exists in credit markets where the firm has more accurate information about the investment project than lenders do. It is further assumed that lenders charge a default risk premium over the risk-free interest rate due to both agency problems [e.g. see Fazzari and Athey (1987)] and incentive effects as described in Stiglitz and Weiss (1983). Following the discussion in the preceding sections, the default risk premium is supposed to be sensitive to the firm's debt-capital ratio in a way that as the latter increases, the default risk-premium also increases. In the following sections, changes in the perceptions of the riskiness of a firm are modelled with the help of a quadratic risk-premium function.

5. 2.1. Definitions and Assumptions:

The model is a discrete time analysis in which the firm is assumed to maximise the present value of the shares received by shareholders. For empirical simplicity, the model developed in this section requires some standard assumptions.

Assumption 1. *The firm uses two inputs of production, capital (K) and labour (L) in its production process.*

Assumption 2. *The capital input K is regarded as quasi fixed, but the labour input L is perfectly variable.*

Assumption 3. *The input K depreciates at a constant rate δ.*

Assumption 4. *The firm's manager is risk neutral, but lenders are risk-averse.*

Assumption 5. *The nominal discount rate is constant ρ.*

Assumption 6. *There are no taxation and investment incentives.*

Assumption 7. *Borrowing is the only external finance option available; the firms neither issue new equity nor retain any earning.*

The purpose of these and similar assumptions is to avoid a highly non-linear dynamic structure for the investment equation. The setting up of the problem is a standard one. By assumption, the following arbitrage equation holds for the representative firm in equilibrium:

$$\rho V_t = D_t + \left[E_t\left(V_{t+1}\right) - V_t\right] \qquad (1)$$

where ρ is the nominal discount rate; V_t is the value of the firm's shares; D_t is gross dividends; E_t denotes expectations conditional on information available at time t. According to (1), firm's discounted value (ρV_t) is equal to the sum of dividends paid in the current period and the expected change in the value of the firm in the next period. The objective of the firm is to maximise the value of the firm's shares, V_t. Solving equation (1) forward with respect to V_t, the following objective function can easily be obtained:

$$V_t = E_t\left[\sum_{t=0}^{\infty} \beta^t D_t \middle| \Omega_t\right] \qquad (2)$$

where $\beta = 1/(1+\rho)$ is the constant discount rate; Ω_t is the information set of the economic agent at time t. A basic cash-flow identity also holds between the firm's financial sources and expenditures. The firm's financial sources are in general internally generated funds and external funds which consist only of borrowing by assumption 7. Internally generated funds are defined as revenue from the sale net of output produced, the costs of borrowing and capital adjustment costs. Finally the cash-flow identity can be represented as follows

$$D_t + q_t I_t = \Pi(K_t, L_t) - i_{t-1}B_{t-1} + \Delta B_t - \Gamma(B_t, K_t) - q_t \Psi(I_t, K_t) \tag{3}$$

where q_t = the price of capital goods; I_t = investment expenditures; B_t = outstanding debt stock; ΔB_t = a change in outstanding debt stock (i.e. borrowing); i_t = riskless interest rate; K_t = capital stock; L_t = labour which is costlessly adjustable production factor; $\Pi(.)$ = the neo-classical revenue function net of labour cost; $\Gamma(.)$ = a quadratic agency cost function or the function of financial distress which captures the premium paid by firms above the safe rate; $\Psi(.)$ = a quadratic adjustment cost function. The model thus has five endogenous variables: dividends, labour, the capital stock, the outstanding debt stock, and investment. The objective function described above is to be maximised subject to some economic and technological constraints. The first one is the usual capital accumulation equation

$$K_t = I_t + (1-\delta)K_{t-1} \tag{4}$$

where δ is the rate of depreciation. The second constraint benefits from the following assumption

Assumption 8. *Dividends are to be non-negative, and cannot exceed the excess of revenue over labour cost, interest rate payment including risk premium, and the costs of capital adjustment* [see e.g. Edwards and Keen (1985), Schiantarelli and Georgoutsos (1990) for example];

that is

$$D_t \geq 0 \tag{5}$$

and

$$D_t \leq \left[\Pi(K_t, L_t) - i_{t-1}B_{t-1} - \Gamma(B_t, K_t) - q_t \Psi(I_t, K_t)\right] \tag{6}$$

Using (6) and the definition of sources and uses of funds (3), one easily obtains the following

$$\Delta B_t \leq q_t I_t \tag{7}$$

which implies that external sources cannot exceed investment expenditures.

In addition to imperfection in credit markets, I also allow for another type of capital market imperfection using the assumption below

Assumption 9: *The firm faces an exogenous upper bound on the level of outstanding debt stock. After that level, the firm becomes too risky for lenders, and is rationed* [Whited (1992)]

$$B_t \leq \overline{B}_t \tag{8}$$

where $\overline{B}_t$ is an exogenous upper bound on the maximum debt stock that the firm is able to accumulate.

5. 2. 2. The Complete Model and The Solution:

In the solution of the model, constraint (5) introduces an additional Lagrange multiplier into the first-order conditions. This unobservable multiplier cannot be eliminated from the Euler equation unless another assumption is made. Since the purpose of the model is to find out the interrelationship between investment decisions and the cost and availability of borrowing, I particularly concentrate on the imperfections related to these issues, which are of great importance in the chapter. In this respect, before starting the solution to the optimisation problem, assume that the following also holds;

Assumption 10: *The upper bound of the dividend constraint is strictly binding; i.e. the borrowing is equal to investment expenditure. This assumption simultaneously states that dividend payment is strictly positive.*

Besides, the assumption also indicates that the firm does not transfer any retained earnings to next periods, and is totally dependent on external borrowing for the finance of investment expenditures; therefore $\Delta B_t = q_t I_t$. In a situation where the slack condition of borrowing ($0< \Delta B_t<q_t I_t$) holds, the borrowing constraint would not influence the first order-condition of the capital stock. However, the purpose of the model here is to see the impacts of a binding exogenous borrowing constraint on the capital stock and investment decisions. With the slack condition, the firm would be able to use some retained earnings which have not necessarily been distributed to shareholders. In this case, the borrowing constraint would occur once retained earnings are exhausted at margin, and borrowing would finance investment without being affected by capital market imperfections. However, the danger of getting a misspecified Euler equation still exists if this assumption does not hold. In that case, the final estimated equation would include the effects of unobservable multiplier associated with constraint (5). In order to concentrate on the imperfections only related to the cost and availability of borrowing, assumption 10 is assumed to hold.

The firm maximises the following discrete problem to find the optimum levels of labour, investment, dividends, capital and debt stocks.

Maximise $$V_t = E_t\left[\sum_{t=0}^{\infty} \beta^t D_t | \Omega_t\right] \tag{9}$$

Subject to

(i) cash-flow identity:

$$D_t = \Pi(K_t, L_t) + \Delta B_t - i_{t-1}B_{t-1} - \Gamma(B_t, K_t) - q_t I_t - q_t \Psi(I_t, K_t) \tag{3'}$$

(ii) constrain on the accumulation of the capital stock:

$$K_t = I_t + (1-\delta)K_{t-1} \tag{4}$$

(iii) non-negativity constraints on dividends:

$$D_t \geq 0 \tag{5}$$

$$\Delta B_t = q_t I_t \tag{7'}$$

(iv) Borrowing constraint:

$$B_t \leq \overline{B}_t \tag{8}$$

where K_t and B_t are both state variables; I_t is the control variable of the model. Consider the case where the firm pays maximum amount of dividends, and then the multiplier associated with the upper bound of dividend will be zero. Let λ_t and η_t be the multipliers associated respectively with capital accumulation equation and with the credit constraint (λ_t, η_t >0). Combining equations (7') and (8), the Lagrangean function can be written as

$$L_t = \left[\Pi(K_t, L_t) + B_t - (1 + i_{t-1})B_{t-1} - \Gamma(B_t, K_t) - q_t I_t - q_t \Psi(I_t, K_t)\right]$$

$$-\lambda_t\left(K_t - I_t - (1-\delta)K_{t-1}\right) + \eta_t\left(\overline{B}_t - q_t I_t - B_{t-1}\right) \tag{10}$$

The first-order conditions of the objective function with respect to labour, investment, capital stock and debt respectively are

L_t $$\Pi_L = 0 \tag{11}$$

I_t: $$-q_t - q_t \Psi'_I + \lambda_t - q_t \eta_t = 0 \tag{12}$$

K_t: $$\Pi'_K - \Gamma'_K - q_t \Psi'_K - \lambda_t + \beta(1-\delta)E_t(\lambda_{t+1}) = 0 \tag{13}$$

B_t: $$\left(1-\Gamma_B^t\right)-\beta(1+i_t)-\beta E_t(\eta_{t+1})=0 \tag{14}$$

$$\lim_{T\to\infty}\left(\beta^T B_T\right)=0 \text{ and } \lim_{T\to\infty}\left(\beta^T K_T\right)=0 \quad \forall t. \tag{15}$$

where superscript and subscript ts indicate time; $X_I^t(.)=\partial X(.)/\partial I_t$ *etc.* [see appendix for the solution in more detail]. The first-order conditions (11) to (14), along with the transversality condition (15), simultaneously give four endogenous variables (labour, the optimum level of the capital stock, the outstanding debt stock, the level of investment to achieve that optimum capital stock level), and two Lagrange multipliers. These endogenous variables are generally functions of the exogenous variables of the model, including interest rates, the price of output, the price of capital goods, and the output level. Particularly, the functional derivation of the Lagrange multiplier η_t (see 14') in terms of exogenous discount factor and the riskless interest rate will enable us to derive the first-order condition of the capital stock by eliminating this unobservable multiplier (see appendix for the derivation).

$$\eta_t=\left(\frac{1}{\beta}\right)\left(1-\Gamma_B^{t-1}\right)-\left(1+i_{t-1}\right) \tag{14'}$$

The economic interpretation of the first-order conditions (11) to (14) are as follows. The first one for labour indicates that the firm equates the marginal productivity of labour to its price in each time period. Remember that labour is a variable productive factor, and that there is no imperfection in labour market. According to (14), one pound increase in debt stock by the firm, net of the risk premium, will be paid back with an additional interest payment in the next period. In the presence of a credit constraint (η_t>0), the price of capital will be augmented by η_t in (12); i.e. the presence of η_t increases the expected marginal benefits from an additional capital. The last condition is the simple transversality condition on borrowing which prevents the firm from borrowing an infinite amount to pay out as dividends. In order to provide economic interpretation for the first-order conditions for the capital stock and investment, the following substitution may be convenient. Solving for λ_t and η_t into the second condition for investment (12), and substituting it in the condition for the capital stock (13) yields the following reduced Euler equation for capital,

$$\Pi'_K-q_t\Psi'_K-\Gamma'_K-E_t\left[q_t-\beta(1-\delta)q_{t+1}\right]-E_t\left[q_t\eta_t-\beta(1-\delta)q_{t+1}\eta_{t+1}\right]$$
$$=q_t\Psi_I^t-E_t\left[\beta(1-\delta)q_{t+1}\Psi_I^{t+1}\right] \tag{13'}$$

The left-hand side of the equation above gives the difference between the incremental profit, which is generated by a unit increase in the capital stock, and its user cost. The right-hand side of the equation is the quasi-forward difference in marginal adjustment costs due to investment. Accordingly the marginal adjustment cost of investing today must be equal to the incremental profit of the new unit of capital stock net of its user cost. Note that the existence of the risk premium, which has been assumed to be elastic to the capital stock, provides some relief from not having high debt-capital ratio for the firm as the capital stock with respect to the stock of debt increases. The last term in (13') including the Lagrange multiplier associated with the borrowing constraint is the net changes in the value of an incremental increase in the capital stock as the borrowing constraint relaxes. Its existence raises the expected user cost of capital.

5.2.3. Empirical Specifications:

In order to obtain an empirical model of investment, we must specify the functions of the risk premium and the costs of capital stock adjustment. In the preceding sections, the costs of borrowing of the firm are assumed to comprise two elements. The first part represents the riskless cost of outstanding debt stock, $i_{t-1}B_{t-1}$, and is not affected by the firm's financial structure, in particular by the debt-capital ratio (i.e. leverage ratio). The second part is, however, assumed to represent the default risk premium (or agency cost) over the riskless interest rate. Due to agency costs and incentive effects in imperfect capital markets, as discussed earlier, the creditors of the firm demand this risk premium against the probability of bankruptcy. According to the theory that has been mentioned earlier, the debt-capital ratio might be a good indicator to measure the riskiness of a firm. An increased debt-dependency of the firm raises the risk of lending money to this firm. Following the current investment literature, the function of this risk premium can be represented by a quadratic, convex function of debt over capital ratio [see Galeotti, Schiantarelli and Jaramillo (1994) and Chirinko (1993) for example], so that

Assumption 11. *The financial distress function is a convex increasing function of debt, and decreasing function of the capital stock as follows:*

$$\Gamma(B_t, K_t) = \frac{a}{2}\left(\frac{B_t}{q_t K_t}\right)B_t, \qquad a > 0 \tag{16}$$

where the term in the parenthesis is the debt-capital ratio. The convexity of the function with respect to debt stock, B_t, provides the increasing risk premium at margin. Also, the agency costs are a decreasing function of the existing capital stock.

Thus, the marginal default risks of the firm with respect to debt stock and the capital stock respectively are

$$\Gamma_B(B_t, K_t) = a\left(\frac{B_t}{q_t K_t}\right) > 0, \qquad \Gamma_K(B_t, K_t) = -\frac{a}{2} q_t \left(\frac{B_t}{q_t K_t}\right)^2 < 0 \tag{16a}$$

The second parameterisation is carried out for the function of the costs of adjustment, $\Psi(.)$. The most popular form of convex adjustment cost functions in the q-theory literature is generally used due to its simplicity. However, unlike many applications in the literature, the capital adjustment cost in this chapter is assumed to be external to the firm which may arise from imperfections in capital goods markets where the firm has no individual effect on factor markets, and where anticipates a rising supply price because all identical firms behave similarly as a result of any demand and price shocks [see Mussa (1977) and Lucas (1967)].

<u>Assumption 12</u>. *The adjustment cost function is a convex function of the rate of investment, and defined as follows*:

$$\Psi(I_t, K_t) = \frac{b}{2}\left(\frac{I_t}{K_t} - c\right)^2 K_t, \qquad b > 0 \text{ and } c > 0 \tag{17}$$

where c is the required minimum level of investment [see Summer (1981)]. The partial derivatives of the function with respect to investment and capital respectively are

$$\Psi_I(I_t, K_t) = b\left(\frac{I_t}{K_t}\right) - bc, \qquad \Psi_K(I_t, K_t) = -\frac{b}{2}\left(\frac{I_t}{K_t}\right)^2 + \frac{bc^2}{2}, \tag{17a}$$

The marginal productivity of capital must also be parameterised for the estimation purpose. This may be specified either by assuming a particular form of the production function [see Abel (1980) for example], or alternatively by relying on a constant returns to scale assumption and the homogeneity of the production function. Despite wide criticisms [see Eisner and Nadiri (1968) for example], if we assume that the production function is Cobb-Douglas, then the marginal productivity of capital can be written as follows

$$\Pi_K^t = \theta\left(\frac{pQ}{K}\right)_t \tag{18}$$

where θ is the share of capital in the production of Q, and the Cobb-Douglas production is $Q_t = K_t^{\theta} L_t^{1-\theta}$.

5.3. The Derivation of Estimateable Euler Equations:

Using (18), two empirical investment equations are derived, depending on whether η_t is greater than or equal to zero. By the first one in which the credit constraint is assumed to be not binding, the significance of the increasing risk premium as well as the Modigliani-Miller irrelevance can be tested. In the second equation where the credit constraint becomes binding, however, the aim is to test the significance of that constraint along with the imperfect market assumption. Before stating the derivation of the estimateable investment equations, one must note that the performance of the estimation results will be closely related to the functional specifications chosen in this section. The empirical results in the following sections may also provide support in favour of, or against those specifications.

5.3.1. An Euler Equation With a Non-Binding Credit Constraint (η =0):

The assumptions here are that the firm issues debt, distributes positive dividends, and is constrained by the upper bound of dividends. The borrowing constraint is assumed not to constrain the firm's behaviour; i.e. $\eta_t = \eta_{t+1}=0$. The Euler equation (15) for capital thus becomes

$$\Pi_K^t - q_t \Psi_K^t - \Gamma_K^t - E_t\left[q_t - \beta(1-\delta)q_{t+1}\right] = q_t \Psi_I^t - E_t\left[\beta(1-\delta)q_{t+1}\Psi_I^{t+1}\right] \tag{15a}$$

(15a) is almost similar to Galeotti, Schiantarelli and Jaramillo (1994) with the minor difference that my definition of the agency cost function is much simpler. The right-hand side of the equation is the quasi-forward difference in marginal adjustment cost. The left-hand side is the incremental profit, obtained as a result of a unit increase in the capital stock, that is net of its user cost and the expected saving in the marginal cost of borrowing avoided by not installing capital tomorrow but today [the second and third term on the left-hand side of (15a)]. Having made use of (16a), (17a) and (18), and arranged the Euler equation (15a), one can easily obtain the following empirical investment equation,

$$\left(\frac{\theta}{b}\right)\left(\frac{pQ}{qK}\right)_t + \left(\frac{a}{2b}\right)\left(\frac{B}{qK}\right)_t^2 + \left(\frac{1}{2}\right)\left(\frac{I}{K}\right)_t^2 + \left(\frac{I}{K}\right)_t + E\left[\Phi_{t+1}\left(\frac{I}{K}\right)_{t+1}\right]$$

$$+\left(\frac{bc-1}{b}\right)E\left[1-\Phi_{t+1}\right] - \left(\frac{c^2}{2}\right) = 0 \tag{15b}$$

where $\Phi_{t+1} = \beta(1-\delta)(q_{t+1}/q_t)$ is the real discount rate; $(1-\Phi_{t+1})$ is the user cost of capital. Let

$$\overline{IK}_t = (I/K)_t, \quad \overline{QK}_t = (pQ/qK)_t, \quad \overline{BK}_t = (B/qK)_t$$

Before estimation (15b), the one-period-ahead forecasted values of investment and the real discount rate variables must be replaced by their observable counterparts. If expectations are rational, replacing all expectations by their realised values introduces a measurement error v_{t+1}, which is a serially uncorrelated forecast error that is the error made in forecasting one-period ahead of the investment rate and the price of capital goods. For the estimation purpose, (15b) can be re-arranged in the following way. Leaving the expected value of the rate of investment on the right-hand side, the first estimateable Euler equation can be written as

$$\overline{IK}_t = \alpha_0 + \alpha_1 \overline{IK}_t^2 + \alpha_2 E_t\left[\Phi_{t+1} \overline{IK}_{t+1}\right] + \alpha_3 \overline{QK}_t + \alpha_4 \overline{BK}_t^2 + \alpha_5 E_t(1 - \Phi_{t+1}) \qquad (15c)$$

where

$$\alpha_0 = -c^2/2, \quad \alpha_1 = 0.5, \quad \alpha_2 = 1, \quad \alpha_3 = \theta/b, \quad \alpha_4 = a/2b,$$
$$\alpha_5 = (bc - 1)/b \qquad (19)$$

The restriction that $2\alpha_1 = \alpha_2$ helps the recovery of all structural parameters from equation (19). The signs of the variables in equation (15c) are similar to those in previous studies [in particular to those in Galeotti, Schiantarelli and Jaramillo (1994)]. The presence of the output term captures the accelerator effect in the output market. The debt term appears because of the assumption of *non-separability* between investment and borrowing decisions. Thus, it reflects the effects of imperfect credit market; with the irrelevance assumption of the Modigliani-Miller hypothesis, this term disappears, and two decisions become separable. The insignificance of α_4 in estimation is an evidence of the irrelevance assumption of the Modigliani-Miller hypothesis as well as of an increasing agency cost. In order to recover structural parameters from the estimates, the exact identification of the model can be provided by imposing the restrictions that $\alpha_2 = 2\alpha_1$, $\alpha_3 = -\alpha_5$.

To estimate (15c), the expected rate of investment must be defined in terms of observables or replaced by its realised value, so that

$$\overline{IK}_t = \alpha_0 + \alpha_1 \overline{IK}_t^2 + \alpha_2 E_t\left[\Phi_{t+1} \overline{IK}_{t+1}\right] + \alpha_3 \overline{QK}_t + \alpha_4 \overline{BK}_t^2 + \alpha_5 E_t(1 - \Phi_{t+1}) + v_{t+1} \qquad (20)$$

The additive error-term in (20) can be regarded as one due to technological shocks instead of measurement. One way to include the error term into the model may be re-writing the adjustment cost function of the capital stock (equation 17) depending on technological shocks; i.e. $\Psi(I_t, K_t) = (b/2)\left[(I_t/K_t) - c - v_t\right]$.

5. 3. 2. An Euler Equation With a Binding Constraint ($\eta > 0$):

The equations above are correctly specified only if the borrowing constraint is not strictly binding. When the credit constraint becomes binding, an additional variable appears in the shadow value of capital (equation 16) through the unobservable multiplier of constraint (8). Using the first-order condition for debt, this multiplier can be defined in terms of observable variables. Using (14')[1]

$$[\eta_t - \Phi_{t+1}\eta_{t+1}] = (1-\gamma)(1-\Phi_{t+1}) + (i_{t-1} - \Phi_{t+1}i_t) + a\gamma(\overline{BK}_{t-1} - \Phi_{t+1}\overline{BK}_t)$$

$$= (1-\gamma)(1-\Phi_{t+1}) + \nabla i_t + \nabla\overline{BK}_t \qquad (22)$$

where $\gamma = 1/\beta$, $\nabla\overline{BK}_t = \gamma(\overline{BK}_{t-1} - \Phi_{t+1}\overline{BK}_t)$ and $\nabla i_t = (i_{t-1} - \Phi_{t+1}i_t)$. A simple substitution of (22) into the Euler equation of the capital stock (13') leads to the following form of the investment demand equation;

$$\overline{IK}_t = -\left(\frac{c^2}{2}\right) + 0.5\overline{IK}_t^2 + E_t[\Phi_{t+1}\overline{IK}_{t+1}] + \left(\frac{\theta}{b}\right)\overline{QK}_t + \left(\frac{a}{2b}\right)\overline{BK}_t^2 + \left(\frac{bc\beta - 1}{b\beta}\right)E_t(1-\Phi_{t+1})$$

$$+\left(\frac{1}{b}\right)\nabla i_t + \left(\frac{a}{b}\right)\nabla\overline{BK}_t \qquad (23a)$$

The difference of this equation from the one derived earlier (15c) is the last two terms emerging due to the binding credit constraint on borrowing. The joint significance of the coefficients of all financial variables is to be tested if there is evidence in favour of the Modigliani-Miller irrelevance hypothesis. Besides, the joint significance of a_5 and a_6 also confirms the binding borrowing constraint in the imperfect credit market. Imposing the restriction that (a_6=2*a_3) reduces (23a) to

$$\overline{IK}_t = a_0 + a_1\overline{IK}_t^2 + a_2E_t[\Phi_{t+1}\overline{IK}_{t+1}] + a_3\overline{QK}_t + a_4E_t(1-\Phi_{t+1})$$

$$+a_5\nabla i_t + a_6\left[0.5 * \overline{BK}_t^2 + \nabla\overline{BK}_t\right] \qquad (23c)$$

where $a_0 = -c/2$, $a_1 = 1/2$, $a_2 = 1$, $a_3 = \theta/b$, $a_4 = a/2b$, $a_5 = (bc\beta - 1)/bc$, $a_6 = a/b$.

Using these equations, the Modigliani-Miller irrelevance theorem will be tested in the next section for Turkey. The joint significance of all finance variables (including quadratic, linear debt-capital ratio, and the interest rate variables) will be an indication of the violation of this theorem. Additionally, the significant positive coefficient of the quadratic debt-capital ratio alone will be an evidence of the

[1] see appendix for the more detailed derivation.

presence of an increasing agency cost resulting from increasing the debt stock and not installing capital. With respect to the theory developed in the chapter, the joint significance of the last two finance variables will prove the existence of the borrowing constraint.

Besides the relevance of the choice of the functional form of the adjustment cost function, the production function can also be tested. The significance of the coefficients of the rate of investment on the right-hand side and the joint restriction tests on these coefficients would provide a justification for the use of quadratic adjustment cost function.

6. Empirical Results:

The model has been estimated for the period 1963-1993 on the aggregate data and for the period 1968-1993 on the sectoral data. I have started with the estimation of the unrestricted equation (23) and subsequently imposed the restriction ($a_6=2*a_3$). In estimating (23), the only problem is that the one-period-ahead forecasted rate of investment is unobservable, and should be replaced by some measure using the rational expectation (or perfect foresight) assumption. The one-period-ahead forecasted values of investment and the real discount rate variables have been replaced by their observable counterparts. If expectations are rational, replacing all expectations by their realised values introduces an additive measurement error v_{t+1}, which is a serially uncorrelated forecast error that is the error made in forecasting the one-period ahead of the investment rate and the price of capital goods [see equation (24)]. We then assume that this is the only component of the error term and there is no error component associated with technology shocks. Including such a technology shock yields an composite stochastic term combining forecasting error and technology shocks. Doing so, however, introduces an additive and orthogonal expectation error made when forecasted values of the one-period-ahead rate of investment are based on information available in period t, and the stochastic error term of the Euler equation becomes correlated with the regressors, so that the OLS estimator may give inconsistent parameter estimations. McCallum (1976) suggests that the instrumental variable estimator ensures consistency, and that the lagged values of the present variables in the equation dated until the period when expectation are formed can be used as instruments.

The Euler equation in (23a) has been estimated for the linear rate of investment instead of the quasi difference dependent variable ($\overline{IK}_t - 0.5\overline{IK}_t^2$) on the left-hand side. Although the estimation has been carried out on both the aggregate data and sectoral data, the results have indicated a strong functional misspecification (very high Ramsey test statistics) for all estimations, and have not been reported here. The equation estimated has finally been chosen as

$$\left[\overline{IK}_t - 0.5\overline{IK}_t^2\right] = a_0 + a_1\Phi_{t+1}\overline{IK}_{t+1} + a_2\overline{QK}_t + a_3\overline{BK}_t^2 + a_4E_t(1-\Phi_{t+1}) + a_5\nabla i_t + a_6\nabla\overline{BK}_t + v_{t+1} \qquad (24)$$

where $a_0 = -c^2/2$, $a_1 = 1$, $a_2 = \theta/b$, $a_3 = a/2b$, $a_4 = (bc\beta - 1)/b\beta$, $a_5 = 1/b$, $a_6 = a/b$.

The results of this first method are reported in table 2 for the aggregate investment model. Two different estimations are presented for the aggregate investment model in table 2. The first column of each estimation reports the unrestricted version of the Euler equation (24), whereas the second column is the restricted version (24) after imposing the restriction (a_6=2a_3). In addition to conventional test statistics [e.g. autocorrelation (SC), functional form misspecification (FF), normality (N) and heteroscedasticity (H)], Sargan's over-identification test (ST) is reported to test the validity of the choice of instrumental variables and to determine whether the instruments are correlated with the disturbances. Two Wald statistics (W1 and W2) are also presented in table 2 to test the restrictions imposed; W1 is the joint significance test of all financial variables, W2 the joint significance test of the last two terms in (24) that arise simultaneously due to the binding borrowing constraint. Finally W3 is the test for the restriction a_6=2a_3. The numbers in brackets below each test value indicate the relevant degrees of freedom. In estimation, a different order of lags of each variable has been tried. Some results in table 2 and in others are in fact derived by regressing the quasi differenced form of dependent variable on some lagged dependent variables. For example, the unrestricted form of the second estimation results (column 3) in table 2 includes only the first order lag of the interest rate variable. The instruments chosen are the second lags of all variables. Although we also estimated the models using the first order lags as instruments, the ST over-identification test indicated that the choice of instruments was not correct.

The explanatory power of all equations in table 2 is very good, around 90 percent. The ST test indicates that the choice of instruments is acceptable. The t-values of the coefficients in the first column are based on the adjusted White's heteroscedasticity consistent standard errors because of the presence of heteroscedasticity. The coefficients in all variables are according to the predictions of the theoretical model developed earlier, except for the signs of the quadratic risk premium variable and the interest rate variable. Despite the theoretical expectations, the quadratic debt-capital ratio has a negative sign, but is statistically insignificant.

Table 8.2
Aggregate Investment Under the Rational Expectation Assumption
(Instrumental Variable Estimation)

$$\left[\overline{IK}_t - 0.5\overline{IK}_t^2\right] = a_0 + a_1\Phi_{t+1}\overline{IK}_{t+1} + a_2\overline{QK}_t + a_3\overline{BK}_t^2 + a_4\left(1-\Phi_{t+1}\right) + a_5\left(i_{t-1} - \Phi_{t+1}i_t\right) + a_6\left(1/\beta\right)\left(\overline{BK}_{t-1} - \Phi_{t+1}\overline{BK}_t\right) + v_{t+1}$$

	(1)[a, b]		(2)[b, d]	
Variables	Unrestricted	Restricted	Unrestricted	Restricted
constant	-0.2026 (-3.967)	-0.1923 (-4.187)	-0.2846 (-3.665)	-0.205 (-4.285)
$\Phi_{t+1}\overline{IK}_{t+1}$	10.722 (9.043)	10.615 (7.840)	12.144 (6.862)	11.380 (7.664)
$\overline{QK}_t$	0.0327 (2.951)	0.0311 (2.775)	0.0372 (2.318)	0.0244 (2.078)
$\overline{BK}_t^2$	-0.1298 (-0.295)*	----	-0.101 (-1.435)*	----
$\left(1-\Phi_{t+1}\right)$	0.2099 (3.996)	0.200 (4.156)	0.2909 (3.685)	0.212 (4.240)
∇i_t	-0.1517E-3 (-6.063)	-0.1524E-3 (-4.903)	-0.1438E-3 (-3.644)	-0.152E-3 (-4.417)
$\nabla\overline{BK}_t$	0.0045 (1.447)*	----	0.0084 (2.179)	----
$\nabla\overline{BK}_t + 0.5\overline{BK}_t^2$	----	0.0041 (1.521)**	----	0.0052 (1.883)
$\overline{R}^2$	0.935	0.937	0.910	0.931
SE	0.0023	0.0023	0.0027	0.0024
SC chi-square(1)	0.969	0.830	1.063	1.061
FF chi-square (1)	0.117	0.002	2.069	0.081
N chi-square (2)	0.481	0.400	0.110	0.817
H chi-square (1)	3.857	3.80	2.819	3.058
ST chi-square	12.504 [6]	4.690 [5]	2.650 [4]	6.083 [5]
W1 chi-square	31.142 [3]	32.272 [2]	20.637 [3]	21.643 [2]
W2 chi-sq	39.026 [2]	42.054 [2]	29.517 [2]	35.715 [2]
W3 chi-sq (1)	0.102 [1]	----	2.047 [1]	----

Notes: W1: The Wald statistics to test the restriction that $a_3=a_5=a_6=0$.; W2: The Wald test statistics to test that $a_5=a_6=0$.; W3: The Wald statistics to test that $a_6=2a_3$; a Without lag of any variable.; b: The second lag values of each variable have been used as instruments.; c: Heteroscedasticity consistent t-values are reported in parentheses.; d: Only the interest rate variable has been lagged once. * indicates insignificant coefficients either at 5 percent or 10 percent significance level. ** shows the variables that are significant only at 10 percent.

$$\Phi_{t+1} = \beta(1-\delta)q_{t+1}/q_t,\quad \nabla i_t = \left(i_{t-1} - \Phi_{t+1}i_t\right),\quad \nabla\overline{BK}_t = \left(1/\beta\right)\left(\overline{BK}_{t-1} - \Phi_{t+1}\overline{BK}_t\right)$$

On the other hand, the interest rate variable again has the opposite sign, but is highly significant. The linear debt-capital ratio (the last one in the first column) is expectedly positive, but is significant only at the 10 percent significance level. However, overall, a joint significance of the last two financial terms, namely the interest term and the linear debt-capital ratio, supports the presence of borrowing constraints at the aggregate level. The test for the restriction (a_6=$2a_3$) confirms this conclusion (see W2) as well. Once this restriction is imposed (see the second column of the first model), only the sign of the interest rate variable remains opposite to our theoretical expectation. W1 indicates the joint significance of all the financial variables in the Euler equation. The results of the second model in table 2 (the third and fourth columns) qualitatively confirm those of the first model. The perverse sign of the interest rate variable still remains a puzzle. However, one explanation of this unexpected result might be the use of the nominal deposit rate instead of riskless interest rate in the calculation of this variable. The result would then suggest that the nominal deposit rate is indeed a very poor proxy for the riskless interest rate.

Another drawback of this estimation is the rejection of the hypothesis that the coefficient of the one-period-ahead expected rate of investment is unity. Therefore it is not possible to recover and estimate the structural parameters, such as the adjustment cost parameter, the coefficient of the agency cost function, and the capital share of production. Despite this result, the expected rate of the investment variable is highly significant and its sign is positive, as expected.

The significance of the output term and the user cost of capital is quite strongly supported by the data. The sign of the user cost variable depends mainly on the relative size of the structural parameters, which is itself a combination of these parameters. The size of output term is, though significant, quite small, similar to results obtained in earlier empirical studies.

Overall, these results indicate that the representative firm faces increasing agency costs of debt which is increasing in the debt-capital ratio (the interpretations are based on the restricted functions since the coefficient of the debt variable has the expected sign, and is significant at 10 and 5 percent levels in the first and the second models respectively). Besides, the borrowing constraint is also binding on the firm. The application of the quadratic form for capital adjustment costs has not been supported by the data, despite the significant coefficients of the expected rate of investment, which has been estimated as greater than unity.

Table 8.3
Sectoral Investment Equations (Instrumental Variable Estimation)

$$\left[\overline{IK}_t - 0.5\overline{IK}_t^2\right] = a_0 + a_1\Phi_{t+1}\overline{IK}_{t+1} + a_2\overline{QK}_t + a_3\overline{BK}_t^2 + a_4\left(1-\Phi_{t+1}\right) + a_5\left(i_{t-1} - \Phi_{t+1}i_t\right) + a_6\left(1/\beta\right)\left(\overline{BK}_{t-1} - \Phi_{t+1}\overline{BK}_t\right) + v_{t+1}$$

	Manufacturing		Agriculture		Mining	
Variables	(1)	(2)	(1)[a]	(2)[b]	(1)[c]	(2)[d]
Constant	-0.381 (-3.246)	-0.435 (-3.956)	-0.638 (-4.859)	-0.449 (-5.652)	-0.0612 (-1.924)	-0.080 (-2.339)
$\Phi_{t+1}\overline{IK}_{t+1}$	8.269 (3.295)	10.353 (5.561)	1.585 (3.228)	----	13.526 (9.199)	12.578 (8.744)
$\overline{QK}_t$	-0.923E-3 (-1.148)*	-0.0014 (-1.944)	0.026 (29.512)	0.025 (38.524)	0.423E-4 (0.140)*	0.286E-3 (0.932)*
$\overline{BK}_t^2$	0.080 (1.254)*	----	-0.0054 (-2.290)	----	-0.511E-4 (-0.188)*	----
$\left(1-\Phi_{t+1}\right)$	0.417 (3.390)	0.468 (3.987)	0.665 (4.900)	0.482 (5.643)	0.0621 (1.919)	0.0811 (2.331)
∇i_t	-0.405E-3 (-4.526)	-0.340E-3 (-4.661)	0.0047 (1.704)**	0.0055 (2.100)	-0.989 (-1.343)**	0.529E-3 (0.840)*
$\nabla\overline{BK}_t$	0.0036 (1.936)	----	0.0015 (2.295)	----	0.121E-3 (1.979)	----
$\nabla\overline{BK}_t + 0.5\overline{BK}_t^2$	----	0.0047 (2.856)	----	0.959E-5 (0.161)*	----	0.125E-3 (2.635)
$\overline{R}^2$	0.942	0.954	0.989	0.987	0.878	0.878
SE	0.0053	0.0054	0.0046	0.005	0.0009	0.0009
SC chi-square (1)	0.709	1.653	0.398	1.376	0.00003	0.020
FF chi-square (1)	0.048	0.460	3.178	0.0585	1.662	0.290
N chi-square (2)	0.108	0.883	0.455	3.622	0.277	0.110
H chi-square (1)	0.854	0.574	0.661	0.293	3.068	0.624
ST chi-square	8.394 [6]	4.915 [5]	1.366 [6]	1.491 [4]	10.138 [6]	7.451 [5]
W1 chi-square	38.430 [3]	35.875 [2]	10.031 [3]	4.722 [2]	8.298 [3]	7.212 [2]
W2 chi-square	38.197 [2]	----	9.912 [2]	----	6.304 [2]	----
W3 chi-square	1.666 [1]	----	5.233** [1]	----	0.0013 [1]	----
W4 chi-square	----	----	1.420 [1]	----	----	----
W5 chi-square	----	----	5.284 [2]	----	----	----

Notes: **a**: The first lags of the quadratic debt-capital variable and the user cost term; **b**: the first lag of the user cost term; **c**: the lags of the linear debt-capital variable; **d**: the lags of the linear debt-capital ratio and the interest rate variable; W4; The Wald statistics to test that a1=1;W5: The Wald stat. jointly to test that a1=1 and a6=2a3. See the table 1 for the explanation of the rest of the legends. The second lags of all variables have been used as instruments.

Table 8.3 (Cont.)
Sectoral Investment Equations (Instrumental Variable Estimation)

	Services		Services	
Variables	(1)	(2)	(1)[a]	(2)[b]
constant	0.0188 (0.4828)*	0.0145 (0.445)*	0.0268 (1.025)*	0.016 (0.621)*
$\Phi_{t+1}\overline{IK}_{t+1}$	8.408 (6.112)	8.763 (6.362)	7.136 (6.465)	7.648 (6.788)
$\overline{QK}_t$	0.668E-4 (1.225)*	0.732E-4 (1.763)	0.984E-4 (2.278)	0.101E-3 (3.092)
$\overline{BK}_t^2$	0.0663 (0.448)*	----	0.463 (1.403)**	----
$(1-\Phi_{t+1})$	-0.0135 (-0.373)*	-0.0086 (-0.275)*	-0.0126 (-0.426)*	0.011 (-0.437)*
∇i_t	-0.0053 (-2.564)	-0.0058 (-2.717)	-0.0057 (-3.419)	-0.006 (-3.519)
$\nabla\overline{BK}_t$	-0.777E-3 (-0.446)*	----	-0.0075 (-1.548)**	----
$\nabla\overline{BK}_t + 0.5\overline{BK}_t^2$	----	-0.001 (-0.689)*	----	-0.837E-3 (-0.766)*
Dummy	----	----	-0.008 (3.000)	-0.008 (-2.973)
$\overline{R}^2$	0.858	0.868	0.914	0.909
SE	0.0041	0.0039	0.0032	0.0032
SC chi-square (1)	1.892	1.151	0.590	0.291
FF chi-square (1)	1.587	0.720	0.104	0.598
N chi-square (2)	0.632	0.564	0.567	0.269
H chi-square (1)	0.054	0.015	0.007	0.145
ST chi-square	6.423 [6]	1.872 [5]	6.711 [6]	4.84 [5]
W1 chi-square	6.718 [2]	7.499 [2]	15.241 [2]	12.827 [2]
W2 chi-square	0.200 [1]	----	1.964 [1]	----

Notes: a: The lags of the quadratic debt-capital ratio and the user cost variable; b: No lags variables. Dummies have been used for outliers in 1981 and 1985. All instruments are the second-order lags of all variables.

Sectoral Estimations:

Equation (24) has also been estimated at the sectoral level. The sectors consist of manufacturing, agriculture, mining, and services. The sample period between 1968 and 1993 is mainly determined by the number of observations available for the production level of each sector. Sectoral results show a great similarity to those of aggregate investment. The Euler equation fits the Turkish sectoral data better; the degrees of freedom adjusted R^2 is about 95 percent for manufacturing, agriculture, services and around 87 percent for mining. The majority of estimated coefficients are significantly different from zero either at the 5 or 10 percent significance level [remember that the sample size for sectoral models is 26]. Generally the estimation suffers from the same drawbacks, in other words the unexpected negative signs of interest rate variables as the aggregate model and the rejection of the unity restriction on the coefficient of the expected rate of investment, at least in the estimations for manufacturing, services, and to some extent mining. However, interestingly, the agricultural sector, to a great extent, differs from others in a way that none of those drawbacks has accounted for. Additionally, imposing the joint restriction of a unit coefficient on the expected rate of investment and that $a_6=2a_3$ appeared to be plausible at 5 percent on the basis of the Wald statistic in table 3 (see W5 in table 3). In the unrestricted estimations, the effects of financial variables seem to be jointly significantly different from zero. But once imposing restrictions, their effects become insignificantly different from zero (see test statistic W1 for restricted estimation). Therefore the data on agriculture sector did not show any evidence that any financial factors such as an increasing agency cost and a borrowing constraint are effective in the determination of the rate of investment in agriculture. On the contrary, the output (i.e. accelerator) effect and the effect of the user cost of capital are the most important factors among the determinants of the rate of agricultural investment.

In mining, while the unrestricted form resulted in the unexpected sign on the interest rate variable -which is significant at 10 percent level-, it turned out to be positive, albeit insignificant, in the restricted version. In addition to the insignificant interest rate variable, the output effect also came up insignificant . The overall significance of the financial variables, including the interest rate and the combination of quadratic and linear debt-capital ratio terms, supports the hypothesis that financial factors are important in mining. With regard to the general issue of which factor among quantity and price variables is dominant in the determination of investment, the data in the mining sector indicated that the financial quantity variable (the availability of debt) as well as the user cost of capital are two important factors to which the rate of investment in mining is sensitive.

For services, the estimation results of two different models are presented in table 3. The first two columns of the table are the results without any dummy variable on the right-hand side. Although the normality test statistics (N) show no indication of non-normality, the visual inspection of the plot of residuals reveals two outliers in 1981 and 1985 respectively. The third and fourth column, however, reports those results with the dummy variable on the right-hand side. Many variables, which had been insignificant previously, became significant in the second model with the dummy variable. As seen in the last column of table 3, the joint Wald test on the significance of all financial variables confirms the same conclusion as given by the data in manufacturing and mining, that financial quantity and price variables are important. The increasing agency cost hypothesis is *weakly* confirmed by the results of the unrestricted form in the third column (note that the estimated coefficient is significant at the 10 percent significance level), but rejected by the restricted model (see the t-value of the combination of linear and quadratic debt-capital ratio). Output is another important factor in terms of its significance, but is negligible in magnitude. More interestingly, the user cost of capital emerged insignificant with respect to other estimation results.

In the derivation of the estimateable Euler equation, I have made use of some specific technology assumptions, such as the quadratic agency cost and the adjustment cost functions, and the Cobb-Douglas production function. Despite these restrictive assumptions, the Euler equation has performed well both on the aggregate and sectoral data. Two issues are quite important for the best fit on the data. The first one is related to the appropriateness of the quadratic agency cost function assumption. Despite the overall satisfactory results, the unexpected negative signs of all interest rate variables shed doubts on the choice of functional form of the agency cost function. The second issue is that the simultaneous effects on the rate of the capital accumulation of decisions regarding demand for labour and other inputs of production are omitted. Despite the fact that the Euler equation approach is flexible to incorporate relatively rich economic relationships into the modelling using optimisation framework, the model here has intentionally ignored the effects of other economic decisions such as labour and raw materials etc. in order to concentrate on the interaction between investment decisions and decisions on financing investment expenditure.

The empirical results obtained in this chapter qualitatively showed that financial variables are quite important determinants of investment. Although the output (or accelerator) variable is also a "significant" factor in many estimations, its quantitative effect is quite small. The indication of the increasing agency cost is the significant quadratic debt-capital ratio in the unrestricted models and the variable derived as a combination of quadratic and linear debt-capital ratio in the restricted models. For the aggregate and the sectoral data from agriculture and mining, the quadratic debt-capital ratio turned up negative, opposite to the theoretical expectation. But once imposing the restriction on the coefficients of this quadratic term and its linear counterpart, the signs become positive. Moreover, because of the rejection of the unit coefficient on the expected rate of investment variable, the structural parameters could not be recovered at the aggregate as well as at the sectoral level, with the sole exception of agriculture. Referring to the restricted Euler equation in the second column of table 3, the structural parameters of agency cost function (a), adjustment cost function (b), minimum required investment (c) are 0.0017, 181.8 and 0.592 respectively. Like other similar studies [e.g. Galeotti *at al.* (1994), and Schiantarelli and Georgoutos (1990)], the estimate for agricultural investment under quadratic adjustment costs yielded very high values for the adjustment cost parameter, implying that huge costs are required in changing the capital stock. This rather unconvincing result of the estimate agricultural sector might be due to the inappropriate form of the adjustment cost function.

7. Conclusion:

In the 1980s, Turkey undertook a large scale structural adjustment programme in which trade and financial liberalisation have great importance. The effects of financial liberalisation on investment and in turn on growth have been studied by many researches [see Zaim (1995), Atiyas and Ersel (1904), Atiyas *et. al.* (1993), Uygur (1993), and Akyuz (1990)]. The aim of financial reform was to increase the availability of financial funds and to improve the efficiency of financial intermediation. They have been done by freeing interest rates, easing entry to capital markets, allowing for foreign competition, and introducing new financial institutions and instruments. Over the ten-year period from 1980 to 1990, the Turkish financial reforms appears to work in terms of increased efficiency in the banking sector [see Zaim (1995)]. However, the market structure still remains imperfect, and the Turkish banking system still rations some companies by non-price measures [see Atiyas and Ersel (1994) and Atiyas *et. al.* (1994)].

Thus far, any study on Turkey has emphasised the impacts of financial market imperfections on private investment expenditures. More importantly, no one has developed any theoretical investment model which is explicitly based on a value maximisation of a representative firm. For this purpose, I developed a model, in which imperfections in financial markets (justified by an increasing debt-capital or leverage ratio) and borrowing constraint exist, using the quadratic capital adjustment cost function. Due to more reliable data availability to develop a rather more well-known theoretical model (such as Tobin's q-models), my model in this chapter aimed directly to estimate the first-order condition of capital from the optimisation of the stock market value of the representative firm. This estimation strategy is known as Euler equation approach to modelling investment. Euler equations have proven that they were more flexible to account for any kind of technical and economical constraints related to the concern of this chapter. The only difference of the model developed here from those in the literature is the presence of the borrowing constraint, and its explicit inclusion into the final investment equation through the multiplier associated with that constraint.

The data from the Turkish economy fit the Euler equation very well, but raised some equations about the appropriateness of the choice of the quadratic agency cost and capital adjustment costs functions. Although I could not recover the structural parameters from the estimates, the results confirmed two suggestive conclusions: The first one is the presence of significant interaction between financial and real decisions in Turkey. This is confirmed by the joint or individual significance of finance variables in estimates. Besides, the data supports the fact that the Turkish firms face an increasing agency cost as well as borrowing constraints in general. In the sectoral level estimations, the same conclusions have been accepted for manufacturing, mining and services, whereas agriculture appeared to be more sensitive to the user cost of capital and the accelerator type of variable than finance variables.

The aggregate level data (either at whole economy level or sectoral level) have shown no supportive evidence to use quadratic capital adjustment cost function. However, as noted before, these results altogether should be regarded as suggestive, and more researches need to be done in this respect; in particular at firm level (using panel data) in order to test the quadratic cost function of capital adjustment, and also to see the interaction between the different financial and real decisions.

Appendix

The Solution of The Intertemporal Maximisation of the Firm's Value

The firm is trying to maximise its objective function (the value of the firm) through time subject to the constraints of (i) its production technology, (ii) the capital account identity, (iii) an upper bound on dividends, (iv) non-negativity of dividend payments, (v) the borrowing constraint. The problem has been solved using a simple dynamic optimisation technique: for technical help, see Dixit (1990) for example. In a dynamic optimisation such as

Max. $$V_t = E_t\left(\sum_{t=0}^{\infty}\beta^t D_t \middle| \Omega_t\right) \quad (A.1)$$

Subject to $$D_t = \Pi(K_t, L_t) + B_t - (1+i_{t-1})B_{t-1} - \Gamma(B_t, K_t) - q_t I_t - q_t \Psi(I_t, K_t) \quad (A.2)$$

$$K_t = I_t + (1-\delta)K_{t-1} \quad (A.3)$$

$$D_t \geq 0 \quad (A.4)$$

$$B_t = q_t I_t + B_{t-1} \quad (A.5)$$

$$B_t \leq \overline{B}_t \quad (A.6)$$

where

$$\Pi(K_t, L_t) = p_t Q(K_t, L_t) - w_t L_t \quad (A.7)$$

we can use the usual Lagrangean function by introducing new variables λ_t and η_t associated with the constraints (A.3) and (A.6) respectively. But before introducing the Lagrange function, substitute (A.5) in (A.6)

$$q_t I_t + B_{t-1} \leq \overline{B}_t \tag{A.6a}$$

This transformation enables us to deal with a relatively simple Lagrangean function, together with assumption-10 in the text. According to this assumption, (A.6a) is strictly binding, and the non-negativity constraint on dividends simultaneously holds. Doing so will eliminate a possible Lagrange multiplier, and simplifies the optimisation problem. Then the Lagrangean function can finally be written as

$$L_t = \left[\Pi(K_t, L_t) + B_t - (1+i_{t-1})B_{t-1} - \Gamma(B_t, K_t) - q_t I_t - q_t \Psi(I_t, K_t)\right]$$

$$-\lambda_t\left(K_t - I_t - (1-\delta)K_{t-1}\right) + \eta_t\left(\overline{B}_t - q_t I_t - B_{t-1}\right) \tag{A.8}$$

The first-order conditions with respect to labour, investment, the capital stock, and the outstanding debt stock are

$$\Pi_L = 0 \tag{A.9}$$

$$-q_t - q_t \Psi'_I + \lambda_t - q_t \eta_t = 0 \tag{A.10}$$

$$\Pi_K - \Gamma'_K - q_t \Psi'_K - \lambda_t + \beta(1-\delta)\lambda_{t+1} = 0 \tag{A.11}$$

$$\left(1 - \Gamma'_B\right) - \beta(1+i_t) - \beta\eta_{t+1} = 0 \tag{A.12}$$

$$\lim_{T\to\infty}\left(\beta^T B_T\right) = 0 \quad \text{and} \quad \lim_{T\to\infty}\left(\beta^T K_T\right) = 0 \tag{A.13}$$

From (A.12)

$$\left.\begin{aligned} \eta_t &= \left(\frac{1}{\beta}\right)\left(1 - \Gamma'^{t-1}_B\right) - \left(1 + i_{t-1}\right) \\ \eta_{t+1} &= \left(\frac{1}{\beta}\right)\left(1 - \Gamma'_B\right) - \left(1 + i_t\right) \end{aligned}\right\} \tag{A.12a}$$

From (A.10)

$$\left.\begin{aligned} \lambda_t &= q_t + q_t \Psi'_I + q_t \eta_t \\ \lambda_{t+1} &= q_{t+1} + q_{t+1} \Psi'^{t+1}_I + q_{t+1} \eta_{t+1} \end{aligned}\right\} \tag{A.10a}$$

Substitute (A.10a) in (A.11)

$$\Pi_K - \Gamma'_K - q_t \Psi'_K - \left[q_t + q_t \Psi'_I + \eta_t q_t\right] + \beta(1-\delta)\left[q_{t+1} + q_{t+1}\Psi'^{t+1}_I + \eta_{t+1} q_{t+1}\right] = 0$$

$$\Pi_K - \Gamma'_K - q_t \Psi'_K - \left[q_t - \beta(1-\delta)q_{t+1}\right] - \left[q_t \Psi'_I - \beta(1-\delta)q_{t+1}\Psi'^{t+1}_I\right] - \left[q_t \eta_t - \beta(1-\delta)q_{t+1}\eta_{t+1}\right] = 0$$

$$\Pi_K - \Gamma'_K - q_t\Psi'_K - q_t(1-\Phi_{t+1}) - q_t(\Psi'_I - \Phi_{t+1}\Psi'^{t+1}_I) - q_t(\eta_t - \Phi_{t+1}\eta_{t+1}) = 0 \quad \text{(A.11a)}$$

where

$$\Phi_{t+1} = \frac{\beta(1-\delta)q_{t+1}}{q_t}$$

<u>The derivation of the term $(\eta_t - \Phi_{t+1}\eta_{t+1})$ in (A.11a)</u>

First, replace (A.12a) in $(\eta_t - \Phi_{t+1}\eta_{t+1})$

$$\left(\frac{1}{\beta}\right)(1-\Gamma'^{t-1}_B) - (1+i_{t-1}) - \Phi_{t+1}\left[\left(\frac{1}{\beta}\right)(1-\Gamma'_B) - (1+i_t)\right]$$

Let $\gamma = 1/\beta$, then

$$\gamma - \gamma\Gamma'^{t-1}_B - 1 - i_{t-1} - \Phi_{t+1}\gamma + \Phi_{t+1}\gamma\Gamma'_B + \Phi_{t+1} + \Phi_{t+1}i_t$$

$$-\left[(1-\gamma)(1-\Phi_{t+1}) + \gamma(\Gamma'^{t-1}_B - \Phi_{t+1}\Gamma'_B) + (i_{t-1} - \Phi_{t+1}i_t)\right] \quad \text{(A.13)}$$

Dividing (A.11a) by q_t and substituting (A.13) in the resulting equation yield the following

$$\left(\frac{1}{q_t}\right)\Pi'_K - \left(\frac{1}{q_t}\right)\Gamma'_K - \Psi'_K - (1-\Phi_{t+1}) - (\Psi'_I - \Phi_{t+1}\Psi'^{t+1}_I)$$
$$+\left[(1-\gamma)(1-\Phi_{t+1}) + \gamma(\Gamma'^{t-1}_B - \Phi_{t+1}\Gamma'_B) + (i_{t-1} - \Phi_{t+1}i_t)\right]$$

Use the functional specifications defined in the text

$$\theta\left(\frac{pQ}{qK}\right)_t + \frac{a}{2}\left(\frac{B}{qK}\right)_t^2 - \left[-\frac{b}{2}\left(\frac{I}{K}\right)_t^2 + \frac{bc^2}{2}\right] - (1-\Phi_{t+1}) - \left[b\left(\frac{I}{K}\right)_t - bc - b\Phi_{t+1}\left(\frac{I}{K}\right)_{t+1} + bc\Phi_{t+1}\right]$$

$$+(1-\gamma)(1-\Phi_{t+1}) + \gamma\left[a\left(\frac{B}{qK}\right)_{t-1} - a\Phi_{t+1}\left(\frac{B}{qK}\right)_t\right] + (i_{t-1} - \Phi_{t+1}i_t) = 0$$

Let

$$\left(\frac{pQ}{qK}\right)_t = \overline{QK}_t, \qquad \left(\frac{B}{qK}\right)_t = \overline{BK}_t, \qquad \left(\frac{I}{K}\right)_t = \overline{IK}_t$$

Hence

$$\theta\overline{QK}_t+\left(\frac{a}{2}\right)\overline{BK}_t^2+\left(\frac{b}{2}\right)\overline{IK}_t^2-b\overline{IK}_t+b\Phi_{t+1}\overline{IK}_{t+1}-\left(\frac{bc^2}{2}\right)+bc-\gamma\left(1-\Phi_{t+1}\right)$$

$$-bc\Phi_{t+1}+a\gamma\left(\overline{BK}_{t-1}-\Phi_{t+1}\overline{BK}_t\right)+\left(i_{t-1}-\Phi_{t+1}i_t\right)=0$$

Having divided by b

$$\left(\frac{\theta}{b}\right)\overline{QK}_t+\left(\frac{a}{2b}\right)\overline{BK}_t^2+\left(\frac{1}{2}\right)\overline{IK}_t^2-\overline{IK}_t+\Phi_{t+1}\overline{IK}_{t+1}-\left(\frac{c^2}{2}\right)+c-\left(\frac{\gamma}{b}\right)\left(1-\Phi_{t+1}\right)$$

$$-c\Phi_{t+1}+\left(\frac{a}{b}\right)\gamma\left(\overline{BK}_{t-1}-\Phi_{t+1}\overline{BK}_t\right)+\left(\frac{1}{b}\right)\left(i_{t-1}-\Phi_{t+1}i_t\right)=0$$

After arranging the last equation, the following estimateable Euler equation under a binding borrowing constraint can be obtained

$$\left(\overline{IK}_t-0.5\overline{IK}_t^2\right)=\left(\frac{c^2}{2}\right)+\Phi_{t+1}\overline{IK}_{t+1}+\left(\frac{\theta}{b}\right)\overline{QK}_t+\left(\frac{a}{2b}\right)\overline{BK}_t^2+\left(c-\frac{\gamma}{b}\right)\left(1-\Phi_{t+1}\right)$$

$$+\left(\frac{a}{b}\right)\gamma\left(\overline{BK}_{t-1}-\Phi_{t+1}\overline{BK}_t\right)+\left(\frac{1}{b}\right)\left(i_{t-1}-\Phi_{t+1}i_t\right) \qquad \text{(A.14)}$$

Chapter 9

Concluding Remarks

This thesis has examined the investment behaviour of firms both at the theoretical and empirical levels. In doing so, financial factors have received particular attention because they have also been a main concern of recent empirical investment literature for developed countries. The theoretical chapters have analysed optimal investment policies and conditions for the interdependence of investment and financial decisions. In this regard, these theoretical chapters have developed various models subject to different assumptions about the financial capital market. The literature for developing countries has also examined the role of financial factors in the determination of private investment in developing countries but without developing a sound microeconomic foundation. The primary aim of this thesis has been to suggest an empirical model(s) with a sound microeconomic foundation for a developing country (namely Turkey) subject to the problem of 'data availability'.

In chapter 2, I examined the neoclassical theory of investment. It was found that this theory reveals two main determinants of investment, namely the cost of capital and the accelerator variable. I also found that the responsiveness of investment demand to the cost and accelerator variables is closely related to the technology assumption about the production function. Chapter 2 noted that investment is more responsive to net changes in output than changes in the relative cost of capital under the putty-clay technology assumption. In Chapter 2, Jorgenson's presentation of the neoclassical model was also reviewed with two important assumptions, namely a perfect capital market and the absence of adjustment cost of capital. The main finding of the chapter in this regard was that Jorgenson's model is, in fact, a theory of the optimal demand for capital, and the derivation of an investment demand equation is inconsistent with the assumptions of the derivation of the optimal capital demand (a particular one is the costless and instantaneous adjustment assumption in the derivation of the desired capital stock, and the violation of this assumption in the derivation of the investment demand function). I also noted that the derivation of a stable and continuous relationship between investment demand and its determinants is possible only if one introduces either the adjustment cost of capital stock, or an upper (or lower) bound on investment (or disinvestment). Particularly, the presence of adjustment costs corresponds to a more general case than imposing constraints on investment that the firm can undertake for each period of time. I showed that if the production function possesses constant returns to scale and future prices are expected to be unchanged, then the convex adjustment cost of capital imposes a constant upper bound on the amount of investment for each time interval during the adjustment process of the capital stock.

Chapter 3 analysed the interdependence of investment and financial decisions. For this purpose, the chapter enlarged the model developed in the previous chapter by incorporating capital market imperfections. I noted that the perfect capital market assumption of Jorgenson's model leads to the Modigliani and Miller theorem in which the financial structure of the firm plays no role in investment decisions. I examined the effects of two forms of capital market imperfections on investment decisions. First, two forms of quantitative constraints on debt financing were examined, namely an upper profit and retained earning constraints. Second, a rising cost of capital schedule for borrowing was assumed. The rate of capital adjustment becomes very sensitive to the forms of capital market imperfections. It was found that profits and retained earnings of firms become important determinants of investment expenditures in a liquidity-constrained model. I also noted in this chapter that the rate of adjustment of the capital stock to its equilibrium level significantly depends on the assumptions in the production function and risk premium function of borrowing cost. By this, I concluded that the speed of adjustment is endogenous variable to the firm, and variable rather than a given to the firm.

The significance of both the neoclassical and financial theories for investment in developing countries was examined in Chapter 4. In addition to conventional determinants of private investment (namely the accelerator, the cost of capital, and financial factors), some other factors significant in the case of developing countries (such as the implication of fiscal and monetary policies, credibility of economic policies) have been discussed, along with the empirical modelling issue of private investment in general. This chapter revealed that there is no acceptable general framework for analysing the determinants of private investment in developing countries. Most studies have studied this issue with an *eclectic* model in the sense that there is no exclusive formal microeconomic framework on which the investment demand function is derived. Chapter 4 also revealed that the literature lacks a suitable theoretical approach to modelling private investment with a microeconomic optimisation framework.

Chapter 5 analysed recent Turkish economic history and its interaction with the pattern of investment both at the aggregate and sectoral levels. This chapter also drew attention to a substantial shift in the composition of sectoral investment from manufacturing toward the services sector. It was noted that the previous studies on private investment in Turkey have been eclectic, and used relatively small sample sizes.

In Chapter 6 - 8 an empirical analysis of the determinants of the investment demand behaviour of Turkish firms at the aggregate and sectoral levels was carried out. The analysis covered the period 1963-1993 and was based on annual data. The data was disaggregated into five sectors (i.e. manufacturing, agriculture, services, mining, and energy). The concern of these chapters was to investigate the roles of the neoclassical and financial determinants of investment in Turkey. In doing so, the novel feature of these chapters was a theoretical approach to modelling investment, in the sense that each model is derived explicitly from an optimisation framework.

Chapter 6 developed the first empirical model to investigate the role of neoclassical and financial determinants of investment. Two essential features of the model are worth noting. First, the model was derived from the cost minimisation problem of a representative firm subject to a given demand level in the output market. Second, two models were obtained subject to two alternative technology assumption about the production function. The first model is derived under the putty-putty assumption in which the rate of substitution between capital and labour is variable ex ante and ex post. The second one is the model derived under the putty-clay assumption by which the rate of substitution between capital and labour is assumed variable ex ante, but constant ex post. The inclusion of financial factors in the model was less sound theoretically, and was carried out by simply adding the variable on the volume of credit to the private sector on the right-hand side of the equations. The putty-clay model fits the data slightly better, and the inclusion of the credit term representing financial constraints in the imperfect capital market improved the explanatory power of the model. At the aggregate level, all three variables - the accelerator, the relative cost of capital, and the credit variable, were quite significant. According to long-run multipliers, the credit availability to the Turkish private corporate sector and the cost of capital have the strongest effects on private investment. In three major sectors in the Turkish economy, namely manufacturing, agriculture, and services sectors, the credit term and the cost of capital are the most influential factors in the determination of private investment decisions. The empirical results of this chapter suggest that fiscal and monetary policies influence investment behaviour both via the relative cost of capital and via the credit availability to the private sector. In particular, the results suggests that a high interest rate policy may have discouraging effects on investment decisions through its direct effect on the user cost of capital. But this negative effect may be compensated, to some extent, by an increase in credit availability as a result of this high interest rate policy.

The model developed in Chapter 7 examined the significance of the accelerator, the cost of capital, and the credit variables, using an alternative econometric methodology. The main motivation of the model was to avoid some statistical problems arising from the non-stationary nature of time series. The different structures of two models do not allow us to carry out any statistical test between these two models, and the result obtained from the model in Chapter 7 should be taken as supplementary to those in Chapter 6. This chapter also suggested a theoretical framework for an error-correction representation of investment demand. The recognition of the adjustment costs of capital was a essential part of this model. The empirical findings from both aggregate and sectoral estimations showed great similarities to those in the previous chapter. One important finding in this chapter was the influence of the credit variable on the short-run fluctuations in private investment.

Thus far, no study on Turkish private investment has emphasised the impact of financial imperfections on private investment using a sound microeconomic basis. Unlike the previous two chapters, the model in Chapter 8 takes into consideration imperfect capital markets with a sound theoretical model for the first time, but in the line of the theoretical discussions in Chapter 3. Accordingly, the model formulated imperfections both in the form of a rising risk premium function and in the form of quantitative constraints on borrowing. The data from Turkey fit the model quite well, but also raised the question of the appropriateness of the choices of the quadratic risk premium and adjustment cost functions at the macroeconomic level. Two suggestive results from the model must be worth noting. The first one is that the data suggest the presence of significant interactions between financial and real decisions in Turkey. Second, the data supported the hypothesis that Turkish firms face increasing agency costs as well as borrowing constraints. In the sectoral estimations, the same conclusions were accepted for manufacturing, mining, services, whereas agriculture appeared to be more sensitive to the user cost of capital and the accelerator type of variables than financial variables.

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