FINANCIAL FACTORS IN THE INVESTMENT DECISIONS OF FIRMS

THEORY AND EVIDENCE

by

IOANNIS GANOULIS

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Department of Economics

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This thesis is dedicated to the memory of my good friend Giorgos.

Summary

This thesis examines the effects of informational imperfections in the financial system on the investment decisions of firms. Its main theme is that such imperfections are relevant for the dynamic aspects of investment decision making, for they affect the cost of flow of new financing. Since their source is ultimately the decentralized nature of the system, where some of the creditors of the firm have not access to the firm's internal operations, the costs involved are likely to arise in every type of financial market and in the use of every kind of financial instrument. The only source of funds not affected by the informational problems is the flow of internal financing, but this is either constrained or involves rising costs for the insiders. Therefore, there are costs of adjustment in capital accumulation that are related to the financial arrangements of the system.

A dynamic optimization model is built to examine the combined financial and investment decisions of a firm operating in an asymmetric information environment. The resulting policies are compared with those of a firm facing conventional adjustment costs and a strongly efficient financial system. The importance of internal financing is confirmed. The role and problems of the equity market as a source of finance is also illuminated. Equity finance is found to differ from debt in so far as equity claims give the right of access to the internal operations of the firm. A model with both types of adjustment costs is also examined. When conventional adjustment costs are dismantling costs (when investment is negative), asymmetries arise between under- and over-leveraged firms with possible implications for policy. Also, Tobin's Q investment approach is reexamined in a model with both type of costs. The Q variable is found to contain interesting information even when capital markets are not strongly efficient.

An empirical model is built after examining the behaviour of firms in output markets when facing a stochastic demand. The model is tested with panel industry level data from Greece for the manufacturing sector in 1973-1983. An error correction specification is used. The results confirm the importance of the impact effect of net profitability. Demand and the associated capacity utilization are also found to have a significant effect in the short and in the long run. The evidence is less clear for the user cost of capital and the gross profit margin.

'But where a system of borrowing and lending exists, by which I mean the granting of loans with a margin of real or personal security, a second type of risk is relevant which we may call the lender's risk. This may be due either to moral hazard, i.e. voluntary default or other means of escape, possibly lawful, from the fulfilment of the obligation, or to the possible insufficiency of the margin of security, i.e. involuntary default due to the disappointment of expectation.'

'The second [type of risk], however, is a pure addition to the cost of investment which would not exist if the borrower and lender were the same person.'

(Keynes 1936, p. 144)

'As an undergraduate, I remember being told with great weightiness that one of Keynes's insights was that savings and investments were undertaken by different people with very different motivations and that somehow this was a very difficult coordination problem. It was never really explained, however, why this coordination problem was any different from the coordination problem of getting buyers and sellers of bread to agree on the quantity.'

(Weiss 1988, p. 594)

Chapter 1

INTRODUCTION

In one of the most general and yet most concise expositions of what modern investment theory is all about, Bliss (1975, p.305) describes the production/investment plan of a firm (or an economy) as a choice of a sequence of input vectors $\mathbf{a}_t$ (and corresponding output vectors $\mathbf{b}_{t+1}$) based on a set of feasible triples $\{\mathbf{a}_{t-1}, \mathbf{a}_t, \mathbf{b}_{t+1}\}$, rather than the simple production constraints expressed by the couples $\{\mathbf{a}_t, \mathbf{b}_{t+1}\}$. Investment theory (and in particular the adjustment costs theory), he claims, perceives investment decisions to be different from the standard production decisions because, if $\mathbf{a}_{t-1}$ and $\mathbf{a}_t$ are different, the possibilities for $\mathbf{b}_{t+1}$ are restricted due to the costs and constraints in passing from one input-output combination to another. Now, such changes entail necessary adjustments in a number of markets, not to mention the internal organization of the firm, and adjustments in any of these markets may be problematic due to institutional inertia, perverse expectations, lack of coordination (by an invisible hand). So, why focus on the financial aspects?

Our interest in issues of investment and finance dates back to the work done for an M.Phil. thesis on the history of economic thought on investment.[1] Comparing the different "traditions" of thought on capital accumulation, we were struck by the simple fact that "capital" in the writings of Smith, Ricardo, Marx and in fact of most authors up to the third quarter of the 19th century signified a *Fund employed in production.*[2] Semantic differences often conceal differences in perception and this would seem to be a point in case. In what we can loosely call "classical tradition"

[1] See Ganoulis (1985).

[2] See Hicks (1974). Note that the emphasis is not only on the concept of capital as a Fund, but as a Fund that has found its way into financing the production process.

command of capital identifies the main decision maker in a market system, the capitalist. And, though command is not necessarily identified with ownership, the latter "...becomes simply the basis for a superstructure of credit".[3] Certainly the most important source of capital is the capitalist's own income (profits including what we would call nowadays the interest on capital). Thus, the distribution of income between the capitalists and the rest of the society conditions production, rather than being a by-product of the functioning of the system.

Compare this with the Walrasian world: "Clearly from a theoretical point of view it is immaterial to the capitalist and to the entrepreneur whether what the one lends and the other borrows is the capital good itself, new or old, or the price of this capital good in the form of money." (Walras 1954, p.270). Together with the capital, the capitalist is relegated to the owner or "provider" of *one* of the production inputs. The entrepreneur coordinates production. Finance is traded in "loanable funds" markets, which in principle differ little from any other market. The functioning of the market system in the Walrasian world is too well known for us to repeat here. Distribution and for that matter production and investment ultimately reflect the fundamental outside limits of the economy, i.e. preferences, 'nature', technology.

In the context of these differences in vision, focusing on the "loanable funds" market does not seem misplaced. This is not purely in the interests of a historical debate. At the heart of the problem of any decision making lies the question of control, in particular when there is the prospect of conflict. To quote Galbraith (1967, p.47), "On coming on any form of organized activity - a church, platoon, government bureau, congressional committee, a house of casual pleasure - our first instinct is to inquire who is in charge. Then we inquire as to the qualifications or the credentials which accord such command." Presumably with the economist's instincts the third question would be what is his objective (what does he maximize) and what are his constraints.

For a decentralized economy these are difficult questions on which the Walrasian paradigm has little help to offer. The credentials of the Walrasian entrepreneur are unidentified and at best we can say that decisions are taken by the credit market "as a whole". Galbraith's own work and

[3] Marx (1981), p. 570.

some of the asymmetric information literature cited in this thesis seem to suggest that it is some type of superior knowledge (know-how) or information that puts an individual or an organization in the position of the decision maker. Even so, the question usually asked is how he can communicate this information to the capital market to secure finance. We would further be inclined to say that it is the command of capital (finance) that often permits access to inside information as well as to any other scarce resource. In other words, we believe that the financial system is so important in a developed capitalist economy because the financial market is where it is "traded" or decided who the decision maker is, if it is not the owner of capital, and what the limits to his authority are.

This specializes some of Galbraith's questions in the context of the financial system and adds some new ones. Questions such as who has access to capital through the capital market and to what extent he can pursue his own interests, have only relatively recently become important part of the mainstream research agenda, despite a long running interest in credit markets.[4] Macroeconomic issues of distribution and cycles, central within a Marxist/Kaleckian tradition, are also becoming part of this agenda. Related are questions as to how financial arrangements may affect adjustment in production, questions that go back to the investment problem mentioned in the beginning of this introduction. This has been the concern of at least a strand of the Post-Keynesian tradition.

This thesis is concerned with a very modest part of this agenda, that of integrating what we see as relevant aspects of the financial arrangements of a decentralized system with the now well established micro-investment literature. We remain deliberately close to the methodology of this literature, for it is the assumptions on finance that we wish to focus on, and we compare our results at each stage with those derived by an alternative approach based on strongly efficient financial markets. Our main theme is that even if we were to accept the conclusions of a Walrasian static production theory, the financial arrangements can still prove relevant for the dynamics of capital accumulation, the essence of investment theory as was mentioned at the start.

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[4] Though earlier controversies concerning for instance the limits of authority of management may be cited as directly relevant to these questions.

In chapter 2 we start by reviewing the micro-optimization literature on investment, putting emphasis on the issues of dynamics and finance. In chapter 3 we construct a model with costs of adjustment of a financial nature and compare it with the more traditional adjustment costs model. In chapter 4 we extend the model and include share trading, previously ignored. We examine the effects of an equity market on the dynamics of investment and re-consider the established interpretation of Tobin's Q. In chapter 5 we digress from our main theme in order to examine in more detail the marginal profitability of capital, a necessary prerequisite in any empirical investment model. In chapter 6 we present empirical evidence from Greece using a set of panel data. Chapter 7 concludes.

Chapter 2

A REVIEW OF THE MICRO-INVESTMENT LITERATURE

Starting from the mid-sixties attention has shifted in the investment literature to optimization micro-models. A number of issues have been raised within this literature, most notably those concerning the dynamics of investment, the factors affecting the incremental return to capital and those affecting the financing of investment. In this chapter we review this literature.

Section 2.1 overviews the post-war micro-investment literature and identifies some of the central themes and open questions remaining in this field. In sections 2.2 and 2.3 we critically examine the two main current approaches to investment, the adjustment costs and the Q investment models. In both cases it is suggested that a more careful analysis of the financial side of the firm's operations may prove rewarding. In section 2.4 we turn in more detail to the financial market and to the issues related to the cost and ability of the firm to raise the necessary finance. This provides the background for the main assumptions of the models developed in the two following chapters. Section 2.5 summarizes and concludes. Some specific issues related to the marginal return of capital and the empirical implementation of the theoretical models are surveyed in more detail in chapters 5 and 6.

2.1 An overview of the postwar investment literature

In the voluminous postwar literature on investment the main issues of debate have remained surprisingly unchanged. These included questions concerning the relative importance of the demand for output, the relative prices, the cost of finance and the availability of internal funds. Other topics that have recently received increased attention have been the role of the equity market and uncertainty and the issue of time lags between the various impulses and their effect. The main focus and established views on these issues have shifted from time to time, following, one suspects, the main currents in macro- and microeconomic theory. The purpose of this overview is to trace the main theoretical and empirical debates through time and establish the central themes that will be examined in more detail subsequently.

In the fifties and early sixties, under the strong dominance of the early Keynesianism, demand variables featured prominently in the empirical investment literature. The flexible accelerator model provided the main theoretical framework of the period. Net investment in the flexible accelerator model depends on the deviation of actual output, $Q(t)$, from the "normal" level of output or the existing capacity[1] of the firm, which is taken to be a linear function of fixed capital in place, i.e. $K(t-1)/\kappa$, where κ is a constant. If k is the reaction or adjustment coefficient and δ the rate of depreciation, gross investment can be written as follows:

$$I(t) = k\,[\,\kappa Q(t) - K(t-1)\,] + \delta K(t-1). \tag{2.1}$$

This makes investment depend on the *level* rather than the *change* in output, contrary to earlier accelerator models. Equally important, the theory at this level predicts that prices and in particular interest rates have no impact on investment. Both predictions were on the whole supported by empirical studies at the time.[2]

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[1] "This "normal" output represents the capacity of the industry (under stationary conditions) in the sense of the most profitable output, but not in the sense of maximum output with given plant" (Chenery 1952, p. 13, fn. 22).

[2] See for instance Chenery (1952), Kisselgorf and Modigliani (1957), Meyer and Kuh (1966). Surveys of the earlier literature are provided by Eisner and Strotz (1963), Jorgenson (1971) and Hay and Morris (1979), ch. 11, among others.

Interest rates and other prices were in fact of minor concern to these early models of investment. Apart from output, the set of variables that appeared most prominently were variables on profitability and internal finance. This was in line with the theoretical contributions of Kalecki (1937) and Duesenberry (1958) that claimed that funds from external sources were not perfect substitutes to internal financing. In one of the most extended early empirical investment studies Meyer and Kuh (1966) suggested that cash flow variables played an important role in the investment process, especially in periods of recession. Output gained in significance during the economic booms. This constituted the basis of the so called accelerator - residual funds approach to investment where both type of variables were considered important. Others, like Grunfeld (1960), found no firm evidence in support of profitability and internal finance. More commonly, critics rejected such statistical evidence as existed on the grounds that it could "generally be shown to result from common trend factors or multicollinearity with unspecified variables".[3] As we discuss in more detail below, the problem here has always been that cash flow and profitability variables are likely to be closely related to output, so that the separate impact of the two may be difficult to distinguish.

In the mid-sixties under the influence of the Keynesian-neoclassical synthesis and the search for solid micro-foundations, attention has shifted to the development of formal micro-optimization models as the basis of deriving the optimal or desired capital stock of the firm, K^*. These models have allowed for the formal introduction of prices and, in particular, of interest rates in investment equations. Jorgenson, who is credited with some of the first attempts in this direction, cast his model in a dynamic optimization framework,[4] but the same point can be made considering the following static maximization problem:

$$\max_{K,L} \ [\, p\, F(K,L) - wL - cK \,]. \tag{2.2}$$

p, w and c are the price of output, the wage rate and the rental (user) cost of capital[5] respectively.

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[3] Eisner and Strotz (1963), p. 191.

[4] See Jorgenson (1967).

[5] $c = q(u+\delta) - \dot{q}$, where q is the price of fixed capital and u the discount rate. Taxes are excluded for simplicity. The time argument is suppressed for notational simplicity.

L is the labour employed and $F(\,)$ is a production function with the usual concavity properties. Note that other inputs such as raw materials and energy do not appear in this specification and have in general been ignored in most investment models. We return to this issue in chapter 5.

The marginal optimality condition for capital is as follows:

$$p \frac{\partial F}{\partial K} = c. \tag{2.3}$$

With a Cobb-Douglas production function it can be written as follows:

$$K^*(t) = \alpha \frac{p(t)\,Q^*(t)}{c(t)}. \tag{2.4}$$

K^* and Q^* are the optimal capital and output respectively and α is the elasticity of output with respect to capital.

To compare this with the flexible accelerator model, consider a similar partial adjustment mechanism as in (2.1). Gross investment is then given by the following equation:

$$I(t) = k\ [\alpha \frac{p(t)}{c(t)} Q^*(t) - K(t-1)\,] + \delta K(t-1). \tag{2.5}$$

The major difference between (2.1) and (2.5) lies with the price ratio $p(t)/c(t)$ that appears in the latter. Its absence from (2.1) has usually been attributed to the implicit assumption of the accelerator models that there is no substitutability between capital and labour, though substitutability between capital and other inputs could also be an issue. The importance of this term becomes apparent if we think that interest rates, entering in c, are perceived as an important part of the "transmission mechanism" between the monetary and real sector and a potential policy instrument. Additionally, tax and other investment incentives can be shown to affect c as well. Not surprisingly, the impact of relative prices on investment decisions became one of the major issues for the empirical work at the time.

The empirical studies of Jorgenson and his collaborators suggested that prices played a significant role, contrary to the majority of earlier studies. Their neoclassical model, based on (2.4), performed better than the simple accelerator or residual funds models.[6] Their work became

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[6] See Jorgenson (1967), Jorgenson and Siebert (1968), Hall and Jorgenson (1967) and Jorgenson (1971).

the focus and the starting point for much of the investment literature of the following decade and has influenced developments ever since.

Their work was firstly criticized on empirical grounds. The tight specification of the model was thought to impose, rather than estimate, some of the central results. The most important part of this criticism was directed towards the use of a Cobb-Douglas production function. Under this assumption both the output and price elasticity of the optimal capital are restricted to unity. Thus, the composite term on the right hand side of (2.4) imposes the restriction that output and prices have the same effect on investment. If instead, say, a CES production function is used, (2.4) takes the following form:

$$K^{*}(t) \ = \ \theta \left[\frac{p(t)}{c(t)} \right]^{\sigma} \ [Q^{*}(t)]^{\frac{\sigma(v-1)+1}{v}}, \tag{2.6}$$

where θ is a constant, σ is the elasticity of substitution and v are the returns to scale. This allows prices and output to have a different impact on the optimal capital. The accelerator model, when there is no capital-labour substitutability (σ=0) and the Cobb-Douglas case when σ=1 are special cases of this model. Subsequent work allowed for such differences between the elasticity of capital with respect to prices and output and even between the elasticity of the various components of the rental cost of capital.[7] The estimated value of the rental cost of capital elasticity was significantly lower than unity. Bishoff (1971) suggested alterations in the lag structure of prices and output on the grounds that if technology is of the putty-clay type, output changes will have a faster effect than price changes. The controversy concerning the impact and time lag of the user cost of capital has continued to date, with almost every major investment study testing for its significance.[8] However, results have remained inconclusive and open to further research.

More importantly, the development of formal micro-optimization models made explicit the underlying assumptions and allowed a closer comparison between the theoretical foundations of the model and its empirical implementation. Thus, Jorgenson's work was criticized on the

[7] See Eisner and Nadiri (1968) and Feldstein and Flemming (1971). Savage (1978) reviews the early evidence on the interest rate elasticity of capital.

[8] See for instance Clark (1979), Bean (1981), Artus et al (1981), Pindyck and Rotemberg (1983a, 1983b), Catinat et al (1988). Wren (1987) and Chirinko (1987a) survey this literature.

grounds that the use of output as an independent variable in the empirical model was inconsistent with the underlying assumption that output markets are perfect.[9] Closer examination of (2.4) reveals that the optimal capital of the firm is related to the *optimal* or *desired* output, $Q^*(t)$, not the current (or past) output, $Q(t)$. The latter is determined by the firm *given its existing capacity*, while the former is the optimal output to be produced once the planned capacity expansion has taken place and it is simply a function of future prices, when markets are perfect.[10] Thus, current output is unlikely even to proxy effectively current desired output, though it may still be claimed that it reflects the firm's planned output of some time in the past (when the orders for the existing capital were put in). Even in this latter case, however, it is not clear what its role in the investment equation is, since it is presumably an endogenous variable, determined in principle by current prices. Since output has consistently proven the single most important explanatory variable for investment, there have seldom been any empirical studies to use exclusively prices as independent variables.[11] A number of studies have assumed output markets to be imperfect or demand constrained in order to justify the presence of some type of output variable in the empirical equations. Others have noted the problem but continued to use a variant of Jorgenson's approach, sometimes with instrumental variables to control for simultaneity.[12] The issue of demand constraints has attracted more attention in the late seventies and the eighties with the emergence of the fixed price / rationing models. We review some of this literature in more detail in chapter 5.

Another issue that has surfaced with the development of micro-optimization models was the essentially static character of the underlying theories as opposed to the dynamic model needed to explain investment. The maximization model (2.2), as well as the accelerator principle, determine in theory only the optimal capital, K^*. Thus, at best they can only explain half of the investment story. For if there were no other costs or constraints involved, then the firm and the economy as a

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[9] See Gould (1969) and Muet (1979).

[10] If (2.3) is combined with the optimality condition for labour, ($\partial F / \partial L = w/p$), Q^* can be solved out as a function of prices.

[11] Schramm (1970) and Muet (1979) have tested such models, the latter with poor results.

[12] In the first category see Brechling (1975), Abel (1978), Muet (1979). An example of the second is given by Bean (1981).

whole could be expected to adjust instantaneously to its new optimal capacity after any parametric change, which is patently unrealistic.[13] Supply constraints, lags in building and delivering fixed capital (as well as dismantling it) and other technological constraints can be mentioned here as possible reasons as to why such instantaneous adjustments do not take place. The partial adjustment mechanism of (2.1) and (2.5) is supposed to be capturing some of these effects. The problem with this approach is that the partial adjustment mechanism is only introduced at a second stage, outside the optimization procedure that is supposed to be the theoretical basis of the model. For a literature that was keen to establish the micro-foundations of investment theory, this two step procedure was considered not only ad hoc, but also inconsistent. Delivery lags were assumed away in the theory and were introduced again in the empirics. The more elaborate theoretical models that followed attempted to derive the dynamic adjustment path as an integral part of the micro-optimization problem.[14] By the mid-seventies the costs of adjustment model had been established as the reference point for this literature, more for its simplicity and generality, as we argue below, than for its strong foundations. The "costs of adjustment" have been used as a catch-all term to describe a variety of convex costs related to the *flow* of investment (or disinvestment) that make it optimal for the firm to adjust gradually, rather than instantaneously, to its long run optimum. A partial adjustment mechanism of the form presented in (2.1) and (2.5) was found to be one of the possible descriptions of the optimal investment path around the stationary equilibrium when such costs exist. Alternative empirical specifications have also been initiated by the costs of adjustment model.[15] This model is the starting point for our analysis. Its foundations and other issues of dynamics are examined in more detail in the next section.

Parallel to the literature that had as a starting point the micro-optimization model, there has been a number of mainly empirical studies examining the role of various factors on investment

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13 For instance Nickell (1978, pp. 14-16), gives an example of how a firm would react to an expected increase in capital goods prices, if it could adjust instantaneously and costlessly. Capital follows a rather unrealistic path with a discontinuous jump upwards, just before prices start rising, and another downwards, just after they stabilize, as the firm buys and sells capital with the only purpose of making capital gains.

14 See Lucas (1967), Gould (1968), Brechling (1975), Nickell (1978). The last reference provides a detailed survey of this literature for the sixties and seventies. Chirinko (1987a) reviews the more recent literature.

15 See Abel (1978), Pindyck and Rotemberg (1983a, 1983b), Shapiro (1986).

other than output and relative prices, most prominent among them variables related to financial factors. These can be divided in two somewhat distinct categories. The first continued the tradition of the accelerator - residual funds model, introducing cash flow or debt capacity variables alongside output and relative prices to test for the existence of financial constraints. The second has examined the possibility of using stock market price information in investment models (Q models). The two types of financial variables have appeared jointly in recent investment models.[16] The main argument, put by Coen (1971), has been that the availability of funds could affect the rate of adjustment to the long run equilibrium if the financial system was not perfect. The underlying argument has usually been some type of "financial hierarchy" in which the costs associated with the *flow* of internal finance are lower than those arising by the *flow* of new debt or equity finance. It is difficult to pass an overall judgment on the empirical success of this literature, especially since a variety of variables has been used to proxy the availability of funds. One of the most important problems seems to have been that there is no unified nor rigorous theoretical argument for this approach that can be related to the rest of the micro-investment theory.[17] We discuss some of the issues arising from financial hierarchies in sections 2.3 and 2.4 of this chapter.

The second branch of this literature linking investment with financial factors was initiated by Brainard and Tobin, based on an idea attributed to Keynes (1936).[18] This was that the market value of the firm over the replacement value of its capital (the Q ratio) ought in principle to give all the necessary information for the desirability of an expansion or contraction of the firm's capacity. Thus, contrary to the previous approach, Q is suggested as the sole explanatory variable of net investment to the exclusion of all other factors. Empirical evidence does not seem to

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16 A number of studies have introduced some type of liquidity variables in their empirical equations. In the following studies cash flow variables have been at the center of their analysis: Coen (1971), Gardner and Sheldon (1975), Anderson (1981), Bergstrom (1986), Fazzari and Athey (1987), Fazzari et al (1988).

17 In a relatively recent survey of investment literature Chirinko notes: "Models based on liquidity variables receive less attention in this study than in previous surveys (e.g., Jorgenson, 1971) because, relative to most of the models considered here, the theoretical basis is less developed." (Chirinko (1987a, p. 136, fn. 64)). Steigum (1983) offers an interesting start in this respect that has largely been ignored. Our analysis in the next chapter starts with a model similar to that of Steigum (1983).

18 See for instance Brainard and Tobin (1977). The market value of the firm had been used in earlier studies *alongside* other variables, proxying expected profits and sales, or the availability of external finance. See for instance Grunfeld (1960), Resek (1966) and Jorgenson and Siebert (1968).

support this hypothesis. Q was generally found to be related to investment, but other factors as well as past values of Q can improve the explanatory power of the model. Also, the implied lags were considered unrealistic.[19] These empirical weaknesses were largely attributed to the fact that in theory it is the *marginal* value of capital (the market value of the marginal unit of capacity over the cost of this unit) that matters for investment, not the *average* market value represented by the Q ratio. In the late seventies the Q model was integrated and reinterpreted within a cost of adjustment model.[20] This also clearly spelled out the conditions under which the observable Q ratio is equal to the marginal value of the firm's capital. In section 3 this formal link between the two theories is critically examined and an alternative interpretation of the Q model is mentioned.

The theoretical and empirical literature of the late sixties and seventies has established the micro-optimization model and in particular the costs of adjustment model as the dominant framework of analysis in investment. The literature of the late seventies and eighties has built on that, integrating, as was mentioned, the adjustment costs with the Q model, giving more emphasis on dynamics and, importantly enough, introducing explicitly uncertainty into the dynamic optimization problems.

This latter extension proved a non-trivial task. Within the deterministic framework the firm is perceived drawing a plan that entails one level of investment for each current and future date and sticking to this plan to infinity. If there is uncertainty, such an (open loop) policy, based say on the expected values of the various stochastic variables, is unlikely to prove optimal in the future. As time progresses and agents find out about the realized values of some of the previously stochastic variables, they may wish to re-optimize and decide on a new investment path (open loop - feedback policy). This, however, creates the following complication. It may be argued that a fully rational agent would have anticipated that the original open loop policy is time-inconsistent and would have wished instead to draw a fully contingent plan. This would have to specify investment each period as a function of the information set available at each future date. Finding such optimal closed loop investment rules has proved an impressive, if not intractable,

19 See von Furstenberg (1977), Clark (1979), Chirinko (1987b), Blundell et al (1987).

20 See Abel (1978) and Hayashi (1982).

problem. The theoretical literature has, thus, concentrated mainly on a specific class of models that possess the certainty equivalence property.[21] For this class of models the optimal dynamic policy can be found with the same methods used in deterministic control theory, substituting all stochastic variables with their expected value. In what follows we examine the dynamics of investment in what is essentially a deterministic framework. An alternative interpretation is that these models describe the feedback policy of agents who are assumed to maximize over expected values or have point expectations. We return briefly on the issue of dynamics and uncertainty in chapter 6.

Apart from the emphasis on dynamics and uncertainty, the main interest for the greater part of the eighties seems to have been in the closer examination of the implications of rationing and/or imperfections mainly in the output and capital markets. [22] Indeed, as has become clear by now, the micro-optimization model established in the seventies does not have to be cast in a world of perfect or clearing markets, as it was first introduced by Jorgenson and his collaborators. The rather dispersed literature that followed this line covered both the traditional neoclassical approach and the Q investment model. It further attempted to offer new answers to old problems such as the justification of using output and profitability variables in empirical equations, the possible foundations of a dynamic theory of investment, the necessary corrections to improve the performance of the Q model. In the following sections and in chapter 5 we refer in more detail to some of this literature and we subsequently try to advance the arguments concerning especially the possibility of imperfections in the financial system. Our starting point is, naturally enough, a costs of adjustment model, which we examine in some detail in the next section.

2.2 The adjustment costs model and dynamic aspects of investment

The original formal models of investment, as well as the textbook theory of the firm, have been exclusively concerned with the static equilibrium, the optimum capacity of the firm after all

[21] See for instance Abel (1983) and Sargent (1987), ch. XIV. Some of the ideas involved in stochastic control and the certainty equivalence property of the linear quadratic models are clearly explained in Salmon (1983). In 7.3 we consider briefly empirical models of investment derived from stochastic control problems.

[22] See for instance Malinvaud (1982, 1983), Lambert and Mulkey (1987), Precious (1985), Schiantarelli and Georgoutsos (1987), Steigum (1983), Lo (1985), Hayashi (1985), Chirinko (1987b), Kort (1988).

adjustments have been completed. The theoretical models that followed have attempted to incorporate the dynamic aspects of investment in the micro-optimization problem. The costs of adjustment model is considered to have done just that. In this section we consider first the analytics of this approach, then critically examine its foundations and the more general question of dynamics in investment theory.

Consider then the case of a firm that chooses the optimal path of capital at time $t=0$ in order to maximize its net present value,[23]

$$V(0) = \int_0^\infty e^{-ut} \; [\,\Pi(K) - qI - FC\,] \; dt. \tag{2.7}$$

$\Pi(K)$ represents the gross trading profit as an increasing concave function of fixed capital (other choice variables such as labour or output have been maximized out). The concavity is usually attributed to decreasing returns to scale and/or imperfections in the output market. Taxes are ignored with no loss of generality. qI is the gross investment expenditure (q is the price of unit of fixed capital), FC are fixed costs (unrelated to the level of output or capital) incurred each period and u the appropriate discount rate, which for the moment we take to be market determined. Although u in (2.7) is time invariant, the model can easily be extended to accommodate variations through time. [24] There is a number of ways one can introduce costs of adjustment in the above model with little practical difference between them. Following Hayashi (1982), we introduce them through the equation of motion of capital, which can be written as follows:

$$I = z(\dot{K}, K) + \delta K, \tag{2.8}$$

where, [25]

$$z_1 > 0,\; z_{11} > 0,\; z_2 \leq 0,\; z_{22} \geq 0,\; z_{12} < 0 \text{ if } \dot{K} > 0,\; z_{12} > 0 \text{ if } \dot{K} < 0.$$

$z()$ is the installation costs function. Diagram (2.1) in the end of the chapter shows that for a net investment of $\dot{K}$, the firm has to spend $z(\dot{K}, K)$. The 45^0 line depicts the case where one pound

[23] Time arguments have been omitted for notational simplicity whenever there is no possibility of confusion.

[24] See Nickell (1978), p. 6.

[25] Numerical subscripts on functions denote always partial derivatives with equivalent variables. Thus, for instance, z_{12} denotes the cross derivative of the $z(\dot{K}, K)$ function.

worth of capital costs to the firm in real terms one pound to buy and have it installed for use. The deviation of $z(\dot{K}, K)$ from the 45^0 line can be seen as a premium above the basic price, which rises as the firm accelerates its accumulation program. The rationale for such a premium is examined in more detail below. Equally, in the negative quadrangle the deviation of $z(\dot{K}, K)$ from the 45^0 line captures the extra costs of dismantling capital and selling it in the second hand market. Both installation and dismantling costs are assumed to be lower, as will be seen below, the larger the size of the capital held by the firm ($K'>K$ in the diagram). Around the origin $z(\dot{K}, K)$ approaches the 45^0 line, i.e. $z(0, K)=0$ and $z_1(0, K)=1$. Note that the above specification assumes that there are no adjustment costs for replacement investment. This can be relaxed with little effect on the following argument.

With the equation of motion (2.8) at hand, we can now maximize the present value $V(0)$ in (2.7). We assume that the non-negativity constraint for K does not bind and denote by μ the costate variable of capital.

The two following conditions must hold for an optimum:

$$\Pi_1(K) - q\delta - q\, z_2(\dot{K}, K) = -\dot{\mu} + \mu u, \tag{2.9}$$

$$q\, z_1(\dot{K}, K) = \mu. \tag{2.10}$$

All functions are evaluated at t.

The interpretation of (2.9) can be facilitated if we multiply it by e^{-ut} and time integrate it to find

$$\mu(t) = \int_t^{\infty} e^{-u(s-t)}\ [\Pi_1 - q\,(\delta + z_2)]\ ds. \tag{2.11}$$

In words, the shadow value of capital at t is equal to the discounted stream of marginal returns of capital from t to infinity. The latter include the gross marginal profit (Π_1), minus the depreciation charges per unit of capital ($q\delta$), plus the gains in terms of lower installation costs from an increase in the size of the firm ($-qz_2$). Condition (2.10) shows that along the optimal path the shadow value of capital will always be equal to the cost of buying and installing an extra unit of capital.

The costs of adjustment model gained its dominant position in modern investment micro-theory because of its simplicity and its ability to interpret a variety of earlier approaches to investment. Jorgenson's model, the partial adjustment mechanism of the flexible accelerator model and the Q theory of investment can all be seen to relate to the optimality conditions (2.9) and (2.10).

In particular, Jorgenson's original theory was specified with no costs of adjustment. As can easily be seen from the above model, when the installation cost function $z(\dot{K}, K)$ coincides with the 45^0 line, (2.9) and (2.10) reduce to a single optimal condition that holds at any moment in time:

$$\Pi_1(K(t)) = q(t)\ (u + \delta) - \dot{q}(t) = c(t). \tag{2.12}$$

In words, the marginal profitability of capital is equal to the user cost of capital. With the additional assumption of a perfect output market, (2.12) turns out to be identical to (2.3), derived from the static optimization model (2.2), when labour is at its optimal level $L^*(t)$. The model in this form has nothing to say about the dynamic process of capital accumulation or else about the link between the optimal investment and the optimal capital. This was originally imposed ex post.

Jorgenson's essentially static theory, however, can take also an alternative interpretation. Following the established literature, we can replace the transversality condition [26] of the above dynamic optimization problem with the requirement that the solution tends to a stationary equilibrium. At such an equilibrium $\dot{\mu}=\dot{K}=0$ and $z_1=1$, $z_2=0$, thus (2.9) and (2.10) reduce to

$$\Pi_1(K^*) = q\ (u + \delta). \tag{2.13}$$

Condition (2.13) is not dissimilar to (2.12), the major difference being that it holds only at the *stationary equilibrium* and not everywhere along an investment path. Jorgenson's model is, thus, re-interpreted as a long run optimal capital theory.

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[26] $\lim_{t \to \infty} K(t)\mu(t) = 0$.

The advantage of this interpretation is that the adjustment to the optimal capital is not imposed ex post with some ad hoc adjustment mechanism. Instead, the optimal path to the equilibrium emerges from (2.9) and (2.10). Substituting out μ and linearizing around the equilibrium, given the concavity of $\Pi(K)$, we find that there exists a single convergent path.[27] If we denote by $-k$ the negative eigenvalue of the system, then this path is described by the following equation:

$$K(t) = -[K^* - K(0)]\ e^{-kt} + K^* \quad \Rightarrow \quad \dot{K}(t) = k\ [K^* - K(t)], \tag{2.14}$$

where K^* is the stationary capital defined by (2.13).

Equation (2.14) describes a partial adjustment mechanism similar to the one of the flexible accelerator model in (2.1). In the investment literature the flexible accelerator was in fact identified with this mechanism, despite the fact that the underlying theory is different in (2.14) and (2.1).[28] Note, in particular, that K^* has no obvious link with the current output and prices as in (2.1) or even in (2.5), though under specific assumptions such a link may be established. In theory K^* refers to a notional long run static optimum characterized by the long run *constant* values of all exogenous parameters, e.g. relative prices.[29]

The above result, i.e. the derivation of an optimal dynamic path for investment, has been the reason of existence of the costs of adjustment models. Their introduction, it was felt, justified the partial adjustment mechanism introduced in an ad hoc fashion in earlier investment literature. As is so often mentioned, however, the introduction of the costs of adjustment is itself rather ad hoc, unless it can be convincingly argued that they capture some real world phenomenon. Roughly speaking, there have been two not necessarily competing interpretations for the costs of

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[27] The linearized system is

$$qz_{11}\ddot{K} - r\ qz_{11}\dot{K} + \Pi_{11}(K^*)\ (K-K^*) = 0.$$

z_{11} is evaluated at the stationary equilibrium. Since $z_{11}>0$ and $\Pi_{11}<0$, the characteristic equation has one positive and one negative root.

[28] Following this convention, we continue to refer to partial adjustment models of the form described in (2.14) as flexible accelerator models, even when the theory underlying K^* differs from the accelerator principle.

[29] Nickell (1978), ch. 11 section 4, derives under specific conditions an optimal investment rule with time varying prices. This proves to be rather more complicated than (2.14), involving a weighted sum of differences between the various levels of optimal capital under different prices.

adjustment. According to the first they arise in the process of integrating new capital into the production process.[30] The second interpretation relates them to imperfections in the capital goods market. We briefly examine each in turn.

We can consider first the case of disinvestment. When the firm is reducing its capacity faster than the depreciation of capital allows, dismantling costs are likely to be high and possibly increasing. At first the firm can probably dispose of the more liquid of its capital assets, but disinvestment will become increasingly costly when fixed capital assets are removed. At the limit, the $z(\dot{K}, K)$ function, depicted in diagram 2.1, becomes horizontal in the negative quadrangle, when capital can be scrapped but not dismantled and sold, because of irreversibility.[31] Clearly, the larger the size of the firm, the more liquid assets it will have, ceteris paribus, and thus the lower the costs of disinvestment, as was seen in (2.8). There is no equivalent problem to irreversibility when we turn to positive investment. Mention can be made here of the costs of planning capital orders, halting and reorganizing production, training workers to the new equipment, training additional managers for new production units.[32] It may also be argued that these costs depend on the initial size of the firm, what would explain the presence of K in the installation costs function, $z()$. These costs are arguably important, but "...in spite of some assertions to the contrary, there seems to be no very good reason why such costs should be increasing at the margin. In fact it seems very much more plausible that reorganization and training processes are subject to large indivisibilities and consequently give rise to diminishing costs over a considerable range." [33] As Nickell (1978) goes on to argue, these indivisibilities may well mean that adjustment costs are best described by function with a considerable initial concave segment before con-

30 Note that in this case we are dealing meanly with *internal* costs of adjustment, i.e. costs related to the level of output and productivity of the firm. Our earlier specification does not allow for such cross-effects, but this has little impact to our main results.

31 Here the possibility of selling off complete units, instead of dismantling them, has also to be mentioned. To examine this, a more complete model is needed that includes a shares market. We return to this issue briefly in chapter 4. For the moment we can note that these transactions are unlikely to be a commonly available and frequently used way of disinvesting, since they usually involve the selling of larger indivisible blocks of capital.

32 See for instance Penrose (1959). Chirinko (1987a), pp. 116-117, fn. 17, argues that it may be useful to differentiate between investment for expansion and for replacement, but in practice the two may be indistinguishable.

33 Nickell (1978), pp. 36-37. See also Rothschild (1971).

vexities come into play. Many of the capital adjustments required by the firm may in fact not exceed the point of inflection of such a function. Concavity in these costs would of course mean that the firm wishes to install capital all at once, rather than spread orders over a longer period.

The second interpretation is that the convexity of the costs of adjustment reflects a rising price for capital goods due to an upward sloping supply curve. For this to be felt at the level of the individual firm, as the costs of adjustment model argues, there must be some monopsonistic or oligopsonistic element in the capital goods market. Equivalently, for disinvestment there must be some oligopolistic elements in the second hand market for capital. An argument in support of this is that some of the capital goods are firm-specific. Here again, however, one could argue that such imperfections are more likely to exist in the second hand, rather than the new capital markets. One would expect that much of the equipment that firms order are standardized and only become firm-specific after they are installed, adjusted and used by the firm. If this is so, there is no particular reason why monopsonistic elements are assumed to be widespread in new capital goods markets, no more so at any rate than, say, in the market for firm-specific trained labour which is usually treated as a variable "factor of production". Second hand markets, however, may still be imperfect. Note that if imperfections in the capital goods market are the source of the adjustment costs, these are unlikely to relate to the capital stock of the firm.

The rejection of the conventional convex adjustment costs does not imply that a firm can increase its capacity instantaneously, if it so wishes. Planning, delivery and gestation lags are a fact of life. These prevent investment from being instantaneous, though it may still come in discontinuous blocks some time after a parameter shift that induces investment. Furthermore, these lags may also be related to aggregate supply and demand conditions in the capital goods market, spreading deliveries to various firms over a longer period when order books for capital are filled.[34] For the individual firm, however, and even for a relatively small size industry such lags and even rises in prices to clear the capital goods market are likely to be taken as exogenous.[35] Also, firms may choose to delay and even spread out orders, if waiting allows them to

[34] Bringing in supply considerations at the *aggregate* level is in line with earlier models in the Keynesian tradition. See for instance Witte (1963).

[35] A counter argument to this is put forward by Precious (1987), ch. 2. He argues that firms with rational

acquire more information about an uncertain event (for instance the possible reversibility of a certain policy). This is more likely to be case if investment decisions taken now can only be reversed at a high cost in the future.[36]

Although the above mentioned lags have long been recognized in investment literature, the theoretical models have continued to rely heavily on the costs of adjustment to interpret the dynamics of investment. One suspects that the reason for this has been the simplicity and tractability of the costs of adjustment model in deriving a well behaved investment function. On the empirical front this model has given rise to new specifications of investment, closely linked to variants of the optimality conditions (2.9) and (2.10). The latter specifies investment as a function of the capital stock, its current price and its shadow value *at any moment in time along the optimal path.* The shadow value depends on future returns, as we have seen from (2.11). Much of the literature in the field has been concerned with the best way of dealing with such a forward looking variable.[37] Since the adjustment costs function $z()$ has been introduced in a rather ad hoc fashion, not much light can be shed by these models on the factors underlying the sluggish response of investment, although the lags involved may be estimated. On the other hand, the lack of the necessary data on orders, deliveries and expectations does not leave much room anyway for testing and comparing the alternative factors involved.[38] Not surprisingly, despite all the theoretical work in dynamic models, the bulk of the empirical literature has continued to rely heavily on the two stage approach mentioned in the previous section. To quote a recent evaluation of investment specifications in UK macro-models, "...the specification of the dynamic form of the

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expectations will anticipate that prices will have to rise to clear the capital goods market, following, say, a parameter shift that induces investment. Thus, they will hold back some of their investment orders until prices start falling. The rational expectations saddle path that he derives shows prices and aggregate capital stock approaching gradually their long run equilibrium. Apart from the fact that such foresight on the side of the firms is questionable, this argument still suffers from the same weaknesses as the supply argument above. A parameter shift that affects only one firm or a small industry is unlikely to have much impact on capital goods prices, especially in conditions of excess capacity in the capital goods industry. For instance, it sounds unlikely that firms in Greece in the seventies would have a sluggish response to an interest rate cut because they anticipated that putting in all their investment orders domestic and international prices were going to overshoot and make such investment unprofitable.

36 The issue of uncertainty and its effect on investment is itself rather complex and open to debate. Here we take the view of Pindyck (1986) that with irreversible investment, uncertainty in future demand reduces the optimal capacity of the firm.

37 See references in the previous section. We return to this and other empirical issues in chapter 6.

38 A notable exception to this is Abel and Blanchard (1986b).

investment function does not usually rest on economic considerations; rather, the speed of adjustment and its dynamic profile is often left as a matter to be determined empirically."[39].

There may be a further reason why the precise factors underlying firm's sluggish response have not been the focus of the literature. Expectation lags, gestation periods and even supply constraints are usually taken to be exogenous for any economic system. Long run policies may have an impact on them, but for the more immediate time span usually involved in policy decisions, they are not dissimilar to technological constraints. If this is the case, the time profile of investment is of interest to the policy maker, but the precise factors underlying it are less so. This point was clearly made by Summers in his comments to Chirinko (1987a), where characteristically he wrote: "It is the capital stock and not the investment process that is fundamental".[40]

This point is arguably acceptable in so far as we believe that the dynamics of investment are not affected by other factors of an institutional nature, that can hopefully be influenced by economic policies. Our priors and some of the literature reviewed above suggest that the way finance is allocated in the economy may be one such factor. In the following chapters we pursue this line further and attempt to relate it more closely to the existing investment micro-theory. We contrast these financial costs with what we call "technological costs of adjustment", or for short "installation costs", for want of a better term. We represent the latter with the installation costs function of diagram 2.1. The analysis can in principle be extended to include other kinds of costs or constraints on the adjustment of capital. Also, using somewhat loose terminology, we call "neoclassical" the models with a perfect or strongly efficient financial system. In the next section we critically examine the interpretation of the Q investment approach within such a neoclassical model.

2.3 The Q investment model

The basic idea of the Q investment approach has been that the market value of the firm compared to the replacement cost of capital contains all the necessary information about the

39 Wallis (1987), p. 100.

40 Summers (1987), p. 171.

optimal investment policy followed by its decision maker. As was mentioned earlier, in the late seventies it was re-interpreted within an adjustment costs model and has since been considered as an alternative empirical implementation of the neoclassical model. In this section we examine this interpretation and focus in particular on extensions of the model that integrate aspects of the underlying financial system.

The neoclassical interpretation of Q is based on the optimality conditions (2.9) and (2.10) of the previous section. It is assumed that $\Pi(K)$ is linear, $z(\dot{K}, K)$ is linearly homogeneous in its two arguments and there are no fixed costs (FC=0 in (2.7)).[41] Multiplying (2.9) and (2.10) with K and $\dot{K}$ respectively, summing up and time integrating, we find the following condition that holds everywhere along the optimal path:[42]

$$\mu(t) \;=\; \frac{\int_t^{\infty} e^{-\mu(s-t)} \, [\, \Pi(K) - qI \,]\, ds}{K(t)} \;=\; \frac{V(t)}{K(t)}, \tag{2.15}$$

i.e. the shadow value of capital is equal to the value of the firm over its capital stock. In other words, the linearity conditions imposed above have the convenient result that the marginal value of capital[43] is equal to its average value.

If the financial system is strongly efficient, one would expect that the present value of the firm as seen by its decision maker, $V(t)$, would be equal to its market price, say $MV(t)$. Replacing this in (2.15), we find that the shadow value of capital along the optimal path is equal to the market value of the firm over its capital stock. The significance of this result cannot be overstated. The shadow value summarizes a host of information about the expected future returns of capital, most of it unobservable to the researcher. As we have seen in the previous chapter, $\mu(t)$ is central to investment decisions and is related to other economic problems as well. If the above conditions hold, it can easily be constructed from series of data on $MV(t)$ and $K(t)$, both of which

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[41] The $\Pi(K)$ function is linear if there are constant returns to scale and perfect input and output markets. Note that, combined, the above assumptions imply that in a static environment the firm will continue to grow indefinitely, though in the short run its size is bounded by the convexity of the adjustment costs.

[42] Use is made also of the condition that the shadow value $\mu(t)$ does not tend to infinity as $t \rightarrow +\infty$. This is ensured by the transversality condition mentioned in the previous section.

[43] Along the optimal path the following is true: $\mu(t) = \frac{\partial V(t)}{\partial K(t)}$.

are in principle observable. Combining (2.15) with (2.10), when the financial system is strongly efficient, we find that the rate of net investment is a function of exclusively the Q ratio:

$$z_1(\dot{K}(t), K(t)) = \frac{MV(t)}{q(t)K(t)}. \tag{2.16}$$

As was mentioned earlier, empirical results have not been supportive of this simple version of the Q approach. Subsequent theoretical and empirical studies have attempted to relax some of the restrictive underlying assumptions and test amended models. The focus of these extensions has been on the linearity conditions mentioned above, the possible distortions of the tax system, the assumption that there is a single homogeneous (capital) input for which there are costs of adjustment and finally on the underlying assumption of a perfect financial system.[44] This literature has highlighted important weaknesses of the original Q approach. On the other hand it has to be mentioned that a number of these weaknesses, such as the assumption of homogeneity in capital inputs, are to be found in most of the other investment models as well. Further, from an empirical point of view, the diversion of the marginal value of capital from the average value of the firm, which is what most of these extensions deal with, does not invalidate the model, if the two move in line through time or along cross sections. There are interesting examples where this is not the case.[45] It remains an issue for further research, however, how important these cases are and whether there are alternative investment models that can deal with them more satisfactorily. For our part the main issue is that of finance, which has also been of some concern in the recent literature in this field.

For all its attention on financial variables the original Q model has nothing to say about the financial decisions of the firm. Following much of the established investment literature, these decisions are kept in the background, separate from any investment plans. Also, surprisingly enough, the Q model hardly addresses questions of how the thinness of the stock market or the ownership structure can affect investment. In theory the market signal is equally strong

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44 See Hayashi (1982), Schiantarelli and Georgoutsos (1987), Chirinko (1984), Chirinko (1987b), Galeotti and Schiantarelli (1988), Hayashi (1985).

45 An often quoted example is that of the oil shock, when future expected profits and the present value of the capital *in place* has fallen, while the marginal value of new, energy saving machinery could have risen.

irrespectively of what percentage of the firm's and industry's shares is traded in the market.

Recent extensions have attempted to incorporate financial aspects in the original model. We critically examine one such extension by Chirinko (1987b) next, for as it proves below it has some features in common with our model in chapter 4. It also serves as a framework to raise some more general issues related to more financially oriented models. The model presented here is a somewhat simplified version of that in Chirinko (1987b).

Consider the case of a firm that chooses its debt and capital policy in order to maximize the present value of its equity,

$$S(0) = \int_0^\infty e^{-\rho t} \; [\,\Pi(K) - \Phi(\dot{B}, B) - qI - FC\,] \; dt, \tag{2.17}$$

where ρ is the discount rate of the shareholders and $\Phi(\dot{B}, B)$ is the net cash flow paid to the debt holders. It depends positively on existing debt and negatively on the flow of net new debt $\dot{B}$. In the simple case, where the firm pays a fixed interest rate, i, and incurs no additional cost when contracting new debt, it can be written as follows:

$$\Phi(\dot{B}, B) = iB - \dot{B}. \tag{2.18}$$

The other arguments in (2.17) are defined as in (2.7).

Chirinko assumes that because of agency problems $\Phi(\,)$ is convex in B. Also, because of flotation and transaction costs $\Phi(\,)$ is also assumed to be convex in $\dot{B}$.[46] The latter convexity implies that the firm cannot costlessly adjust to its long run optimum debt, but chooses instead an optimum dynamic path to it. If λ is the shadow value of debt, the following conditions must hold along such a path:

$$\Phi_2 = \dot{\lambda} - \lambda\rho \tag{2.19}$$

$$\Phi_1 = -\lambda. \tag{2.20}$$

All functions are evaluated at t. The optimality conditions for capital remain as in (2.9) and (2.10) with the only exception that u is replaced by ρ in (2.9). It is clear from (2.20) that if $\Phi(\,)$ is

[46] In Chirinko (1987b) the flotation and transaction costs are related to the gross, rather than net, flow of new debt. Also, in his theoretical model the above adjustment costs are internal, i.e. they are related to the output of the firm. None of these affects the following results.

linear in $\dot{B}$, as in (2.18), the shadow cost of debt will be equal to unity. The firm would be able to adjust its debt to its optimum, determined by (2.19), instantaneously and costlessly.

Suppose now that the linearity conditions imposed earlier still hold. In addition we assume that $\Phi(\,)$ is linearly homogeneous in its two arguments. Then multiplying (2.9), (2.10), (2.19) and (2.20) with K, $\dot{K}$, B and $\dot{B}$ respectively, summing up and time integrating, we derive the following condition:[47]

$$\mu(t)\,K(t) \;+\; \lambda(t)\,B(t) \;=\; \int_t^{\infty} e^{-\rho(s-t)}\;[\,\Pi(K) - \Phi(\dot{B}\,,B) - qI\,]\;ds$$

$$\mu(t)\,K(t) \;+\; (\lambda(t){+}1)\,B(t) \;=\; S(t) \;+\; B(t) \;=\; V(t). \tag{2.21}$$

This is a very revealing result. If debt can be adjusted costlessly and instantaneously, the shadow cost of debt will be unity, as we argued above, and (2.21) reduces to (2.15). If, however, debt is quasi-fixed, the value of the firm reflects not only the shadow value of capital, but also the shadow cost of debt. This result can be generalized to any number of quasi-fixed choice variables, such as multiple capital inputs, or quasi-fixed labour.[48] The model presented here is of particular interest for our purposes, because it highlights the financial side of the firm and addresses the question of costly adjustment in its financial position. As Chirinko points out, an interest rate fall could have an impact on the shadow value of debt, leaving the shadow value of capital unaffected. The capitalized value of the firm would then rise signaling profitable investment opportunities in *financial, not physical,* capital.[49]

Chirinko's analysis suffers, however, from a number of weaknesses. Critical in it has been the assumption that $\Phi(\,)$ is convex in $\dot{B}$, due to flotation and transaction costs. The problem is that, as with capital, there are no particularly good reasons why such costs should rise in the margin. If anything, one's priors would be that there are indivisibilities in contracting debt.[50] The same problem arises in a number of models where asymmetric information results to "financial

[47] As before, the transversality conditions have been used to bound λ and μ.

[48] See for instance Chirinko (1984) and Galeotti and Schiantarelli (1988).

[49] Following this result, Chirinko (1987b) suggests ways of amending the empirical Q model, with little success, however.

[50] Note that this may still allow for convexity in B and thus an optimal debt policy, contrary to Modigliani-Miller's theorem.

hierarchies".[51] As we discuss below, agency costs of debt arising from asymmetric information are likely to be related to the *stock* positions of the firm, which leaves something to be desired from these models.

Even more importantly, the equity market in Chirinko's model is left in the background once again. As we have seen earlier, an implicit assumption that the shares market is strongly efficient is required in order to link the present value of the firm, $V(t)$, with its market value, $MV(t)$. In an earlier presentation of the model Chirinko reveals indeed that this is assumed to be the case.[52] This separates the investment from the financial decisions, since it implies that the firm has no informational problems in raising all the capital that it needs to finance its investment plans through the equity market. Such an assumption seems to be at odds with the introduction in the same model of agency problems in the debt market.

This dichotomy between the debt and the equity market is not something unusual in investment models. Imperfections in the debt market have been combined with implicit or explicit assumptions that the equity market is perfect, save perhaps for tax distortions.[53] The problem is not simply one of inconsistency. It runs even deeper than that, for these models fail to distinguish between *financial instruments* (e.g. debt or equity) and

financial sources (e.g. finance from "insiders" involved in the internal operations of the firm and finance from "outsiders"). Clearly, insiders and outsiders may use a variety of financial instruments in their transactions, but if the fundamental problem is one of asymmetric information it is likely to affect in one or another way the cost of all such instruments. We consider this issue in more detail in the next section.

The reason for this two sided approach may be that there is no well established framework of analysis for non-strongly efficient equity markets. Abandoning the familiar area of perfect information raises a number of side problems, such as signaling and shareholders' conflicts, with no easy solutions. For the Q models there is the additional problem of linking the evaluations of

51 See for instance Fazzari et al (1988).

52 See Chirinko (1985), Appendix B.

53 See for instance Bernstein and Nadiri (1982), Lo (1985) and Hayashi (1985).

the decision maker ($V(t)$) with the perceptions of the market ($MV(t)$). This link, as we have seen, is essential for the empirical implementation of the model. This dependence of the Q model on the premise of a strongly efficient equity market is somewhat puzzling, given the fact that Keynes, who is credited with the original idea, did not share such a view.[54] This does raise the question of whether an alternative interpretation of the Q approach exists that is not based on the assumption of a strongly efficient equity market. The best known argument along these lines has been put forward by Fisher and Merton (1984). It runs somewhat as follows.

The stock market can function as a competitive placement to physical investment. If market prices are believed to be unreasonably low, a value maximizing decision maker (manager) will choose to shift resources from physical investment and buy back equity or refrain from making new flotations. These arbitrage gains will only cease to exist when the marginal return to capital has been raised to what the manager believes these shares yield. The opposite will happen when shares are believed to be overpriced. The value of equity held by *existing* shareholders would increase by issuing shares at the inflated prices to finance extra investment that otherwise would have not been profitable. Thus, even if a value maximizing decision maker believed that the equity market over- or undervalues shares, he would still find it profitable to adjust the investment plans of the firm in line with the stock market's valuations.

Fisher and Merton's argument clearly needs further elaboration. In particular, it does not address any of the side problems that arise when there is no perfect information, such as signaling and shareholder conflict of interests.[55] In a richer environment there may be important constraints to the arbitrage mechanism that they describe, coming for instance from the threat of a takeover if equity is issued at too large scale. Also, there may be institutional constraints, such as a prohibi-

[54] In the section immediately following the widely quoted passage on the influence of the stock market on investment, Keynes argues that equity valuations are based on conventions and "all sorts of considerations... which are in no way relevant to the prospective yield." (Keynes (1936), p. 152).

[55] Fisher and Merton do refer to the conflict between the interests of preexisting and new shareholders when equity is issued at inflated prices. (See Fisher and Merton (1984), fn. 27). Note that an equivalent problem exists when equity is bought back at low prices, since the old shareholders that sell all their stake in the firm clearly make a loss. These problems represent only one aspect of the possible conflicts among shareholders when there is asymmetric information. In the following chapters we refer to these problems and the other constraints mentioned below in more detail.

tion or heavy taxation of equity buy-backs. Buying shares of other firms in this case is mentioned by Fisher and Merton (1984) and Keynes (1936), but it is hardly a compelling alternative. Managers presumably have better information -or believe they do- about the prospective returns of *their own* firm, not of other firms.

Their argument, nevertheless, does set the basis for an alternative interpretation of the Q approach. Note that in this case equity prices are important because in a way they reflect the cost of finance for the firm, not because they efficiently signal about the future profitable opportunities open to the firm, as is the case with the conventional interpretation of Q.[56] Even if the firm has alternative sources of finance, such as debt or internal funds, when equity prices are low it still makes sense to use these in buying shares, rather than investing in physical capital. Thus, the return in the equity reflects the opportunity cost of investment funds. Note, further, that the argument at this level still implies that a thin equity market can in principle play the same role as a well established, active market. This issue as well as some of the earlier caveats to this argument are examined in more detail with the use of a formal model in chapter 4.

Our review of the adjustment costs and Q investment models has indicated that there is a need to examine closer the financial side of the operations of the firm and its influence on the dynamics of investment. In the next section we look in more detail at the hypotheses concerning the financial system and underlying most of the investment literature surveyed above.

2.4 The cost of finance

The standard costs of adjustment and Q investment models considered so far all assume that the financial operations of the firm are characterized by price taking behaviour. The discount rate or cost of finance, u, was assumed to be exogenously given for the individual firm.[57] In this section we review the main arguments that underlie this assumption with the view also of establishing the foundations of our subsequent investment model.

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[56] This is the way equity prices have been used in earlier studies. See for instance Grunfeld (1960).

[57] We have also assumed that u is time-invariant, but this was only for notational simplicity and will be retained in this section will little loss of generality.

We focus on two related issues: The first is whether the cost u is affected by the stock or flow of funds needed to finance the activities of the firm. As can be seen from the optimization programme with the target functional of (2.7), an essential assumption has been that u is independent of the capital stock, K, or the investment flow, I, and thus from the stock and flow of finance needed by the firm. The second issue is whether u is related to the identity of the creditors. By "creditors" we mean all those that have a placement in the firm and, as will be seen below, they are identified depending on whether they have direct access to the internal operations of the firm. As was mentioned in the introduction, this has interesting implications for the relation of income distribution and investment. Both issues above are aspects of the more general question of separation of the financial from the production/investment decisions. Note that much of the relevant literature surveyed below has a somewhat different focus. The main question in this literature is whether the cost of finance, u, is affected by the mix of the *financial instruments* used by the firm, e.g. debt or equity claims. For our purposes this question is only of interest in so far as it relates to the two issues mentioned above or to measurement and other problems arising in the empirical implementation of the standard investment models.

To fix ideas, then, we abstract for the moment from questions related to the capital structure of the firm and examine the main premises of the neoclassical model in a world with a single type of claim. We assume in particular that all profits are paid out and all activities are financed by shares, each of which gives the right to a return equal to the net profit per unit of capital stock. For the neoclassical analysis such shares will be traded in financial markets that differ little from other markets. The most interesting question that one may ask in this framework is the standard one concerning competition.

The reason why financial markets may not be competitive, despite the large number of traders, is that they may be segregated. On the one hand, shares of different firms may be perceived by the creditors as differentiated products because of the different risk characteristics of future returns of each firm. On the other hand, creditors may also differ in their evaluation of a share because of the various risk preferences, subjective probabilities about future states or unequal tax treatment. The result of such segregation is that firms whose shares have no close substitutes will face a demand in the financial market that is not perfectly elastic. The price of a share or equivalently the required return per pound worth of a placement in the firm may vary with the stock or flow of shares supplied by the firm. Also, the matching process, whereby shares of firms are first bought by those who evaluate them highest, will depend on the income (and savings) of the creditors that are best disposed towards that particular firm. Since they are likely to be the ones already holding much of the outstanding shares of the firm, its current return will affect its cost of capital.[58]

The standard response within the neoclassical model to the problem of competition has been that substitutability between claims issued by different firms is likely in fact to be high. In the original Modigliani-Miller paper this was expressed by an assumption that there exist large "risk classes", i.e. groups of firms whose uncertain cash flow streams are perceived to be perfectly correlated and therefore perfect substitutes.[59] This assumption has subsequently proved unnecessarily restrictive, for, as asset pricing theories suggest, substitutability may also exist for claims issued by firms in different risk classes.[60] If shares of firms are traded in large markets with close substitutes, the idiosyncratic characteristics of the various creditors will be more relevant in the analysis of the market equilibrium rather than the optimization problem of the individual firm. For example, higher income in the hands of the risk neutral or more optimistic agents may lower the return required by the market from all risky firms. For the individual firm this is likely to be regarded as an exogenous change in the cost of finance.

The Modigliani-Miller theorem

So far we have abstracted from the questions concerning the capital structure of the firm, but much of the literature on the cost of finance has in fact revolved around these questions. Thus, for the rest of this section we turn to the controversy surrounding this issue trying to isolate the aspects more relevant for our purposes.

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58 For a model along these lines see Nickell (1978) chapter 8, section 4.

59 See Modigliani and Miller (1958) and Ross (1988).

60 See for instance the Capital Asset Pricing Model in Copeland and Weston (1988), ch. 7.

The Modigliani-Miller (M-M) theorem is the starting point of this controversy. The theorem showed that for a given future activity (investment plan) in a world with competitive capital markets (large risk classes), full information, no bankruptcy and no distortionary taxation the mix of financial instruments used by the firm cannot affect its cost of finance or equivalently its present value. The proof was along the lines of a now familiar arbitrage argument: A creditor can always rebalance his private portfolio to replicate any pattern of returns that the firm with a given future cash flow may produce changing the mix of its financial instruments. Thus, such a financial repackaging is worth nothing to the creditor and the value that he attaches to the firm is unaffected by it.[61]

To see what this means for the cost of the various financial instruments, consider the following simple example of a firm with riskless debt B for which it pays an interest rate i. If S is the present value of all equity claims and ρ the discount rate of the shareholders, using the earlier notation we can write:[62]

$$\rho S \;=\; \Pi(K) - qI - FC - iB + \dot{B} + \dot{S}. \tag{2.22}$$

The present value of the firm is $V = B + S$. The weighted average cost of capital is

$$u \;=\; i \,\frac{B}{B+S} + \rho \,\frac{S}{B+S}, \tag{2.23}$$

so that (2.22) can be re-written as follows:

$$u\,V \;=\; \Pi(K) \,-\, qI \,-\, FC \,+\, \dot{V}. \tag{2.24}$$

All functions are evaluated at t. The functional in (2.7) can be derived from this last expression. The M-M theorem states that the present value of the firm, V, and the cost of capital, u, are unaffected by the choice of the leverage ratio in (2.23). For instance, if i is lower than ρ, because say the equity return is risky, an increase in the leverage would appear to lower the cost of capital, as earlier theories had suggested. Against this, however, ρ would be rising with the leverage because the firm would be committing more of its future return to the riskless debt and a smaller

61 See Modigliani and Miller (1958), Miller and Modigliani (1961) and for a general equilibrium approach Stiglitz (1974).

62 See (2.17) in conjunction with (2.18).

equity basis would have to bear all the future income variation. The weighted average cost, u, would remain unaffected by such leverage changes. The implication is that since the financial packaging does not matter, we might as well consider only the single asset world mentioned earlier.

The controversy that followed the M-M theorem revolved around three main issues: Taxes, bankruptcy and asymmetric information. We turn to each of these issues next.

Taxes

The tax treatment of income from different financial instruments is in many countries unequal and it may produce distortions. Interest payments are often tax deductible at the corporate level, but are taxed with a different rate at the personal level; the contrary is usually true for the dividends, while capital gains are often taxed when realized, rather than when accrued. The tax system may thus make some forms of financing preferable for both the firm and the creditors. The early investment studies by Jorgenson and his collaborators adjusted accordingly the cost of capital to take account of the tax shields due to debt (ignoring personal taxation). This is clearly contradictory with optimizing behaviour, for if debt were a cheaper form of finance, then firms would be 100% debt-financed. The fact that they are not implies that there is some real or perceived counterbalancing cost of debt, which these models ignore.

Miller (1977) claimed that much of these perceived tax gains from using one form of finance rather than another are in fact illusory. His argument for the case of debt went somewhat as follows: Firms have an advantage in issuing debt (instead of equity) for as long the interest rate net of tax is lower than the required return on equity before taxes (abstracting from risk considerations). To start with, this debt is bought by low taxed agents, but their "debt absorption" capacity is exhausted with their wealth and as the total outstanding debt of the economy increases, the marginal debt-holder has a higher tax rate. At the market equilibrium his personal tax rate is equal to the corporate tax rate, so that both him and the firms are indifferent between issuing a unit of debt or a unit of equity. Note in particular that while there exists an optimal debt level for the economy as a whole, the individual firm is faced with a set of equilibrium returns on equity and debt that make it indifferent between debt and equity. This framework can be extended to take account of such things as tax exhaustion and differential tax treatment between dividends and capital gains.[63]

The "Miller equilibrium", as it is known, may appear farfetched, but it serves as a warning against placing too much weight on apparent tax wedges. Empirical evidence on marginal tax rates are hard to get, but tax variables have started to loose much of the center stage in capital structure studies, following the generally disappointing early results.[64] As Mayer recently noted, "This is by no means the first study to have found a surprisingly small role for taxation in corporate finance. The finance literature is littered with them. The prima donna is retained not out of respect but for want of anything better."[65]

In the theoretical models of the following chapters we abstract altogether from taxation issues. In the empirical investigation in chapter 6 we introduce elements of the tax system in Greece, but we assume that no financial instrument has had any significant tax advantage, in line with Miller's equilibrium.

Bankruptcy

Unless debt is fully covered by collateral, its return is risky when limited liability rules protect the shareholders. Riskyness in the return of debt on its own does not affect the M-M theorem. The arbitrage argument mentioned earlier does not depend on the existence of a riskless asset and, with the other assumptions in place, any change in the financial structure of a firm will only redistribute the overall risk and return of the firm among the various financial instruments leaving the weighted average cost of finance unaffected.[66] Bankruptcy becomes important if there are significant costs associated with it. These may be fees and other payments to third persons (other

[63] See Auerbach (1983), DeAngelo and Masulis (1980) and Mayer (1986).

[64] See Copeland and Weston (1988), ch. 14 for a survey of the empirical evidence.

[65] Mayer (1988), p. 1177.

[66] Limited liability and the corporate bankruptcy laws are one case, however, where individuals may fall under different institutional rules than the corporations and therefore they may be unable to replicate the corporate financial decisions. To put it differently, this is one case where a change in the firm's financial policy may result to a change in the space of state contingent commodities available to the creditors, by creating a pattern of returns previously not available to them. See Stiglitz (1974), Nickell (1978) pp. 176-177, Hellwig (1981) and Miller (1988). This can be seen as an aspect of the more general issue of optimal financial arrangements when contracts are incomplete, on which we refer below.

than the creditors of the firm), costs of reorganization or liquidation and "dead weight" losses, such as losses of sales, reputation and high quality personnel. The scarce empirical evidence that exists suggests that, if opportunity costs are taken into account, bankruptcy costs may well be significant.[67] Thus, if changes in the capital structure of the firm affects its bankruptcy risk, financial decisions do not only have an impact on the distribution of a given future return among the various instruments, but they also affect the total net return itself and thus the cost of finance of the firm.

As with the case of taxation, the above argument is more relevant to the question of the optimal mix of financial instruments, rather than that of the source of finance (identity of the creditor) and the independence of the "real" from the financial decisions. Indeed, if bankruptcy is a characteristic of the debt contract, existing and potential creditors may choose to make alternative contractual arrangements that will reduce the risk of it occurring and still provide the necessary capital at the constant cost predicted by the M-M theorem. All-equity finance is clearly one possibility, but other arrangements also exist that do not involve bankruptcy unless the total present value of the firm falls below its liquidation value. If debt is used in these circumstances it has to be the case that it enjoys other advantages (e.g. tax gains), that at the margin outweight precisely the increased risk of the bankruptcy costs occurring.[68] In other words, an optimal mix of financial instruments will exist, but the weighted average cost of capital will still be independent of the "real" decisions or the identity of the creditor. Consequently, we can consider the financial and investment decisions as separable and examine the latter keeping the former in the background. This is similar to the point raised in the previous section when we noted that many investment models have a two sided approach to the debt and equity markets. Imperfections in the one market are often combined with an assumption that the other operates along the lines of the M-M world, leaving ultimately the main approach to investment unaffected.[69]

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[67] See Copeland and Weston (1988), pp. 498-500 for a survey.

[68] See DeAngelo and Masulis (1980).

[69] Hayashi (1985) presents a model where bankruptcy costs related to debt are combined with constraints and high tax costs for the *flow* of internal and external equity finance respectively to produce a model where investment is affected by profitability. This still misses the point that if all creditors have the same access to the inside operations of the firm (information and decision making), then there is no reason for them to use a financial instrument that introduces the probability of bankruptcy and a loss to all of them. If there are tax ad-

The bankruptcy and capital structure literature becomes more relevant for our purposes in its more recent approach to bankruptcy not as a peculiarity of one type of credit contract, but rather as a manifestation of the costs involved in deviating from first best solutions because of the incompleteness of contracts (and the absence of a full set of Arrow-Debreau markets). Such an incomplete contract approach is naturally but not necessarily linked with asymmetric information. We describe below one of the more recent and interesting approaches to this issue when there is symmetric information, before turning to models of asymmetric information.

In Aghion and Bolton (1988) bankruptcy is perceived as an (optimal) mechanism of transferring the control of the firm from the entrepreneur to the creditors after some state of the world has realized in the first period.[70] The two do not share the same objectives: The entrepreneur incurs private costs that vary with the firm's action plan (investment project) and he is covered from losses by limited liability. The creditors are only interested in the firm's returns. A contract contingent on states or actions that can solve potential conflicts cannot be written by hypothesis. Instead the contract specifies the payments to each party contingent on the return of the firm and a "governance structure", i.e. a set of rules as to who decides the action plan for the firm. In the first period the efficient outcome is for the entrepreneur to hold control. Aghion and Bolton show that there are circumstances when it is efficient in the second period to have control be determined by the first period outcome and therefore some times to pass from the entrepreneur to the creditors (bankruptcy). This is because the action choices of both parties in the second period are only efficient in some states of the world. Thus, if states are correlated across time, it may be more efficient to allocate control in the second period according to the state realized in the first.[71]

Their paper serves to clarify some of the main issues of the literature considered below. First, the essential part of the problem is that each party takes its decisions when in control disregarding the costs or gains that these impose on the other party. This is why they may not be the

vantages from debt, the firm can still issue bonds with income related return to avoid bankruptcy.

[70] See also Aghion and Bolton (1989) and references therein.

[71] Aghion and Bolton (1988) argue that this may still hold if renegotiation after the first period's outcome is permitted.

most efficient ones. Second, the source of this opportunistic and distortionary behaviour is not the contract "signed" itself, as was the case earlier with the debt contract that introduced the possibility of bankruptcy. Thus, the emphasis shifts from the contract to the underlying conflict of interests. The payment structure and the other elements of the contract can be negotiated to deliver a Pareto efficient outcome, *given* the feasibility (budget) constraints and the contractual limitations. The entrepreneur cannot pay more than what he owns (or there is limited liability), his private costs cannot be part of a deal (presumably because they are not verifiable). These limitations are important, for they do not allow a payment structure to be negotiated that would "internalize" the externalities of the actions of the decision maker. Control over decisions matters not only because it may redistribute returns, as was the case with the mix of financial instruments in the M-M world, but because it affects the total net return itself. These inefficiencies would not exist if the entrepreneur relied exclusively on his own capital. Bankruptcy is a mechanism of limiting these overall losses, though it may also involve costs itself.[72]

It is clear from Aghion and Bolton's paper that "non-contractibles" are at the heart of the problem. These are not necessarily linked with asymmetric information, but a natural environment where they can be expected to arise is one with such asymmetries. We turn to this issue next.

Asymmetric information

Rasmusen (1989, p. 133) has noted that asymmetric information has now replaced price discrimination as the prime suspect for all "anomalies" observed in the economy (i.e. anything that does not fit our Walrasian paradigm). This being so, one is not surprised to find a vast literature relevant to asymmetric information and the capital market. There is, however, at least one reason why the financial market may be particularly affected by the related problems. In a decentralized system firms can ill afford to reveal their private information on issues such as know-how, R & D and investment for fear of competition. Thus, it may be reasonable to assume that

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[72] The novelty of Aghion and Bolton's approach is that bankruptcy has to do with control rights and decisions to be taken in the second period, rather than being just a part of a payment structure (that might affect ex ante decisions), as in the literature cited below. See Aghion and Bolton (1989) for an elaboration of this point.

some of the creditors may well not be able to see or to infer what is going on behind the "corporate veil". This constitutes a major departure from the M-M world and indeed for the neoclassical perception of the firm and the market. Unfortunately, the plethora of very specific models in this area does not permit one to easily draw a unified framework. The survey below concentrates, instead, on only a few of the more influential approaches that are also more relevant for our investment models in the next two chapters.

In the presence of asymmetric information firms (entrepreneurs) that have -or believe to have- different future prospects may look indistinguishable in the eyes of the outside potential creditor. If, as a consequence, their cost of capital is the same, there will be a misallocation of resources due to what is in effect an externality exerted from the low "quality" to the high "quality" firms.[73] This cost of deviating from the first best is at the heart of the problems (and costs) associated with the use of external finance. Inside finance does not suffer from these additional costs, but in all of the models below it is either assumed to be constrained, or to carry an additional cost due to the imperfect diversification of the entrepreneurs' portfolio. Moreover, the effects of this problem on the functioning of the market may be non-trivial.

Credit rationing is one outcome that has been extensively discussed.[74] It arises in situations where creditors have no means of distinguishing between the various firms and prices cannot move to clear the credit market, mainly because they adversely affect the "quality" of the pool of entrepreneurs either by driving the most "productive" ones out of the market, or by giving them the wrong incentives for action. More interestingly for our purposes, creditors may use screening devices and firms may willingly or unwillingly give signals with their actions that convey information about quality. An essential property of such communication devices is that the relevant costs should be such that they prevent a low "quality" firm passing for a high "quality" one. Some of the earliest models on asymmetric information in the capital market referred to capital structure as such a mechanism.

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[73] See Stiglitz (1982).

[74] See Jaffee and Russell (1976), Stiglitz and Weiss (1981), Allen (1983), Stiglitz and Weiss (1986). Zephirin (1990), chapter 7, offers an up to date survey of this literature.

Leland and Pyle (1977) argued that the entrepreneur may signal to the other shareholders his hidden knowledge about a project's high return by holding a high stake of the total equity. The costs involved with such a signal come from the imperfect diversification of the entrepreneur's portfolio. Ross (1977) instead argued that high debt could convey similar information if the entrepreneur was known to incur a high (presumably non-pecuniary) cost in the case of bankruptcy. In one of the more interesting approaches to signaling , Majluf and Myers (1984) argued that equity flotations convey a negative signal to the stock market. Managers who act on behalf of the existing shareholders (before the flotation) and have inside information are more likely to issue shares when they believe that the market overvalues rather than undervalues the shares. As a response, flotations are considered by the market as probable bad news which therefore depresses the share price of the firm. The reason why flotations do not give an unequivocal negative signal (that would have prevented the market from opening) is that firms will occasionally also issue shares even in depressed markets in order not to pass up projects with sufficiently high positive net present value (due to lack of alternative financing). Nevertheless, Majluf and Myers show that some projects with net present value may still not be undertaken because of the negative signal that a necessary flotation would give. Based on this approach, Myers (1984) suggested a pecking order theory according to which the firm has no well defined long run optimal capital structure, but uses in each period more expensive sources only after the cheaper ones have been exhausted.

Empirical evidence supports the Majluf and Myers conclusions on the effect of flotations on the stock market price.[76] Further, secondary distributions of equity and especially those that originate from what can be considered as "insiders" also have a depressing effect on stock prices. To quote Mikkelson and Partch (1985) p. 166, "We find that secondary offerings are associated with significant decrease in share price... Among the categories of sellers, the average price decrease is largest for the secondaries by officers and directors, sellers most likely perceived to hold inside information about the firm." Following this literature, we introduce in chapter 4 an equity market

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[76] See Copeland and Weston (1988) pp. 522-523.

where the (flow) demand for new shares is not perfectly elastic.

So far we have considered mainly the issues closely related to the original lemons' and adverse selection problem as discussed by Akerlof (1970). This assumes that one of the parties involved has less information before even contracting with the other party. The literature on moral hazard and incentives in the capital markets focuses, instead, more on the *ex post* asymmetry of information, i.e. asymmetry that arises only after the contract has been signed.[77] We turn next to this literature.

In one of the earliest contributions on this field, Jensen and Meckling (1976) pointed out that different financial instruments involve different types of moral hazard due to hidden actions taken by the entrepreneur (decision maker and partly owner) that affect the outside creditors rather than himself. Debt induces him to choose riskier projects the possible losses of which he and the other shareholders do not incur due to limited liability. Outside equity invites slack the (social) costs of which are only partly born by the entrepreneur, while he enjoys its benefits. These are externalities that the entrepreneur does not take into account when formulating the firm's policy. Therefore his actions involve purely dissipative "agency costs", not simply a redistribution of income. Accordingly the cost of outside finance is higher than under full information. Monitoring may alleviate some of the informational asymmetries, but this is considered again to be costly. The optimal mix of financial instruments and sources, Jensen and Meckling argued, is thus chosen in order to minimize the sum of agency, monitoring and bonding costs, but typically these will be higher than zero and will affect therefore the cost of capital and the level of total activity.[78]

In the more recent literature this framework has been extended to allow for *any set* of financial instruments being chosen and not just for combinations of the standard debt and equity. The fundamental requirements are that these optimal contracts should not violate limited liability,

[77] The distinction is more for expositional reasons and models with ex ante asymmetry in information usually also imply ex post asymmetry. Note, however, that for Myers and Majluf argument this may not necessarily be the case. First time buyers of shares will find that their interests are represented by the managers and therefore in a sense they may even be considered as insiders. We return to this issue in more detail in chapter 4.

[78] Stiglitz (1985) offers a recent version of these arguments.

must be incentive compatible for both parties and consistent with the underlying asymmetry in information and costly verification.[79] Typically, this literature is concerned with the problems arising from hidden information about the state of the world and the return of the firm and derives as optimal a financial contract that is not dissimilar to debt: A fixed payment to the outsiders is agreed for all contingencies (unobserved to the outsiders). Failing that, the firm is audited at a cost and the outsiders receive whatever is left.[80] Note that the "auditing cost" of these models can be thought of in similar terms as the bankruptcy costs mentioned earlier. It is, however, a reflection of the underlying agency costs, rather than a peculiarity of one of the financial contracts.

Gale and Hellwig (1985) show that the ex post informational asymmetry ultimately results in a higher marginal cost of funds and this in turn affects total investment. Bernanke and Gertler (1989) build on this approach and examine closer the relation between the borrowers' balance sheet position, the auditing (bankruptcy) costs and the optimal aggregate investment.[81] Their results can be summarized as follows. The agency costs and the probability that auditing will occur are inversely related to the entrepreneur's contribution to a project. Thus, also the cost of finance and the individual (and aggregate) investment will depend on the net worth of the firm compared to its total liabilities. Firms' profits play an important role in the propagation of shocks. The analysis in the next chapter is very much in the flavour of Bernanke and Gertler's results. Unlike their approach, however, we focus on the dynamic aspects of the investment decision and link our analysis to the existing investment micro-literature.

To summarize, much of the micro-investment literature has found it convenient to separate the financial from the investment decisions. More than the independence of the cost of capital from the mix of financial instruments, the essential assumption has been that this cost is independent of the level of investment and the indentity of the creditor. However, recent literature, and in

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[79] Note that most of these models predict that a risk neutral insider will optimally commit all his savings to the firm, so that limited liability is in fact a condition that the insider cannot take negative positions.

[80] See Gale and Hellwig (1985). Some of the features of this optimal contract may change if probabilistic auditing or a multi-period setting is considered (See Bernanke and Gertler (1989) and Hellwig (1989)). Gertler (1988) surveys this literature.

[81] See also Bernanke and Gertler (1986) and Greenwald and Stiglitz (1988).

particular the asymmetric information approach, has stressed the additional costs arising when funds are drawn from outsiders. In the next two chapters we build on this literature using the familiar micro-investment framework.

2.5 Summary and conclusions

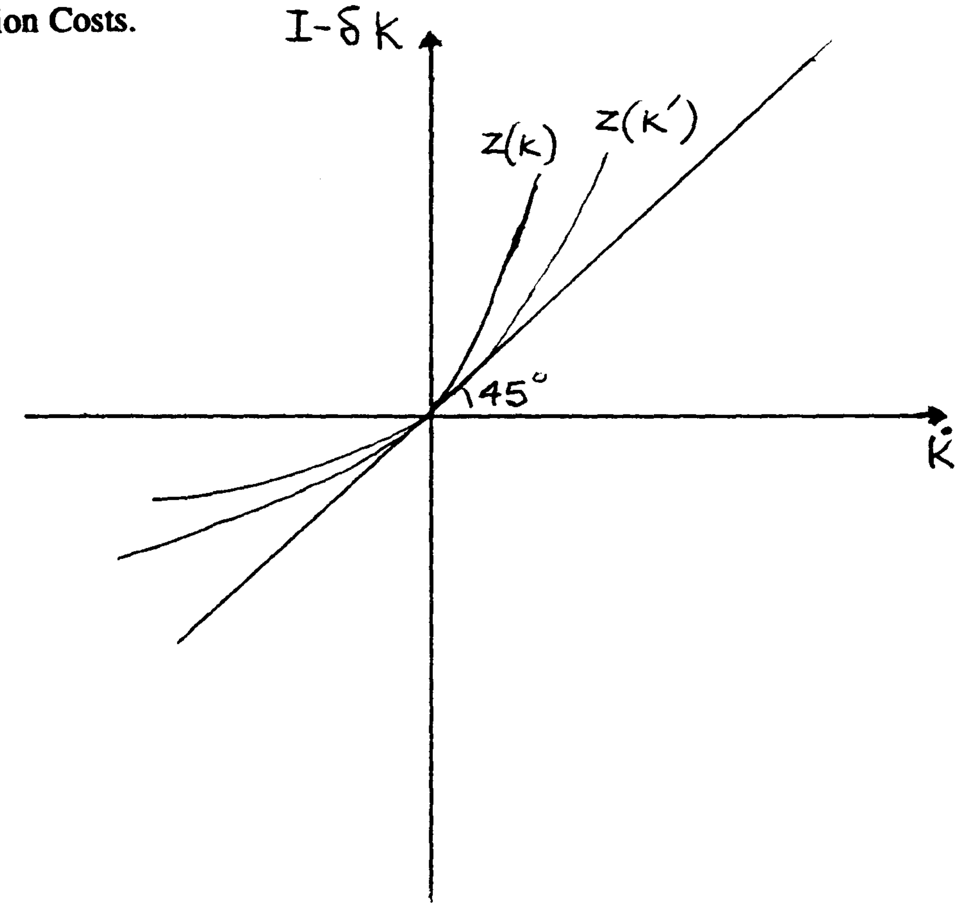
The treatment of dynamics in the investment literature strongly reflects the more general perception of the accumulation process within the neoclassical paradigm. In the pure neoclassical models the optimal static capital decision depends on prices, which within the more general framework reflect the fundamental outside limits of the economy, i.e. preferences, 'nature', technology. Dynamics have largerly been conceived as an additional technological constraint that restricts the speed of transition from one input-output combination to another. Introducing instead institutional constraints of a financial (or other) nature is not perhaps a revolutionary leap in the theory of investment. It can, nevertheless, open some new policy discussions on the timing and behaviour of investment over economic cycles. It also can be seen as a step towards providing a richer institutional background for the study of a complex decentralized system, than the one provided by the 'Robinson Crusoe' type of economy described essentially by the pure neoclassical models.

Concerning finance in particular, we have seen that much of the investment literature has found it convenient to rely on some version of the Modigliani-Miller theorem on the independence of investment and financial decisions in order to leave the latter in the background. This is true even for the more financially oriented mainstream models, such as the Q investment model. Furthermore, some of the attempts to incorporate financial aspects in the investment theory have been half-hearted, in the sense that imperfections in one financial source have often been combined with implicit assumptions that another source is perfect. This often revealed a failure to distinguish between financial instruments and financial sources. Exceptions to this have been some of the more empirically oriented studies on financial constraints. To our knowledge, however, this literature has failed to provide a consistent theoretical framework that can be integrated in to the rest of the micro-investment literature, despite the contributions in the more static oriented literature on optimal financial contracts.

In the last section we have reviewed the underlying arguments concerning this separation of the investment from the financial decision. Its basis seems to be the perception that the firm has no distinct financial identity, no budget constraint and no separate objective function from that of the market "as a whole". Thus, the intermediation of a market in the flow of finance is inconsequential. Recent literature on asymmetric information stresses, on the other hand, the potential conflicts and therefore agency costs involved with external finance. Internal finance and the financial credentials of the "insiders" can be expected to play a more central role in this case, much as they do in the Kaleckian model. In the next chapter we examine these issues within a micro-optimization framework.

Diagram 2.1

Installation Costs.



Chapter 3

INTERRELATED FINANCIAL AND INVESTMENT DECISIONS

In the last section of the previous chapter it was argued that within an imperfect information environment outside finance may involve important agency costs. Combined with internal financing that is either constrained or involves rising costs, this could suggest that financial and investment policies are interrelated and the firm has to decide simultaneously on the level and sources of net investment each period. This combined decision is the subject matter of this and the following chapter.

In section 3.1 a general model comprising both financial and other adjustment costs is specified. In 3.2 the first order conditions for an optimum are derived and the stationary equilibrium is examined. Section 3.3 turns to the optimal dynamic path. The derived optimal policies for investment and finance from a model with convex financial costs are compared with those from a model with conventional costs of adjustment. Both approaches support the flexible accelerator model as a satisfactory description of the investment process around the stationary equilibrium, with important differences, however, in the factors affecting the adjustment coefficient. In 3.4 elements of the two main approaches are combined in a diagrammatic analysis and a richer set of dynamics is examined. Section 3.5 summarizes and concludes.

3.1 The model

In this chapter we examine the optimal financial and investment policies of the firm when there is no equity trading. This approximates closer the environment of a decentralized economy with no developed equity market. Equity trading is introduced in the next chapter. The analysis is done in what is essentially a deterministic framework. Alternatively, we can think of the following models as describing the open loop optimal policies of a firm which does not intend to default (it has an infinite horizon) and whose owners maximize over expected values (or have point expectations).[1] The financial market possesses limited information concerning the firm's expected return and is unable to judge whether the firm concerned is following a non-default policy for the future. It therefore imposes an increasing marginal cost and restricts access to external capital, as was described in the previous chapter. Combined with convex costs of internal finance, this delivers a dynamic theory of investment. In this section we set up a model that captures the main features of such a financial theory of investment.

In line with our earlier arguments we separate the creditors of the firm according to the information and decision power that they possess. For simplicity we can take present shareholders at any moment in time to have all the information available to the firm. We can call them insiders and, since for the moment we are assuming that there is no equity trading and hence no dilution of ownership, we can consider them as an unified group with a single objective function, or more simply as a single owner.[2] With little loss of generality we assume throughout that credit from insiders takes only the form of equity (shareholders do not lend money to their firm). Thus, all debt is provided by outsiders.[3] This saves us from having to distinguish between sources and instruments of finance for the moment. We start by considering the costs associated with the

[1] The open loop optimal policy means that the firm is drawing a plan now *as if* it were going to stick to it to infinity, but it may in fact re-optimize in the next period if circumstances have changed. Thus, also the assumed non-default policy would be valid only for as long as the current plan is considered optimal. We return to these issues in chapter 6.

[2] The following results would change little if the decision power was with only a subgroup of owners. We return to this issue in the next chapter.

[3] If debt from outsiders has priority in the case of bankruptcy, then the choice of financial instruments held by the insiders is in a world of no distortionary taxation of no real relevance, in line with the Modigliani-Miller argument. If all debt has the same status, as is often the case, then the insiders can be expected to hold equity, since this will reduce the agency costs associated with outside debt.

internal financing.

Much of the asymmetric information literature reviewed earlier does not distinguish clearly between stock and flow constraints and costs associated with internal financing. In a static framework this may not be a very meaningful distinction, but for the purposes of our dynamic model it is rather important. In the long run it may be argued that insiders can accumulate enough funds to finance whatever the stationary capital of the firm might be, if they consider this optimal. In the short run, however, there are likely to be constraints and rising costs associated with the flow of new equity placements in the firm. Shareholders can finance such placements by either reducing their current consumption or restructuring their portfolio. They may take out debt using their private wealth as collateral, or they may switch some of their placements into the firm. Concerning this restructuring of their portfolio, we assume initially that the only liquid or collaterizable assets that they own are those placed in the firm, but we return to this issue in section 3.4. All other assets of their portfolio can not be used as safety for debt (e.g. human capital) and can only be liquidated at a rising flow costs (presumably because of highly imperfect second hand markets). At the limit there is a credit constraint related to the value of the combined portfolio of the owners. Effective flow costs of new equity placements rise, then, towards infinity. Concerning, on the other hand, the possibility of reducing consumption, this will presumably also involve an increasing marginal cost of disutility. In what follows we also assume originally that similar increasing costs exist when the firm is de-accumulating equity. In section 3.4 this assumption is dropped.

If the only tradable assets ever found in the shareholders' portfolio were their placements in the firm, then the idea of rising marginal costs for new equity could be captured by a concave utility function, $u(Y-R)$, as in Steigum (1983). Y is here the net income of owners from all sources and R their net new placements in the firm. Instead, we use a somewhat less familiar but more tractable specification which has more in common with the conventional costs of adjustment. For this, we assume that the owners incur increasing convex costs, C, as their net new placements in the firm, R, rise relatively to their net income from all sources, Y, at any single period.

$$C = C(R, Y), \tag{3.1}$$

with

$$C_1>0\,,\ C_{11}>0\,,\ C_2\leq 0\,,\ C_{22}\geq 0\,,\ C_{12}<0 \text{ if } R>0\,,\ C_{12}>0 \text{ if } R<0.$$

Diagram 3.1 in the end of the chapter depicts a possible functional form of the costs of self-finance C. In this case $C(0,Y)=0$ for all Y. The 45^0 line depicts the usual case where $C=R$ regardless of the level of reinvestment. In the area to the left of it, the implicit cost to the owners of one pound worth of ploughback is higher than a pound. In the negative quadrangle the owners are reducing their placements in the firm. For any point to the left of the 45^0 line the implicit worth of their receipts is lower than the full disinvestment.[4] The convexity of the $C()$ function captures the idea that as the owners, say, increase their new placements in the firm at any single period while their total net income remains constant, they incur an increasing marginal cost. In the negative quadrangle, as they reduce the total ploughback and increase their receipts, the marginal value of the extra gain falls. The total cost of self-finance $C()$ falls for given R as the net income of owners rises and the C curve becomes flatter ($Y_2>Y_1$ in the diagram). Hence, around the origin it approaches the 45^0 line and its derivative when $R=0$ will be unity, i.e. $C_1(0,Y)=1$.

For reasonable values [5] of R and Y the following is a simple example for a specification of $C()$:

$$C = R\, e^{(\beta \frac{R}{Y})}\,, \quad \beta\geq 0. \tag{3.2}$$

Note that when $\beta=0$, there are no convex costs of internal finance, i.e. $C=R$.

The costs of self-finance are subtracted from the net income of the owners to derive their one period objective function, $(Y-C(R,Y))$. It is not difficult to see that this has similar convexity properties with the concave utility function, $u(Y-R)$, especially for $R>0$. Also, in both specifications the long run optimal stationary equilibrium is unaffected by the existence of these convexities and directly comparable to the results from a more conventional investment model with costs of adjustment.[6] As will become clear below, however, our specification is preferred to

[4] In section 3.4 we assume that $C=R$ for $R<0$.

[5] $Y>0\,,\ \frac{R}{Y}>-1$

[6] This result would change if $C()$ had gross rather than net equity flows as an argument. As with the conventional investment models, costs of adjustment would enter the long run optimal condition through their ef-

that of a concave utility function on the grounds of tractability and the main arguments can still be expected to hold with a formulation that will remain closer to first principles. Apart from the flow costs of moving equity in and out of the firm, there is also an opportunity cost which we continue to denote by ρ and assume for notational simplicity that it is time invariant.

Next we turn to the cost of debt. Debt holders are preoccupied with the possibility of becoming forced lenders and finally facing a bankrupt borrower. In our model we are examining a firm that by hypothesis is planning a non-default policy. The essence, however, of asymmetric information is that lenders cannot say a priori what the future intentions of the decision makers are. They also lack inside information concerning the prospects of the firm and the market value of the firm if it goes bankrupt. Hence, even in this simplified setting we would expect lenders to be concerned with the balance sheet position of the firm, as in Bernanke and Gertler's (1989) model. Ceteris paribus debt will be more easily accessible and cheaper for the firms with low gearing.[7] As their debt-capital ratio rises, lenders will demand more assurances and impose their terms easier. These may be higher collateral requirements and compensating deposits or even exclusion from certain forms and sources of longer term cheap debt, all of which raise the effective average interest charge, r. To capture these effects we allow r to be affected by the gearing ratio of the firm g, i.e.

$$r = r(g), \quad r_1 > 0, \tag{3.3}$$

where

$$g = \frac{B}{qK}.$$

B is the total debt of the firm, K is the fixed capital and q is the (replacement) price of capital.

In reality several debt contracts with different terms and maturities may co-exist among the firm's liabilities. Restrictions, for instance, imposed when old debt was taken out may make new

fect on stationary depreciation charges. The following analysis can be adjusted to take account of such a case.

7 In reality we would expect the gearing ratio to start causing concern to lenders only after it had exceeded some critical level and in conjunction with other information monitored by the lenders. On the other hand, the second hand value of the fixed capital or of the firm as a going concern after bankruptcy may well be below its replacement value used in (3.3). Hence, the following specification can only be seen as a simplification of a more complex reality.

debt more expensive. But these are specific institutional arrangements for one set of debt holders to protect itself against another. The agency costs of the firm's debt as a whole can be expected to be in fact related to the total stock position of the firm. Thus, at this level of abstraction the most reasonable assumption would seem to be that r is capturing the average cost of all such debt and includes, apart from interest charges, other costs like foregone profits due to compensating deposits or any other explicit or implicit term of the debt contract.

We would normally expect the $r(g)$ function to be convex with effective interest charges rising sharply as g tends to unity. All the results that follow hold for any such increasing convex function, but for simplicity we will use extensively a linear version of (3.3) keeping in mind at the same time that $0 \le g < 1$:

$$r = i + bg \quad , \qquad b \geq 0. \tag{3.4}$$

i can be thought of as a minimum lending rate, the effective interest charged by the lenders if they considered the firm risk free. In our model, if the debt market were informationally strongly efficient, the firm under consideration would have been recognized as being default free and b would be zero.

Having specified the cost of the two alternative sources of finance, we can now turn to the optimization problem of the firm. In the absence of taxation, the net profit of the firm is equal to the gross trading profits, $\Pi(K)$, minus the depreciation expenses, $q\delta K$, the interest charges, rB, and the fixed costs incurred each period, FC. For short we denote the net profits with $f(K,B)$ and the net income of owners from other sources with y. Hence the total net income of the owners in any single period is

$$Y = f(K,B) + y \ , \qquad f_1 > 0 \, , \; f_{11} \leq 0 \, , \; f_2 < 0 \, , f_{22} < 0 \, , \; f_{12} > 0. \tag{3.5}$$

Thus, in the start of the planning period ($t=0$) the present value of equity held by the owners is [8]

$$S(0) = \int_0^\infty e^{-\rho t} \, [f(K,B) - C(R, f(K,B) + y) \;] \, dt. \tag{3.6}$$

[8] The time argument will be omitted for clarity in integrals whenever this does not cause any confusion.

The policy of the firm planned at t=0 will have as its objective to maximize $S(0)$. To examine the investment policy we only have to substitute the net new equity, R, from the identity of uses and sources of funds:

$$R \equiv q(I - \delta K) - \dot{B}. \tag{3.7}$$

I is the gross fixed investment and $\dot{B}$ is the net borrowing.

Also for comparison with the standard models, we can introduce adjustment costs in the way we did in chapter 2:

$$I = z(\dot{K}, K) + \delta K, \qquad z_1 > 0,\ z_{11} > 0,\ z_2 \leq 0,\ z_{22} \geq 0.$$

$\dot{K}$ is the net change in fixed capital and $z()$ what we called for short the "installation cost" function. As was mentioned in chapter 2, the $z()$ function can be expected to have a similar shape as that of $C()$ in diagram 3.1 with $\dot{K}$ in the horizontal axis, $(I - \delta K)$ in the vertical.

We can now use the flow identity and (3.7) to rewrite the present value of equity as follows:

$$S(0) = \int_0^\infty e^{-\rho t} \, [f(K,B) - C(q\, z(\dot{K},K) - \dot{B}\, , f(K,B) + y)] \, dt. \tag{3.8}$$

This is the objective functional that we will be using in the rest of this chapter. It is general enough in that it encompasses the traditional micro-dynamic model with a perfect financial system as a special case. In particular, if there are no convex costs of internal finance (β=0 in (3.2)) and the debt market is strongly efficient (b=0 in (3.4)), $C()$ reduces to $(qz(\dot{K}, K) - \dot{B})$ and the firm can borrow at a constant interest rate of i. The present value of the firm in (3.8) reduces to that considered in the previous chapter . In all other cases, however, the present value of the firm depends on the financial credentials of its owners. In particular we can notice immediately that as the income of the owners from other sources, y, rises, the present value of the firm increases. This could give rise to takeover bids if groups with ampler financial resources that were currently not engaged in other major investment projects had inside information. In the spirit of the model of course these kind of bids would involve financial flow costs for the firm that would be taking over.

We next use (3.8) to determine the optimal investment and financial policy of the firm.

3.2 The optimal plan and the stationary equilibrium

The optimal policies of the firm will be chosen at $t=0$ so as to maximize $S(0)$ given the non-negativity constrains for K and B.[9] This is an optimal control problem with state variables K and B and controls $\dot{K}$ and $\dot{B}$. We take y to be unrelated to K and I. If μ and λ are the current value costate variables of K and B respectively, the following conditions must hold for an interior optimum:

$$f_1(1-C_2) - qz_2C_1 = -\dot{\mu} + \mu\rho \tag{3.9}$$

$$qz_1C_1 = \mu \tag{3.10}$$

$$f_2(1-C_2) = -\dot{\lambda} + \lambda\rho \tag{3.11}$$

$$C_1 = -\lambda. \tag{3.12}$$

All functions are evaluated at t.

To facilitate the interpretation of these conditions, we can multiply (3.9) and (3.11) by $e^{-\rho t}$ and time-integrate them. The resulting expressions give us the shadow value of capital and debt at t:

$$\mu(t) = \int_t^{\infty} e^{-\rho(s-t)} [f_1(1-C_2) - qz_2C_1] \, ds \tag{3.13}$$

$$\lambda(t) = \int_t^{\infty} e^{-\rho(s-t)} [f_2(1-C_2)] \, ds. \tag{3.14}$$

From (3.13) the shadow price of capital at t is equal to the discounted stream of its marginal returns from t to infinity. The marginal return of capital in a single period includes the marginal net profit of capital, f_1, as well as the fall in the costs of self-finance because of the higher profits and lower installation costs due to the higher capital, (f_1C_2) and (qz_2C_1) respectively. A similar interpretation can be given for the shadow value of debt λ from (3.14).

Condition (3.10), then, requires that along the optimal path the shadow value of capital is every period equal to the marginal cost of net investment. The latter includes the cost of a unit of

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[9] The analysis could be extended to include the case where the firm is a net lender, i.e. $B<0$. In section 3.4 we consider briefly the possibility that the firm may hold assets other the fixed capital.

fixed capital, q, and the marginal costs of installation and internal finance, z_1 and C_1 respectively. Similarly, (3.12) links the shadow cost of debt with the marginal fall of the self-finance costs when net borrowing is increased by a unit.

The long run steady state equilibrium of this model has many familiar properties. When $\dot{K}=\dot{B}=0$, by assumption $C_1=z_1=1$ and $C_2=z_2=0$. Combining (3.9) with (3.10) and (3.11) with (3.12) we get the optimal steady state policies of the firm for finance and investment:

$$f_1 = q\,\rho \quad => \quad \Pi_1 + q\,b\,g^{*2} = q(\rho+\delta) \tag{3.15}$$

$$f_2 = -\rho \quad => \quad g^{*}b + r = \rho. \tag{3.16}$$

Equation (3.15) is the familiar condition that at the stationary optimum the marginal net profit of capital is equal to the rental cost of capital. There are two unfamiliar features in it, however. First, the marginal net profit of capital, f_1, includes the gains in interest charges from an increase in the size of the firm, qbg^{*2}. Second and more important, the rental cost of capital is based on the opportunity cost of the equity holders ρ, which is not necessarily the same as the safe lending rate, i, as can be seen from (3.16).

The conceptual difference between the opportunity cost and the lending rate, i, is a distinct feature of this approach. In a world with complete information it is difficult to see how the two may differ in the absence of tax or other imperfections, without allowing for infinite arbitrage gains. Hence neoclassical investment models with perfect financial systems have implicitly or explicitly assumed that $\rho=i$ and $b=0$.[10] This leaves the optimal steady state gearing in (3.16) indeterminate, as the Modigliani-Miller theorem on the irrelevance of financial policies would predict. It also makes the effect of ρ and i on investment virtually indistinguishable.

In an environment with imperfect information differences in the perceived alternative investment opportunities of the owners will be more persistent. The opportunity cost, like the profitability of the firm, depends on private information available only to the owners of the firm. Hence the only ones who can take advantage of any wedge between the minimum interest rate

[10] We are abstracting here from questions of risk aversion. If uncertainty matters the two rates will differ but only because of the different risk attached to the underlying assets. The underlying argument still holds.

and the opportunity cost of the firm are the owners of the firm concerned. They, moreover, face an increasing effective interest charge. Consequently, as (3.16) shows, the unconstrained optimum in the financial policy requires that the opportunity cost is equal to the cost of debt *at the margin*. In our model this determines an optimal steady state gearing ratio, g^*. Using for simplicity the linear version of the $r(g)$ function and taking into account the non-negativity constrain on B, this is:

$$g^* = \begin{cases} (\rho - i)/2b & \text{if} \quad \rho \geq i \\ 0 & \text{if} \quad \rho < i \end{cases} \tag{3.17}$$

In what follows we concentrate on the more interesting case in which $\rho \geq i$. This is depicted in diagram 3.2 in the end of the chapter.

In this approach, then, it is not required that lending rates and returns on all assets move necessarily always in line. This allows us to examine the effect of a change in the opportunity cost when the lending rates remain constant and vice versa. We first eliminate g^* in (3.15), using (3.17):

$$\Pi_1(K^*) = q\,(\delta + \rho) - q\,\frac{(\rho - i)^2}{4b}. \tag{3.18}$$

From this it is easy to see that the optimal capital stock is a decreasing function in ρ even when the lending rate, i, remains unchanged, i.e.

$$\frac{\partial K^*}{\partial \rho} = \frac{q\,(1-g^*)}{\Pi_{11}} < 0.$$

The implication is that the optimal steady state capital of different firms will depend on the alternative investment opportunities open to their shareholders. Firms, whose shareholders have a higher opportunity cost, will have, ceteris paribus, lower fixed capital and a higher gearing ratio at the steady state. If on the other hand, differences in the opportunity cost are only transitory (due to temporary information advantages of one group versus an other), then in the long run firms will have an identical capital and gearing policy as the pure neoclassical models would predict.

In theory, the cost of borrowing also affects the steady state capital in this model. If $\rho \geq i$, this is negatively related to any increase of either the minimum lending rate, i, or the slope of the effective interest, b.[11] Their effect comes in a rather indirect way, however. The optimal gearing and the marginal gains in interest charges from higher capital, qbg^{*2} in (3.15), fall with i and b. The firm borrows proportionally less and therefore the importance of having a large absolute size in order to borrow at better terms decreases. In the limit, when the minimum lending rate is higher than the opportunity cost, the firm holds no debt at the steady state and the cost of lending has no impact on the steady state capital.

In practice one would expect this indirect effect of i and b to be of limited importance. If there is any impact of the cost of borrowing on investment, this can be expected to come either through its influence on the return of other assets, ρ, or through the adjustment process, as we will see below.

Before completing the analysis of the steady state, it can be noticed that the positive relation of (3.16) between the opportunity cost, ρ, and the gearing of the firm has been exploited in the empirical investment literature. ρ is often unobserved and can be approximated by the observed quoted lending rate, i, and the gearing ratio of the firm.[12] The relation can be expected to be a non-linear one at high values of g when $r(g)$ is probably also non-linear.

The next section turns to the optimal adjustment process which together with the steady state determine the rate of investment. Our primal aim is to compare this process in the alternative cases where adjustment costs are related to the flow of financial and of real capital. The optimal financial policy is also examined in each model.

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11 From (3.18) we can find that

$$\frac{\partial K^*}{\partial i} = \frac{q\,(\rho-i)}{2b\,\Pi_{11}} < 0$$

$$\frac{\partial K^*}{\partial b} = q\,\frac{(\rho-i)^2}{4b^2\,\Pi_{11}} < 0$$

Similar results follow if $r(g)$ is not linear.

12 See for instance Bernstein and Nadiri (1982).

3.3 The optimal path

Traditionally capital theory has largely ignored issues related to the optimal dynamic path of capital outside the steady state (static equilibrium). In so far as modern theoretical micro-models have analysed such issues, they have usually focused on installation costs or capacity constraints in the capital goods industry as the factors constraining the individual firm from reaching its long run optimum immediately. This makes the rate of adjustment to be primarily determined by exogenous, technological factors which cannot be influenced by policy measures at least in the short run. It is to this strand of literature that we wish to compare with the financial-costs approach. Both are special cases of the model presented above. We consider them separately and contrast the adjustment coefficients derived in each case.

The first order conditions (3.9)-(3.12) together with the transversality conditions determine in theory the optimal dynamic path of the state and costate variables. In infinite horizon problems the transversality condition is typically replaced by the requirement that the optimal path converges to the steady state. The system (3.9)-(3.12) can be reduced to two second order, non-linear differential equations by substituting μ, λ, $\dot{\mu}$, $\dot{\lambda}$ in (3.9) and (3.11) from (3.10) and (3.12). This gives the two following Euler equations:

$$f_1(1-C_2) - qz_2 C_1 = \rho C_1 qz_1 - \frac{d}{dt}(C_1 qz_1) \tag{3.19}$$

$$f_2(1-C_2) = -\rho C_1 + \frac{d}{dt}C_1. \tag{3.20}$$

Following the established procedure in investment literature, we derive the optimal path of investment formally from a linearized version of this system around its long run equilibrium. If K^* and B^* are the long run optimal values of K and B, then the linearized system becomes:

$$\mathbf{J}\begin{bmatrix}\ddot{K}\\ \ddot{B}\end{bmatrix} - \rho\,\mathbf{J}\begin{bmatrix}\dot{K}\\ \dot{B}\end{bmatrix} + \mathbf{H}\begin{bmatrix}K-K^*\\ B-B^*\end{bmatrix} = 0, \tag{3.21}$$

where,

$$\mathbf{J} = \begin{bmatrix} q^2C_{11} + qz_{11} & -qC_{11} \\ -qC_{11} & C_{11}\end{bmatrix}$$

and **H** is the Hessian matrix of the profitability function f, i.e.

$$\mathbf{H} = \begin{bmatrix} f_{11} & f_{12} \\ f_{12} & f_{22} \end{bmatrix}$$

Some of the standard results of the investment literature can now be shown to follow as special cases of the system (3.19)-(3.20) and its linearized version (3.21). We examine below three different models which correspond to alternative approaches found in the investment literature. In the first one, "the neoclassical model", the financial system is assumed to be perfect. The next two examine the case with an imperfect debt market and alternative assumptions about the costs of internal finance.

If the debt market is strongly efficient, our default-free company can borrow all that it wants at a constant interest rate i, so that $f_{12}=f_{22}=0$ and $f_{11}=\Pi_{11}$. Also under the implied perfect information of this approach and in the absence of other imperfections, the opportunity cost ρ will be equal to the lending rate i, as it was argued in the previous section. This makes the optimal steady state debt, B^*, and gearing ratio, g^*, indeterminate. Solving the above system under these conditions and definitizing the solution, we find the familiar flexible accelerator model:

$$K(t) = -[K^* - K(0)]\, e^{-k_1 t} + K^* \quad => \quad \dot{K}(t) = k_1\,[K^* - K(t)]. \tag{3.22}$$

K^* is the steady state capital given by (3.15) when b=0. The speed of adjustment coefficient, k_1, is the absolute value of the negative real root of the characteristic equation,[13] i.e.

$$k_1 = -\frac{i}{2} + \left[\frac{i^2}{4} - \frac{\Pi_{11}}{q\, z_{11}} \right]^{\frac{1}{2}} \tag{3.23}$$

All functions in (3.23) are evaluated at the steady state.

It can immediately be observed that neither the long run equilibrium nor the rate of adjustment to it are affected by the costs of internal finance in this case. Since the lending rate is equal to the opportunity cost, and the owners face an additional cost of raising equity, they will choose to finance investment entirely by debt. Not surprisingly the results for investment are identical to

13 The characteristic equation is $C_{11}(k^2-ik)[qz_{11}(k^2-ik)+\Pi_{11}]=0$, with three additional real roots, two positive and one zero.

that derived from the conventional partial adjustment model with no costs of internal finance, which was considered in chapter 2. This accords to the thesis that under a perfect financial market we can "...ignore the preferences of the firm's owners when considering the firm's decisions"[14] and use as an objective functional the stream of dividends discounted by the market rate of interest. In this case this amounts to ignoring the additional costs incurred by the owners in raising the necessary equity capital.

Next we examine what happens if the debt market is imperfect.

We consider first the case where the owners face no convex costs or constraints in financing their firm, possibly because they possess adequate liquid assets. Contrary to the Modigliani-Miller theorem, the firm has an optimal financial policy which moreover remains constant throughout the dynamic path. As it can be seen from (3.20) when $C_1=1, C_2=0$, the optimal gearing is equal to that established in the steady state in (3.16) and (3.17). The dynamic problem reduces to one of choosing the path of capital alone, the optimal debt being then determined at any moment in time by (3.17).

Formally, when $C_{11}=0$, the **J** matrix is singular and the system of equations (3.21) collapses to one differential equation with one positive and one negative eigenvalue. The optimal path around the steady state capital takes the form of a flexible accelerator model like (3.22), with K^* being determined by the system of equations (3.15)-(3.16). The adjustment coefficient, k_2, is given by:[15]

$$k_2 = -\frac{\rho}{2} + \left[\frac{\rho^2}{4} - \frac{\Pi_{11}}{q\, z_{11}}\right]^{\frac{1}{2}} \tag{3.24}$$

As was the case with the steady state, the introduction of an imperfect debt market stresses the importance of the opportunity cost, ρ, as opposed to the lending rate, i, for the optimal capital policy. Indeed, the striking result of this model is that the lending rate has very little direct effect on either the long run capital or the speed of adjustment to it. It influences the optimal financial policy, as (3.17) revealed, and it may have an indirect effect on the steady state capital in the way

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[14] Nickell (1978), p. 7.

[15] The characteristic equation is $qz_{11}(k^2-\rho k)+\Pi_{11}=0$.

mentioned in the previous section. If we ignore the latter as a secondary effect, however, this model predicts that lending rates will only have an appreciable impact on investment if they affect the return of other assets and hence the opportunity cost ρ.

Setting aside the differences in the predicted financial policy and the role of the cost of borrowing, the investment adjustment process in this approach differs little from that in the neoclassical investment theory examined above. Installation costs play the central role in both cases, being the only reason why the firm does not move immediately to its long run optimum capital. Their similarity comes from the common assumption that the firm has unlimited access to financial capital at a constant cost from at least one source, be it the debt market or the owners themselves. There is a large number of possible variations within this framework but in each case the marginal cost of new finance is constant, at least after a certain point, and the rate of investment is then determined by other costs such as installation costs.

In contrast to the two models above, we consider next what happens if both the debt market is imperfect and the owners have no liquid or collaterizable assets to finance their investment plans. To keep things simple and comparable to the above results, we assume that there are no installation costs, i.e. $z(\dot{K},K)=\dot{K}$. There is some further consideration of this assumption in the next section. The necessary conditions determine an optimal gearing ratio for the firm, though this is no longer constant throughout the dynamic path. Combining (3.19) and (3.20) when $z_1=1$, $z_2=0$, delivers the following condition:

$$f_1 = -q f_2 \quad \Rightarrow \quad \Pi_1 + q\, b\, g^2 = q\ (\delta + i + 2bg\ ). \tag{3.25}$$

This implicitly defines the optimal debt given the fixed capital of the firm at any moment in time. It is clear from it that the optimal gearing falls as the fixed capital of the firm rises, as long as the marginal profitability, Π_1, is decreasing in K.

Since (3.25) plays an important role in what follows, some further comments are here in place. Note first that this relation bears close resemblance to the stationary optimal condition (3.15). In the left hand side we have again the marginal net profit of capital evaluated, in this case, at any point of the dynamic path. In the right hand side the expression resembles again the rental cost of capital. However, the appropriate discount rate in this case is the marginal effective cost of debt $(i+2bg)$. This, as we will see, is *not* generally equal to the opportunity cost of capital, appearing in (3.15), when the firm is not in the stationary equilibrium.

We can interpret (3.25) in the following way. According to our assumptions, in the model under examination the firm faces convex flow costs in raising or reducing equity, but no such costs for the *flow* of new debt or fixed capital. Hence the optimization problem can be reduced to two subproblems, one static and one dynamic.[16] In the former, given the level of equity, as capital and debt increase the marginal profitability falls and the cost of borrowing increases. At the optimum (3.25) will hold, i.e. the marginal profitability of capital will be equal to the effective interest-based rental cost of capital. In the intertemporal problem the insiders choose the flow of net new equity, R, taking into account the cost of internal finance, C. As equity, say, increases, the optimal fixed capital rises, the marginal profitability falls and with it also the optimal gearing and the effective interest cost, as (3.25) shows. This process continues until the firm has accumulated enough equity to bring down the debt-equity ratio to the level where the effective interest is equal at the margin to the opportunity cost of capital as (3.16) showed. In the stationary equilibrium both the effective interest-based and opportunity-based rental cost of capital are equal to the marginal net profitability of capital.

The dynamic path of fixed capital follows in this analysis the path of equity, E. Given $E(t)$ at any moment in time, $K(t)$ can be determined from the increasing concave function $K(E)$ determined implicitly by (3.25) and the stock identity $(E \equiv qK-B)$.[17]

Formally we can derive the optimal path of capital solving the linear dynamic system (3.21) when $z(\dot{K},K)=\dot{K}$. Similarly to the last case above, the J matrix is singular and the system has one positive and one negative eigenvalue.[18] The path approaching the steady state takes the form of a

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16 This case is similar to the problem considered by Steigum (1983).

17 From (3.25)

$$\frac{dK}{dE} = \frac{f_{12}+qf_{22}}{f_{11}+2qf_{12}+q^2f_{22}} = \frac{-2b(1-g)}{\Pi_{11}K-2bq(1-g)^2} > 0.$$

18 The characteristic equation is $C_{11}(k^2-\rho k)\left[q^2f_{22}+f_{11}+2q\,f_{12}\right] + |\mathbf{H}| = 0$,
where $|\mathbf{H}|$ is the determinant of the Hessian matrix $\mathbf{H}$.
Since $(q^2f_{22}+f_{11}+2qf_{12}) = \Pi_{11}-\frac{2bq}{K}(1-g^*)^2 < 0$ and $|\mathbf{H}|$ is positive, this has one positive and one

flexible accelerator model like (3.22), where K^* is again determined by (3.15)-(3.16). The difference with the previous model lies with the adjustment coefficient, which is now:

$$k_3 = -\frac{\rho}{2} + \left[\frac{\rho^2}{4} - \frac{|\mathbf{H}|}{C_{11}(q^2 f_{22} + f_{11} + 2qf_{12})}\right]^{\frac{1}{2}}.$$

All functions are evaluated at the steady state.

It can be written in a more concise form if we use the $K(E)$ function mentioned above, i.e.

$$k_3 = -\frac{\rho}{2} + \left[\frac{\rho^2}{4} - \frac{\Pi_{11}}{q\,C_{11}(1-g^*)}\,\frac{dK}{dE}\right]^{\frac{1}{2}}, \tag{3.26}$$

where $\frac{dK}{dE}$ is the marginal change of the optimal capital when equity changes, evaluated like all other functions in (3.26) at the steady state. An easy, though not strictly correct, way of thinking about dK/dE is to assume for the moment that the optimal gearing ratio remains constant at its steady state value throughout the optimal path. Then $dK/dE = K^*/E^* = 1/[q(1-g^*)]$ and the adjustment coefficient in (3.26) would simplify accordingly. [19]

The most distinctive feature of this adjustment coefficient is its dependence on financial variables. The costs of internal finance play in this model the same role as the installation costs in the previous two. They introduce the necessary convexity that lies behind the partial adjustment to the long run equilibrium. Contrary to the conventional costs of adjustment, however, which have usually a technological interpretation, C_{11} depends on the financial resources available to the owners of the firm and can be affected by economic conditions that have an impact on their net income. To see this more clearly, we can assume that the $C()$ function takes the form given in (3.2). Then along the steady state we have:

$$C_{11} = \frac{2\beta}{Y} \tag{3.27}$$

where Y is defined in (3.5).

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negative root. The same result can be proved if $r(g)$ is strictly convex.

[19] In theory the optimal gearing would only remain constant if there were constant returns to scale and perfect input and output markets, i.e. only if $\Pi(K)$ is a linear function.

In words, the slope of the marginal costs of internal finance are inversely related to the net total income of the owners. If we substitute C_{11} in (3.26) from (3.27), we find that the adjustment coefficient, k_3, depends non-linearly on the total net income of the owners as the diagram 3.3 in the end of the chapter depicts. This relation gives formal support to the argument that liquidity variables, related to the costs of internal financing, influence the accumulation rate of a firm, independently of the marginal profit and the rental cost of capital. For instance, factors, other than the opportunity cost, affecting y, owners' net income from other sources, will have an impact on the rate of adjustment in (3.26) through C_{11}, though they do not affect the long run stationary values. Firms will proceed, ceteris paribus, faster to the same long run equilibrium the ampler the unused financial resources available to their owners. Lower fixed costs, also entering the net income of owners as can be seen in (3.5), will have a similar effect. On the other hand, both of these factors have no influence on investment in either of the two first models considered.

Apart from the adjustment coefficient, the alternative approaches considered also differ, as we saw, on their predictions concerning the optimal financial policy and the initial adjustments undertaken by a firm which is off the optimal dynamic path. Diagram 3.4 in the end of the chapter summarizes the case for the two latter of the models considered. We will call them for short the "installation-costs" model (with adjustment coefficient k_2 in (3.24)) and the "financial costs" model (with k_3 adjustment coefficient in (3.26)). This diagram depicts the relation between fixed capital and total equity of the firm. Equity is defined here to be equal to the current value of fixed capital minus total debt, i.e. $E=qK-B$.[20] The non-negativity constraint on debt together with the fact that firms hold by assumption no other assets than fixed capital, restrict for the moment our attention in the area above the 45^0 degree array from the origin. K^* and E^* are the stationary values of capital and equity determined by (3.15) and (3.16) in conjunction with the stock identity ($qK \equiv E-B$). They are common for both models.

For the installation costs model the optimal capital-equity (and gearing) ratio is constant throughout the optimal path and equal to that of the stationary equilibrium, K^*/E^*. This is

[20] Note that this may be different from the accounting definition of equity. For instance, if there are installation costs for fixed capital, the book value of equity could be higher than that considered here.

depicted in the diagram by the straight line OSA passing through the origin. To see the adjustment path to the long run optimum S, consider an initial position of the firm at C. Here the firm has both capital and equity below the long run optimal values, K^* and E^* and a capital-equity ratio higher than the optimal K^*/E^*. Hence its initial (short term) reaction would be to increase (costlessly) its equity reaching the optimal capital-equity ratio on OSA. Thereafter, (in the medium term) it would follow a policy of proportional increases in capital and equity to the long run equilibrium, S, along the path OS. The adjustment rate along OS depends primarily on the installation costs, $z(\,)$, as (3.24) reveals. Any other initial point not on OSA entails similar immediate adjustments in *equity* that are depicted by the horizontal movements to OSA.

We turn next to the financial model. Here the optimal capital-equity ratio is implicitly determined by the optimal condition (3.25) and depicted by the $K(E)$ function in the diagram. When the firm is growing and the marginal profitability is high, the capital-equity ratio is higher than its stationary optimum, K^*/E^* and vice versa. At the initial position C the firm has a capital-equity ratio below that determined by $K(E)$. In terms of (3.25) this means that its marginal profitability is at C higher than the effective interest-based rental cost of capital. If, as we are assuming, the firm can increase its debt and fixed capital without additional flow costs, its initial (short run) reaction will be to order a block of capital paying for it by new debt. This is depicted by a vertical movement from C to $K(E)$. Thereafter it will proceed to the long run equilibrium along $K(E)$ raising equity more than fixed capital. This medium term adjustment path is approximated in our linearized model by BSB', the tangent of $K(E)$ at S. Along this path the ratio of net fixed investment over the net change in equity, $(q\dot{K}/\dot{E})$ remains constant.[21] The rate of adjustment depends on the costs of *equity* accumulation, as it becomes apparent from (3.26). Any other initial position entails similar short run adjustments in *capital* and *debt*, depicted by vertical movements to $K(E)$ (or BSB' if the linearized model is considered).

Finally we can briefly refer to the first model considered above where the debt market was taken to be perfect and the owners faced convex self-finance costs. The stationary capital is in this

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21 $\dot{K} = \frac{dK}{dE}\dot{E}$ and $\frac{dK}{dE}$ is constant.

case slightly higher than in the previous two models since $b=0$. There is no unique optimal stationary equity level. Adjustment from any initial point, such as C, would follow a vertical movement towards K^* with the rate of adjustment for capital being determined by the installation costs, as (3.23) revealed. Debt-equity would rise continuously as all investment would be financed by new debt.

The differences in the short and medium run adjustments of these models are characteristic of the assumptions made about flow costs and determine what we can loosely call the "direction of causation" between capital and equity. In the financial costs model it is changes in equity that are related to flow costs. Consequently the model predicts that, following parameter changes, fixed capital (orders) will respond initially more than equity and will subsequently adjust with a rate determined by equity accumulation. The opposite can be said about the installation costs model and to some degree about the model with a perfect debt market. These differences will be further explored in the next section where a combined installation and financial costs model is examined.

Concerning finally the financial side of the alternative models, it can be noted that similar divergencies in optimal policies have also been predicted by Baumol et al (1970) and Auerbach (1984), among others. Similar to the financial costs model, they argued that a theory of financial hierarchy[22] would lead us to expect that observed financial policies vary with the marginal profitability of capital. To quote Auerbach (1984, p.38), "...in periods when firms are observed to use more expensive forms of finance, the projects they undertake have a higher marginal product." A correlation between financial variables and the profitability of the firms has been used to test this theory against the hypothesis that financial and real decisions are unrelated. The optimal condition (3.25) seems to support such a relation. In line with Auerbach's argument, a higher gearing ratio does indeed reflect more expensive debt finance and it is easy to see that for $0<g<1$ this is positively (and non-linearly) related to the marginal profitability of capital. If the debt

[22] According to this approach the cost per unit of financial capital will differ depending on the source of finance and possibly the type of contract, e.g. internal equity, debt, new flotations. More expensive sources will thus be used only after cheaper sources have been exhausted. See Myers (1984).

market was assumed to be perfect (b=0), no such relation would be predicted. The same holds for the installation costs model where gearing was predicted to remain constant throughout the optimal path. Note, however, that here, as in Auerbach's model, the firm faces no constraints or rising costs in adjusting the gearing ratio instantaneously, upwards or downwards. In the next section we find that highly geared firms may actually find such adjustments costly and thus remain in the medium run with a debt-equity higher than what (3.25) predicts. In their case the marginal return to capital may actually be increasing while their debt-equity is falling.

In conclusion, in this section we have examined the optimal financial and investment policies of a firm outside its stationary equilibrium. All three approaches considered are variants of the more general model set up in 3.1. In all cases the flexible accelerator model has proved to be an adequate approximation to the medium run optimal adjustment of capital around the stationary equilibrium. The adjustment coefficient, however, differs in the case where the adjustment costs are related to the accumulation of financial (rather than fixed) capital in that it is influenced by what we can loosely call "liquidity factors". These are factors that affect the flow of net income and available liquidity in the hands of the owners. Additionally, the models differed considerably in their predictions concerning the optimal financial policy and the initial adjustments following, say, a shock that would set the firm off its optimal path. Both these issues are further explored in the following section where the installation and financial costs models are combined.

3.4 Integrating the installation and financial costs models

So far we have considered the convex installation and financial costs as competing alternatives. Both were assumed to be effective throughout the range of possible values for the respective variables and to determine the accumulation as well as the de-accumulation process of the firm in the respective models. Such symmetry in the treatment of the two processes is not necessarily true, however. To start with, it has already been noted that the contraction and expansion of fixed capital are likely to involve rather different flow costs. In the former the costs are related with the dismantling of fixed capital and its sale in second hand markets[23]. These, it was

[23] Alternatively the firm may reduce its capital by selling complete subsidiary enterprises. This is further examined in the following chapter where trading in equity claims is considered.

claimed, are likely to be increasing at the margin as the firm has to reduce increasingly more of its fixed assets. The same will not necessarily hold with fixed capital expansion. As was argued in section 2.2, much of the costs in this case, such as transaction and information costs, are probably concave in nature. Thus, a firm with a small share in the total demand for capital goods is likely to face constant or concave installation costs when expanding at least up to a threshold of investment. Below we assume that installation costs for new investment are linear.

A similar case can be made for the flow costs associated with equity. By assumption the owners have initially no assets that can be used as collateral or can be costlessly liquidated. Thus, switching resources into the firm involves either a liquidation or a disutility cost. Both, we claimed, are convex. At the limit there is an absolute credit constraint set by the combined portfolio of the owners. No such constraint exists in buying new assets when switching resources out of the firm. Further, if new asset markets are competitive, new assets can be bought at constant prices. Flow costs in reducing equity are thus constant.[24]

The above arguments suggest that both the installation and financial costs models may be valid and apply in different circumstances. This case may be explained with reference to diagram 3.5 in the end of the chapter. The financial cost model and the path on $K(E)$ (or BSB' for the linearized model) is only relevant when equity is increasing and hence when other fixed assets have to be liquidated or current consumption has to be decreased. Thus, from $K(E)$ only the section OS is relevant. Similarly, the installation costs model is mainly relevant for the case where the firm is disinvesting. In this case the "installation costs" represent actually costs of dismantling and selling in the second hand market parts of the fixed capital of the firm. Hence, only the SA section of the relevant path will be considered. Related to the paths OS and SA are two different adjustment coefficients, (3.26) and (3.24) respectively.

Consider now alternative initial positions, first in the area between OS and SE^*, in I. In this area the firm wishes to increase both capital and equity. Since it faces convex flow costs for the increase of the latter, but no such costs for the former, the initial adjustment will take place with a

24 We return to the costs of equity expansion and contraction in more detail below.

jump in capital, as was explained in the previous section. A similar initial adjustment, this time of equity, will take place from any initial position in III, above the projection of K^*S. In this area the assumptions of the installation costs model hold true.

In area II, the firm has excessive equity but too little capital. It faces neither financial nor disinvestment costs. In this case the firm can move to its stationary equilibrium as soon as delivery lags and capacity constraints in the capital goods industry permit it. Investment orders are equal to the difference between K^* and the initial capital.

Finally, we consider initial positions above OSA, (area IV). The firm has here excessive debt- and capital-equity ratios. No costless initial adjustment is possible since both an increase in equity and a decrease in fixed capital involve increasing flow costs. Also, there is no simple optimal path that leads to the stationary equilibrium S of the form derived in section 3.3. Solving (3.21) for this case, we can see that the flexible accelerator model does not describe adequately the optimal path even for the linearized model (3.21). The adjustment coefficient is not time invariant and investment each period depends on the deviation from the steady state of both fixed capital and equity.[25] Depending on the relative costs of raising equity and decreasing fixed capital, the high leveraged firm may be doing both in order to reduce its high debt charges.

Of particular interest in this case is the fact that this pressure to disinvest may also apply for firms that are highly indebted but have capital below their long run optimum. Such a case is represented by G in diagram 3.5. At this position the firm's marginal return to capital is above the opportunity-based rental cost of capital (see (3.18)). Equity, however, cannot be raised costlessly to replace expensive debt. On the other hand, the effective interest-based rental cost of capital is higher than the marginal return of capital due to high capital-equity ratio (see (3.25)). Hence there is pressure for the firm to disinvest before it can start investing again when enough equity will have been accumulated. Such a case is a good example of an "over-indebted" firm that

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[25] The characteristic equation of the system (3.22) is

$$qC_{11}z_{11}(k^2-\rho k)^2 + (k^2-\rho k)\,[C_{11}\,(f_{11}+q^2 f_{22}+2qf_{12}) + qz_{11}f_{22}] + |\mathbf{H}| = 0,$$

with two roots with positive and two with negative real parts.
We will continue to refer to OSA as the optimal path, for simplicity, although it is clear that other paths to S may exist from IV.

cannot take advantage of good investment opportunities.

The combined approach considered in diagram 3.5 has much more interesting dynamics than any of the single models considered earlier. On the financial side it is interesting to note that there is a clear difference between the short run policies available to low geared and highly geared firms. Firms that are found initially with too low debt-equity ratios (right of OSA) have at least one instrument available for short run adjustment to OSA. The same does not hold for firms initially with a high debt-equity (left of OSA) which, as we argued, may remain highly geared also in the medium run. The implication is that we are more likely to observe "over-leveraged" firms rather than "under-leveraged" ones. Also, firms with high debt-equity will often be observed reducing their leverage at the same time as they are decreasing their capital and raising their marginal profitability. Hence, the monotonically positive relation between marginal return of capital and gearing, suggested in the previous section and by Auerbach (1984), does no hold, unless presumably it is restricted to growing firms on OS. Such a restriction would also rule out firms on SA which are predicted to have constant capital-equity ratios throughout the path.

Turning to fixed capital accumulation, we see that there is a difference in the factors affecting the investment and disinvestment process of a firm. Investment is represented by movements to OS from areas I and II, and movements along OS towards S. As (3.25) and (3.26) reveal, financial factors, such as the cost of debt and the rate and costs of equity accumulation, are the main factors in the investment process. For the disinvestment process, on the other hand, the costs of fixed capital contraction play a predominant role. Along SA the firm is disinvesting at a rate determined by (3.24) where the above mentioned financial factors play no role. To the left of OSA firms are also under pressure to disinvest and both financial and disinvestment costs are important.

These asymmetries between investing and disinvesting and high and low geared firms give rise to a complicated set of comparative dynamics. Below we use this framework to examine the impact of an unexpected but permanent change in the cost of debt. Similar comparative dynamics exercises can be examined for other parameters such as the opportunity cost or parameters affecting the marginal profitability of capital.

By a change in the cost of debt we mean a shift in either the riskless lending rate, i, or the marginal effective cost of debt, b, in (3.4). The results are qualitatively the same in the two cases. Consider the diagram 3.6 in the end of the chapter where the path BS of the linearized model has been omitted for simplicity. A fall in the cost of borrowing increases the optimal capital-equity ratio determined by (3.25) and rotates the $K(E)$ curve from OS_2 to OS_1. The new stationary equilibrium has a higher gearing ratio and optimal fixed capital (from (3.17) and (3.18) respectively). The latter, however, is a secondary effect and can be ignored with little loss of generality. Hence, the new equilibrium is at S_1. The S_1A_1 array (passing from the origin) represents the new stationary capital-equity ratio. It is easy to see from 3.6 that the change in the cost of borrowing has a different impact on fixed capital accumulation depending on the prior position of the firm. In line with our analysis above, at the time of the parameter shift the firm may have been anywhere on the path OS_2A_2 or to the left of it. If it was growing, it would have been on OS_2, with investment being determined by the rate of equity accumulation. Cheaper debt means that it can immediately arrange for new borrowing that will allow it to buy a bulk of new capital. The new position will be somewhere on OS_1, including the new stationary equilibrium S_1. Hence a permanent fall in the cost of borrowing has a strong short run positive effect on investment of growing firms. In the medium run this effect dies down as the firm approaches the same long run optimum capital as before (but with a higher gearing ratio).

This strong short run effect does not necessarily carry through to a non-growing firm, however. If the firm was previously at its long run optimum, at S_2, or along the disinvesting path, S_2A_2, a fall in the cost of borrowing would only lead it to replace some of its equity with new debt (vertical movement from S_2A_2 to S_1A_1). Both the long run capital and the rate of adjustment to it (in (3.24)) are little affected by lending conditions.

Finally, highly leveraged firms have a variety of reactions depending on their position at the time of the parameter change. Below OS_1A_1 the firm finds that the costs of debt fell enough to justify its high gearing and perhaps even an increase in debt. The extra debt goes towards investment if the firm is below its long run optimal capital, K^*, and to the replacement of equity if it had more capital than justified by (3.18). In other cases (left of OS_1A_1) the firm may still find that its effective interest-based rental cost of capital is higher than the marginal return to capital. Hence it will still be under pressure to disinvest at least in the short run.

The analysis above has some interesting policy implications. It suggests that in investment a reduction in the cost of borrowing is hardly a substitute for high profitability. Low interest rates may have a strong short run effects in a growing economy or one that is financially depressed (industry is highly leveraged) but only if profitability was high to start with. In the longer run this effect dies down anyhow and low borrowing costs induce the firms to remain highly leveraged. Further, if profitability is low to start with, this policy may prove largely ineffective apart from allowing the owners to withdraw faster some of their equity.[26]

Note in this respect that a policy aiming towards higher profitability, on the other hand, would rotate $K(E)$ as in 3.6 (see (3.25)), but leave the long run gearing, represented by the array S_2A_2, unaltered (see (3.17)). The new stationary equilibrium would be a point such as H. The policy would have more permanent effects and would also affect a firm which was previously in its long run equilibrium or even disinvesting along S_2H. Further, it would not induce any immediate exit of equity even for a firm that continued to disinvest along HA_2.

The second point we can notice is that the predicted effects from an unexpected increase in the cost of debt are not symmetrical in the short and medium run with those of a decrease in the cost of capital. Contrary to the case examined, an increase in the cost of debt, that will shift the optimal path from OS_1A_1 to OS_2A_2, will probably have a medium run effect on the investment policy of the firm, whatever its initial position. The firm, which previously was located along or to the left of OS_1A_1, will currently find that it is over-leveraged and unable to instantaneously increase its equity or decrease its capital without its owners incurring prohibitively high costs. So, short run adjustment of the form examined above are unlikely to be observed. Firms may be

[26] It has to be stressed here that these conclusions follow from a ceteris paribus analysis of the effects of the cost of borrowing. This, among other things, means that lending interest rates do not affect the opportunity cost, ρ.

forced to slow down their investment and even disinvest under the pressure of high debt charges in the medium run while moving always towards the same long run optimum.

The results above heavily depend on the assumptions concerning the flow costs, so some further comments are here in place. The assumption that equity may be costlessly withdrawn from the firm may be challenged on the grounds that excessive dividends and re-purchase of equity is in many economies heavily taxed or even prohibited.[27] The force of this objection diminishes, however, if we allow for the fact that a firm may own assets in other than its main activities. The switching of finance away from capital can take place in this case within the firm's portfolio.

The second possible objection concerns our assumption that owners possess initially no liquid or collaterizable assets (at the planning period t=0). In view of the previous argument these also include assets owned by the firm itself, such as securities of other enterprises, that do not contribute towards the main productive activities of the firm. If such assets are available, then the previous analysis has to be modified. For example, the initially high-leveraged firm at G, in diagram 3.5, could substitute some of its expensive debt with equity and move to OS, if its owners could raise the necessary equity at a constant flow cost. Even more, if all necessary finance was immediately available, the firms could adjust to the long run optimum S. In other words, the extent to which financial costs and constraints bind depends upon the previous history and the initial portfolio of the owners (at the time of planning t=0).

In this respect, notice that if the firm at t=0 (and before any parameter change) has a capital-equity ratio above the long run optimum, then, ceteris paribus, this firm can be assumed to have no access to liquid or collaterizable assets (or else these would have been used by t=0 to adjust the capital-equity ratio). Hence, for our comparative dynamics analysis the assumption that insiders hold no such assets is a plausible one for a firm found originally on the OS expansion path (excluding the stationary equilibrium) and in the area IV. On the contrary, results have to be modified for the case of firms that were previously on the stationary equilibrium or along a

[27] Notice that this would still leave much of our arguments concerning fixed capital investment in I and II unaffected.

disinvesting path such as SA.[28]

Finally, it has to be stressed that the comparative dynamics exercise above concerned an unexpected change in the cost of debt. Expected changes can be examined within a model with time varying coefficients. As in the models with irreversibility of the investment decision,[29] future expected parameter shifts will affect current decisions, if future initial adjustments (when the shift occurs) cannot be carried instantaneously without costs. In our model, for instance, we would expect a firm to remain below the optimal expansion path OS, investing less than it can, if a future rise in interest rates was expected that would rotate the optimal path to the right as in diagram 3.6.

To summarize, in this section we have combined the installation and financial cost approach in a diagrammatic analysis. This has thrown some light on the very interesting but largely ignored problem faced by firms with good investment opportunities that are forced to disinvest because of their accumulated debt burden from the past. It has also suggested important asymmetries and differences in the factors affecting the investment and disinvestment process of the same firm. The analysis has provided a much richer set of dynamics than any of the earlier models, with interesting implications, among else, for interest rate policies.

3.5 Summary and conclusions

The introduction of imperfect information allowed us to distinguish between the opportunity cost of capital and the cost of debt, even in the absence of other imperfections such as taxation. The two will only be equal at the margin and in the long run, when all adjustment flow costs can be ignored. This established an optimal financial policy for the firm for the short and for the long run, contrary to the Modigliani-Miller theorem. It also allowed us to examine the impact of the opportunity and lending rates on fixed capital accumulation separately. We thus found that the optimal long run capital of the firm will depend on the alternative investment opportunities

[28] For instance, when there is an interest rate rise and the optimal path shifts in diagram 3.6 from OS_1A_1 to OS_2A_2, insiders of firms that previously were at S_1 or along S_1A_1 may have accumulated liquid assets to finance an immediate equity increase and replace expensive debt.

[29] See Nickell (1978), ch. 4.

available to its owners, but it will be largely unaffected by the cost of borrowing.

When this was combined with convex costs for internal finance, we derived a dynamic theory of investment without costs of adjustment of the usual technological nature (installation costs). The accumulation of capital proved to be largely dependent on the accumulation of internal finance (equity) in this model. Consequently, the net income of the owners from the firm and from other sources acquired a central importance in the accumulation process. On the other hand, lending rates and credit constraints were also found to be important in short run adjustments, for they influence the "debt capacity" of the firm, i.e. how much debt the firm will optimally raise for each extra unit of equity. The adjustment path of this model was contrasted with that from an installation costs model with constant financial costs. Their main difference was found to lie with the factors affecting the adjustment path and the implied optimal financial policy of the firm along this path.

The differentiation between the opportunity cost and the (effective) lending rate and the opportunity cost and the additional flow costs of raising equity threw also some light on the important problem of financially depressed firms with good future prospects for expansion. Having exceeded their optimal "debt capacity" (possibly because of a past shock), these firms redirect equity funds towards repaying expensive debt and possibly disinvest before returning to a positive investment path. The diagrammatic analysis in the last section also pointed out interesting differences between the accumulation and de-accumulation process of the firm with possible policy implications.

Critical for our analysis have been the assumptions that there are important convex costs associated with the flow of new internal funds and agency costs that rise with the ratio of the external to internal finance. The particular functional forms used to capture these costs may be challenged, but it would be fair to say that the argument presented here can be expected to be more generally valid. The question of whether the underlying conditions characterize the environment of growing firms is ultimately an empirical one. In the next chapter we make a step towards extending our model allowing for active equity trading.

Diagram 3.1

Costs of Self-Finance.

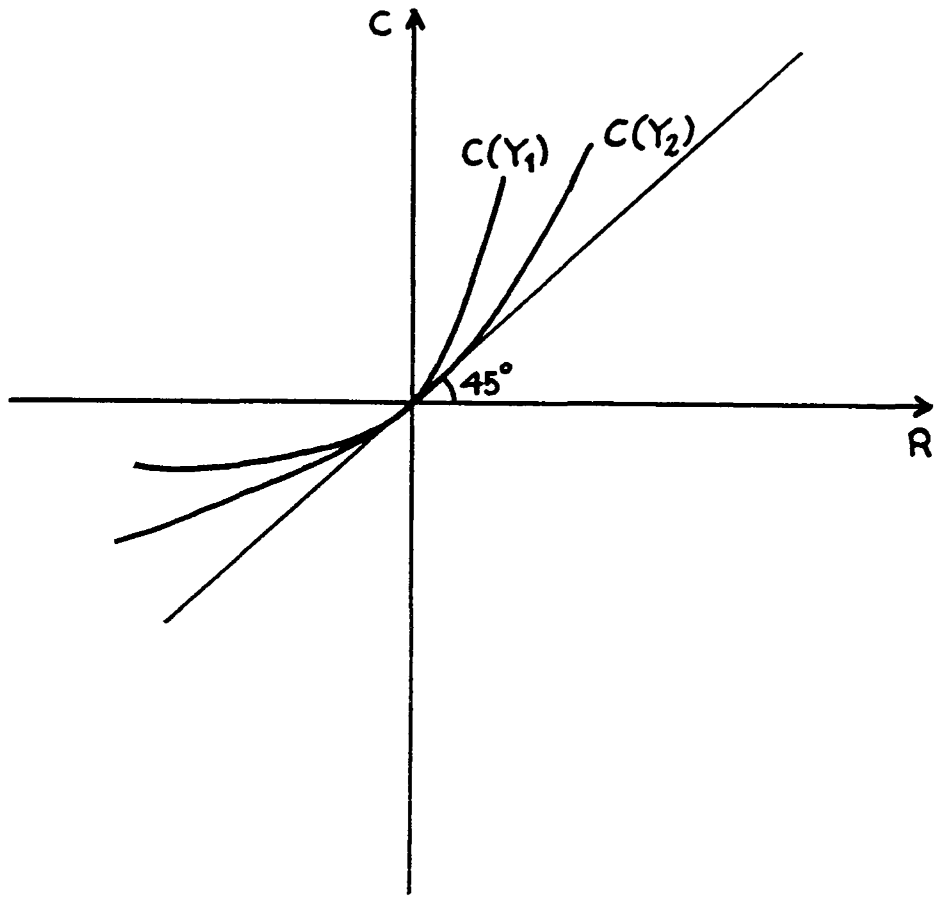


Diagram 3.2

The Optimal Stationary Gearing.

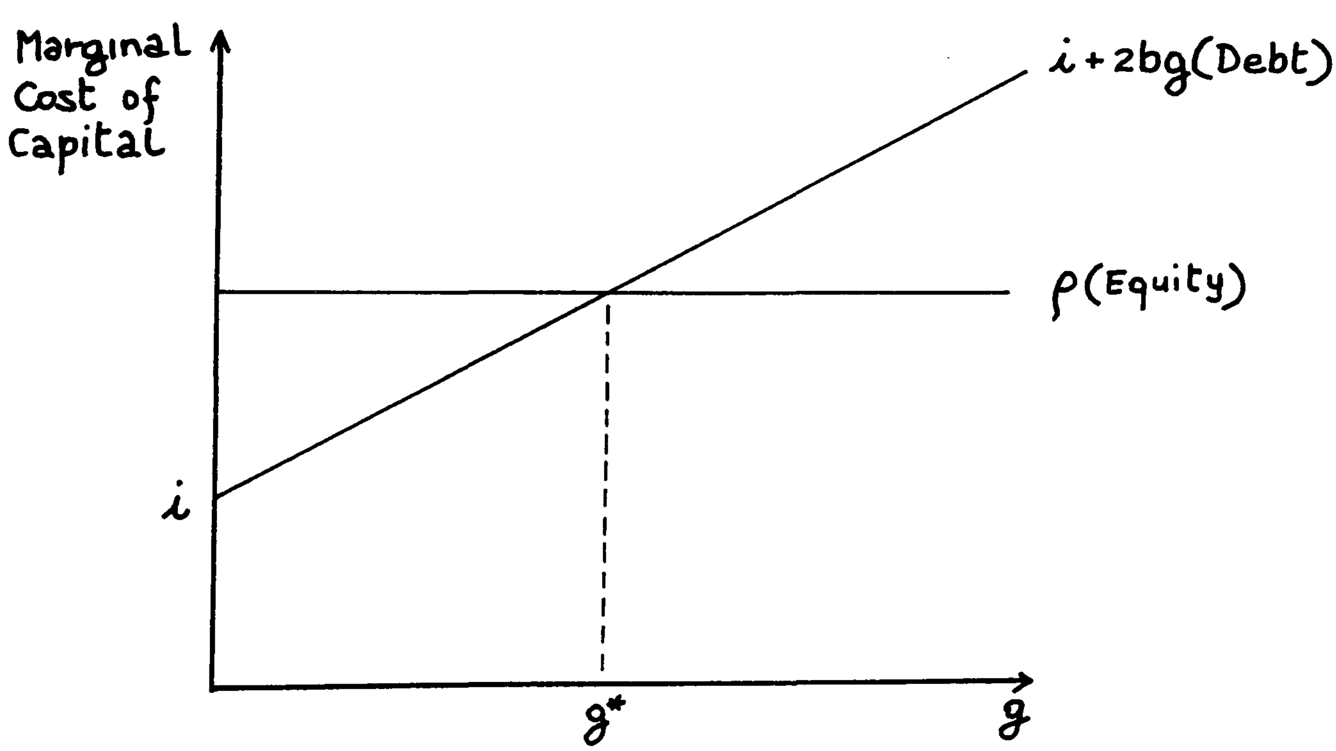


Diagram 3.3

The Adjustment Coefficient and the Net Income of Owners.

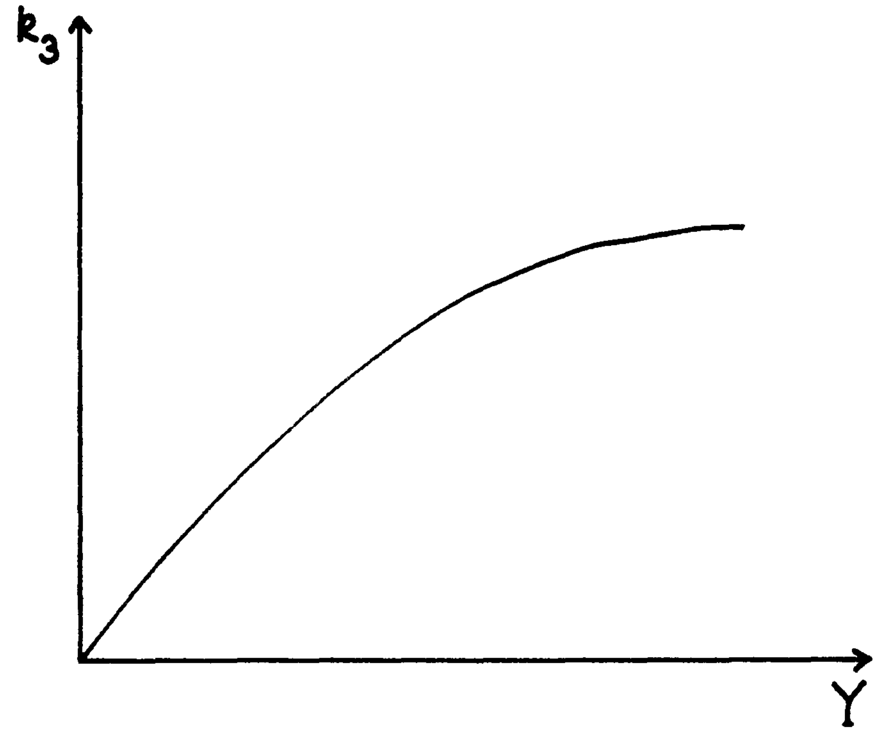


Diagram 3.4

The Adjustment Paths of Capital and Equity.

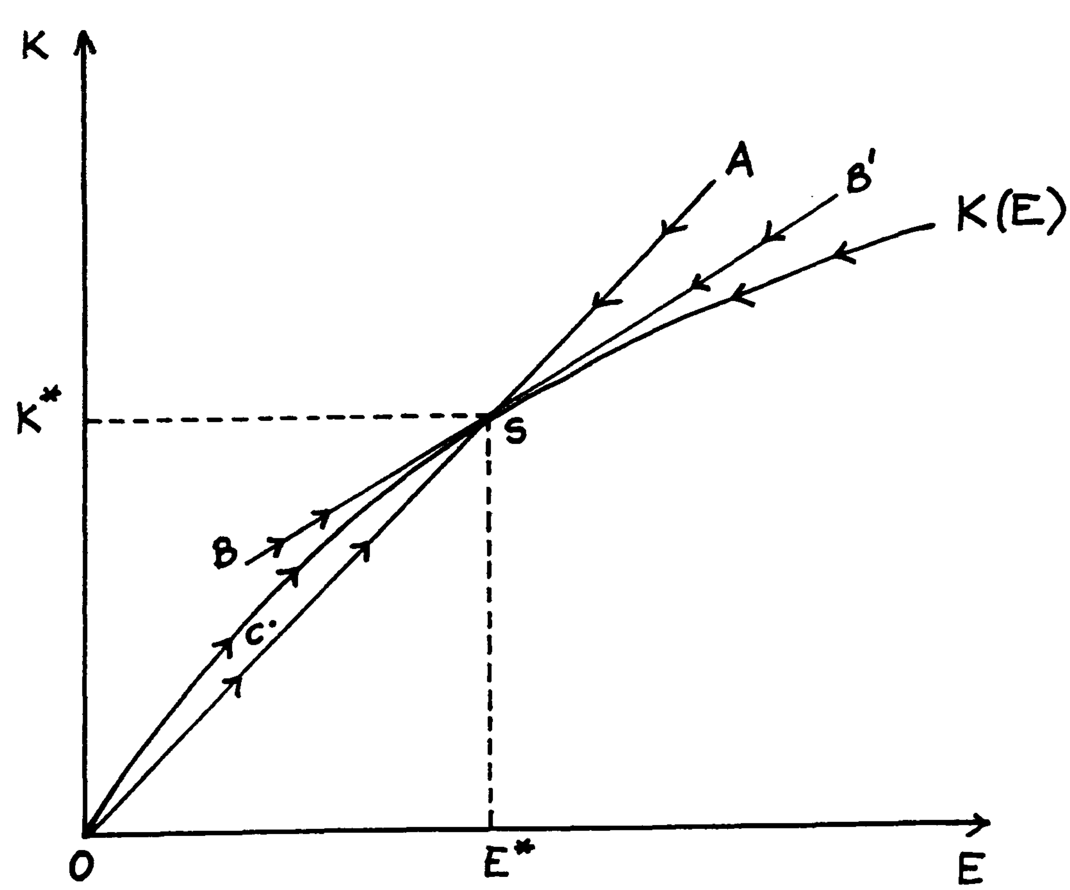


Diagram 3.5

The Adjustment Path of the Combined Model.

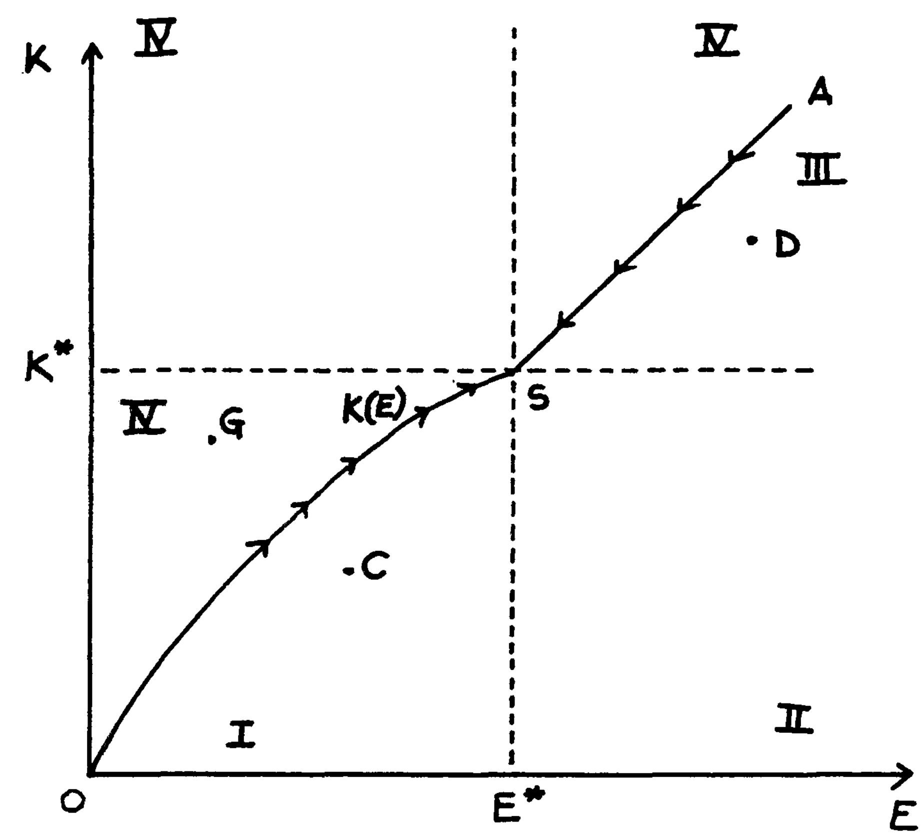
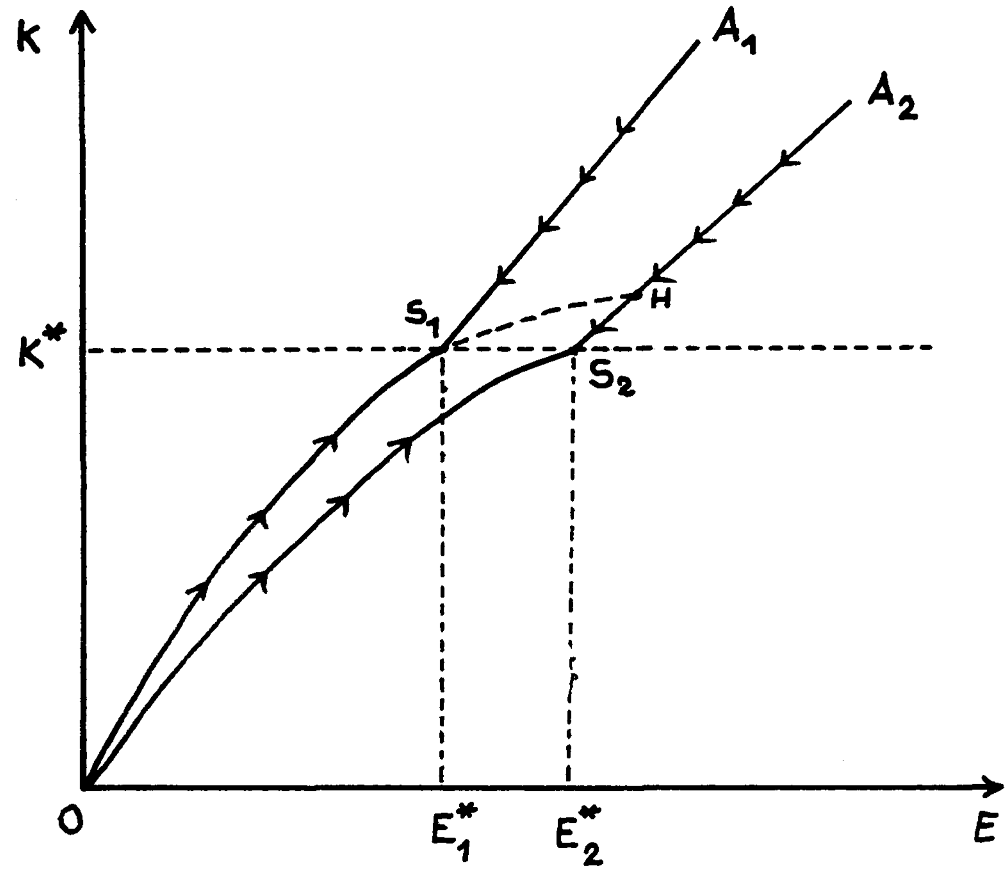


Diagram 3.6

Comparative Dynamics.



Chapter 4

THE EFFECT OF THE STOCK MARKET ON INVESTMENT

In the financial costs model of the previous chapter capital adjustment was found to be largely determined by the rate of equity accumulation by the insiders. A natural extension of this framework is to allow for the possibility of trading shares in order to examine how equity finance from outsiders may affect our previous results. An additional reason for such an extension is that the stock market and its relation to real decisions has been the focus of much of the existing investment and financial literature. It is also the main subject matter of this chapter.

So far in our analysis equity claims have carried a special right for its holders, that of having access to the private information and the decision making process of the firm, i.e. the right to be an insider. This needs some re-examination when equity trading is introduced. Also, the introduction of a non-strongly efficient stock market requires that we specify how outsiders with incomplete information price shares. Both these issues are taken up in section 4.1. The resulting model has much in common with that of the previous chapter. In section 4.2 we find that the introduction of equity trading leaves the static equilibrium intact, but has an impact on the adjustment rate in the financial model of investment. In the linearized version around the stationary equilibrium, in 4.3, the capital accumulation process is found to be adequately described by a flexible accelerator model, with the coefficient being affected by stock market variables reflecting the role of the market as a new source of equity finance. The analysis is completed with a re-examination of the informational content of stock market prices and of Tobin's Q within a model with an inefficient or even an irrational equity market in 4.4. Section 4.5 summarizes and concludes.

4.1 Equity market, information and control

Debt has been so far in our model the only type of claim that the firm can sell to draw outside finance. We now introduce a stock market as another possible source of financial capital. New equity flotations by the firm will be reflected in the flow of funds identity, which now becomes:

$$q\,(I-\delta K) \equiv R+\dot{B}+nA. \tag{4.1}$$

A denotes the number of new equity claims sold by the firm to outsiders in any single period.[1] With no loss of generality we define the number of outstanding claims at any moment in time to be $E=qK-B$. The face value of each claim adjusts accordingly.[2] Equity claims are traded in the market for the price of $n(t)$.

Apart from the firm, shareholders may also sell equity claims privately to outsiders in secondary distributions. Such transactions serve to reduce the owners' net new placements in the firm in any single period and increase their current income. Thus, if for the moment we assume that the firm has currently a single owner, his costs of self-finance will be

$$C = C(R-nN\,,f+y).$$

N is here the number of equity claims sold in secondary distributions at the price of $n(t)$.

Finally, we have to consider separately the case of equity trading between firms when this involves the transfer of control of complete production units. For the individual firm these transactions are in effect an alternative way of investing or disinvesting in fixed capital, possibly without incurring important installation or dismantling costs. Hence, they have to appear in the equation of motion of capital. At the same time, equity titles of established production units are likely to be sold at a market price reflecting their present value, rather than at their replacement cost q. Thus, they would have to appear in the flow of funds identity (4.1) separately, with a different price than the rest of the investment.

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1 Note that new issues sold to existing shareholders (e.g. rights' issues) are continued to be treated as internal finance and are therefore included in R.

2 For instance, if there are no installation costs the face value of an equity claim will be one monetary unit.

With little additional notation these transactions could be introduced in our formal model, but in practice one would expect that they take place only subject to the (infrequent) availability of relevant opportunities to be properly considered as choice variables of the firm. Further, provided that they take place in a market with similar characteristics with the rest of the equity market (in effect demand and supply are not perfectly elastic), their introduction would add little new insight for the investment process of the individual firm.[3] We therefore abstract from them in the formal model below.

Having formally introduced in our model primary and secondary equity distributions, we now have to take account of the dilution of ownership that these imply. The problem is complicated by the fact that equity carries a claim not only to future earnings but also, in principle, to private information and control of the firm. The complications involved can best be explained with an example.

Consider a firm which is run by a single shareholder with the majority of shares. At $t=0$ he plans a certain policy that involves a future dilution of ownership either through new flotations or secondary distributions. A first problem is that the dilution of ownership may involve a future loss of control. If the original decision maker still has a stake in the firm after that, he has to take into account the objectives of the future controlling group. On the other hand, even if control is not lost, new shareholders may still have access to private information. This will presumably be reflected in equity prices, as non-controlling shareholders use their information to deal in the market. Hence, once again the decision maker has to make some conjecture about the preferences of other existing or potential shareholders.

One way of dealing with these complications is to assume that the controlling group does not anticipate any hostile takeover bid and non-controlling shareholders have no access to private information. This could be a reasonable assumption when equity ownership outside the controlling group is highly dispersed. Equity financing differs little from debt financing in this case, and the model of the previous chapter can easily accommodate such an extension.

[3] In the aggregate these transactions are netted out, but may still play a role since they redistribute liquid assets and rights of control and information.

More interesting for our purposes is the case where equity sales widen the group of insiders and hence the future potential source of internal finance. This is most likely to be the case if equity is held by few large groups of shareholders, all with important stakes in the firm and access to inside operations of the firm. For this more demanding problem to be tractable, we have to impose a certain degree of uniformity between shareholders at any moment in time, so that there is no conflict of interests among them. Such unanimity is a rare phenomenon in the real world. In this, however, we follow the established investment literature, which, for the most part, has focused on markets rather than internal operations of the firm, usually using the assumption of a perfect capital market. Since financial imperfections are the very focus of this analysis, unanimity is imposed instead by a number of "linearity" assumptions that ensure that the present value of an equity claim at any moment in time is the same for all shareholders, regardless of their share of total equity. In particular the following assumptions are made:

Assumption 1: At any moment in time all shareholders face the same opportunity cost and the same cost function for internal finance, $C(\,)$.

Assumption 2: The cost function, $C(\,)$, is linearly homogeneous in its two arguments.

Assumption 3: In any single period, the income from other sources, y_j, of any shareholder, j, is proportionate to his share of equity holding. In other words, if j ow s s_j of total equity and y is the total income from other sources of all shareholders, then $y_j = s_j\, y$.

Assumption 4: The secondary offerings of equity by any shareholder in any single period, N_j, are proportionate to his equity share, i.e. $N_j = s_j\, N$.

The proportionality imposed by these assumptions hints towards an implicit hypothesis that portfolios of different shareholders are identically structured, though of different sizes. We do not pursue this point further, however, since there is no presumption that assumptions 1 to 3 represent necessarily any aspect of reality. They are defended instead on the grounds of tractability of the model, while we argue below that they are not essential to the argument. Assumption 4, on the other hand, can be seen as a short cut to what would normally be a decision taken within a game theoretic framework. If one shareholding group realizes that the equity transactions of another group holding shares in the same firm affect equity prices, as we argued, then the decision of how much equity to sell has to be taken within a dynamic oligopolistic framework. Assumption 4 is imposed as a solution to this game.

If assumptions 1 to 4 hold, we can easily see that at any moment in time the following is true:

$$C(\, s_jR-nN_j\,,\, s_jf+y_j\,) \;=\; s_j\, C(\, R-nN\,,\, f+y\,) \quad , \quad \text{for } every\ j \tag{4.2}$$

In words, the costs of self-finance faced by the shareholder j are proportional to his equity share. From (4.2) it follows that the value attached to equity held by j at time τ is equal to:

$$S_j(\tau) \;=\; \int_{\tau}^{\infty} e^{-\rho(t-\tau)}\; s_j(t)\; [\, f(\, K\,,\, B\,) \;-\; C(\, R-nN\,,\, f+y\,)\,]\; dt. \tag{4.3}$$

Equity dilution can now be introduced by examining how primary and secondary distributions affect the equity share, s_j, of a random shareholder j.

Given assumption 4, it is easy to show that the rate of dilution is the same for all shareholders and equal to the primary and secondary distributions during the period over the total existing equity of the firm,[4] i.e.

$$\frac{\dot{s}_j(t)}{s_j(t)} \;=\; -\,\frac{A(t)+N(t)}{E(t)}. \tag{4.4}$$

Solving the differential equation we find

$$s_j(t) \;=\; s_j(\tau)\; e^{-D(t-\tau)}, \tag{4.5}$$

where

$$D(t-\tau) \;=\; \int_{\tau}^{t} \frac{A+N}{E}\; dv. \tag{4.6}$$

In words, the equity share of j at time t is equal to his initial equity share, say at τ, multiplied by a dilution factor, akin to a discount factor, which depends on the rate of dilution

[4] We know that: $\dot{E}_j = s_j(\dot{E}-A)-N_j$
Given assumption 4, this can be written as $\dot{E}_j = s_j(\dot{E}-A-N)$.
Substituting $s_j = E_j \,/\, E$ and rearranging, we find (4.4)

throughout the period $[\tau\,,\,t]$. Note that the dilution factor, $e^{-D(t-\tau)}$ is the same for all shareholders (due to assumption 4).

Substituting (4.5) into (4.3), we find that

$$S_j(\tau) \;=\; s_j(\tau) \int_{\tau}^{\infty} e^{-\rho(t-\tau)-D(t-\tau)} \;[\, f(K, B) - C(R-nN\,,\, f+y)]\; dt \qquad (4.7)$$

$S_j(\tau)$ is the value of equity held only by j shareholder. We can nevertheless see that it can be used as an objective functional at τ for the firm as a whole. For this first notice that $s_j(\tau)$ is a constant. Further, the integral in the right hand side, representing the value of total equity (when $s_j(\tau)$=1), is common for all shareholders. Hence, its maximization is their common objective at τ. Further, this policy is in theory also time consistent. If it is optimal for j shareholder at τ, it will also be optimal for him at some future date t.[5] If it is optimal for j at t, then, according to (4.7), it will also be optimal for any other shareholder, including those that joined after the initial period τ. In short, equity shares at the time of planning (or replanning) do not matter in this model. Hence, with no loss of generality we can set below $s_j(0)$=1 and consider as objective functional the present value of total equity at t=0, which we denote with $S(0)$.

To summarize, we have formally introduced in our model primary and secondary equity trading and the dilution of ownership that these cause. In order to avoid issues of conflict among shareholders and time inconsistency of optimal policies, we had to assume an unusual degree of unanimity among shareholders at any moment in time. Unlike the models with perfect capital markets, however, our assumptions still allow us to examine the impact of the financial resources available to the owners on the value and optimal policy of the firm, as we did in the previous chapter.

To complete the optimization problem, we only have to determine how shareholders form their expectations concerning the market price of equity shares, $n(t)$. For this, they have to conjecture what the demand of outsiders for equity claims of their firm will be at each point in the future.

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[5] According to Bellman's principle of optimality.

In section 2.4 we referred to empirical evidence which suggest that the demand for both primary and secondary equity offerings is not perfectly elastic. Two non-mutually exclusive interpretations were given. Firstly, it was argued that the stock market may not be perfectly competitive, despite the large number of traders, possibly because equity claims of different firms are not perceived as perfect substitutes. In the short run at least the market price of a share may fall with primary and secondary distributions in order to attract investors that preferred to hold other assets. Prices may recover in the longer run, when perfect matching is completed. [6] More in line with our argument, the second interpretation focuses on asymmetric information. Outsiders are assumed to have limited information concerning factors affecting the present value of an equity claim. Hence, the market price may differ from the present value attached to an equity claim by insiders. The higher is the wedge between the two, the larger is the equity offering ceteris paribus. Accordingly, outsiders take offerings to be a negative signal and react by lowering the price at which they are willing to buy a share. Prices recover as new information becomes available to the public in the future.[7] Both comments above suggest that insiders should reasonably expect the demand for equity at any single period to be non-perfectly elastic, as diagram 4.1 in the end of the chapter shows.

The effect of an equity distribution on prices may be expected to be smaller, the larger the outstanding equity is. By holding on to a large percentage of the firm's equity insiders are giving the signal that they are not trying to pass to the market bad shares. In this case $n(t)$ can be written as a decreasing function of the dilution rate, $\dot{D}(t)=[A(t)+N(t)]/E(t)$. A linear version of this function is the following:

$$n(t) = \bar{n}(t) - h\,\dot{D}(t), \quad h>0. \tag{4.8}$$

$\bar{n}(t)$ is the insiders' prediction of the opening price at t, i.e. the price established in the market before any equity offering by the insiders. There is no single simple pricing mechanism for claims when the prospective buyers lack important information about the prospects and future

6 Note that in this argument shareholders are not as uniform as they were assumed in our model.

7 Incomplete aggregation of information reinforces also the first argument concerning competition. Substantial offerings can only be sold at lower prices to attract less informed and more hesitant buyers.

policies of the firm. Thus, predictions from insiders about opening prices of equity will also vary. To establish some general rule, we can assume that the market processes information relatively fast and equity prices at t are expected to reflect all available public information by that time, such as the net profitability (or earnings per share) of assets *in place*. Thus, the present value attached to a share by outsiders (before any equity offering) can be expected to adjust with the current average net profitability per share. If opening prices reflect this present value, they can be expected to take a functional form such as

$$\bar{n}(t) = \frac{1}{\rho} \frac{f(K(t), B(t))}{E(t)} + e(t). \tag{4.10}$$

The first term in the right hand side is the present value of an equity claim (using insiders' discount rate) if current average profitability of the firm is projected in the future. It coincides with the present value attached to an equity claim by insiders *at the stationary equilibrium*. The second term, $e(t)$, captures the expected reactions of the market on other public news, including the announcement and undertaking of new investment projects by the firm. We assume that insiders take these variations in the equity price to be exogenous. Further, with little loss of generality, we assume that in the neighbourhood of the stationary equilibrium $e(t)$ is expected to be zero. The underlying idea is that in the long run (at the stationary equilibrium) the equity market can be expected to behave as if it were strongly efficient.

Pricing mechanisms in the equity market are no doubt much more elaborated than what (4.8) and (4.10) suggest. Our intention here is not to describe in detail such a mechanism but to set a workable framework for our investment analysis that captures the main characteristics mentioned in earlier chapters. The single most important assumption for our analysis below proves to be that of the non-perfectly elastic demand for shares by outsiders at any moment in time, which was discussed in chapter 2.

To restrict the necessary notation below, we will express with $m(\,)$ the total revenue of insiders from equity distributions. Thus, using (4.8) and (4.10) we can write:

$$\begin{aligned} m(\dot{D}, K, B) &= n(\dot{D}, K, B) \quad (A + N) \\ &= (\bar{n} - h\dot{D}) \quad (qK - B)\ \dot{D} \end{aligned} \tag{4.11}$$

Using (4.11) and the flow of funds identity (4.1) the objective functional of the firm at $t=0$ becomes:

$$S(0)=\int_0^{\infty} e^{-\rho t-D(t)}[f(K,B)-C(qz(\dot{K},K)-\dot{B}-m(\dot{D},K,B),f(\,)+y)]dt \tag{4.12}$$

When compared with (3.8), the objective functional in (4.12) summarizes all the new issues raised in this section with the introduction of equity trading. Insiders can reduce their costs of internal finance, C, by selling equity claims (both primary and secondary distributions are included in $\dot{D}$). The total expected revenue received from these sales each period, m, depends on the assets in place, or state variables of the firm at the time of the sale. The tradeoff is that the ownership is diluted, as the dilution factor, $e^{-D(t)}$, reveals. Under our linearity assumptions this does not affect the objective of the firm, which is still the maximization of the value of total equity, $S(0)$.

Next we use (4.12) to determine the optimal investment and financial policies of the firm. We compare these with the policies derived in the previous chapter and focus in particular on the new issues raised by the existence of an active equity market.

4.2 The optimal plan and the stationary equilibrium

With the introduction of the equity market, insiders have four choice variables each period; investment, borrowing, primary and secondary distributions of equity. The latter two enter the present value functional in (4.12) in an identical way (through $\dot{D}$), which means that insiders are indifferent between them as channels of selling equity to the market. In other words, in the frictionless model considered here, higher retentions combined with private sale of equity have the same effect on present value with that of a higher new flotation with a corresponding decrease of retentions and secondary distributions.[8] Thus, in what follows we only need to consider the

[8] An optimal mix between the two could be established if imperfections such as distortionary taxation or signaling effects of dividends were introduced, with little effect on the rest of the analysis. Even in these cases, however, it is important to notice that an active secondary equity market may play the same role financing investment as a new equity market. Data exclusively on new flotations reveal nothing about the financing functions of the equity market.

aggregate sales of equity by insiders each period, $(A+N)$, or the aggregate dilution rate, $\dot{D}=(A+N)/E$.

Formally, the optimal dynamic plan maximizing $S(0)$ in (4.12) must determine the net investment, $\dot{K}$, net borrowing, $\dot{B}$, and dilution rate, $\dot{D}$, each period. Related to these controls are the three state variables, K, B, D and the current value costate variables μ, λ and ψ respectively. The plan maximizes $S(0)$ subject to the non-negativity constraints for K, B and $\dot{D}$. For an interior solution the following conditions must hold:

$$e^{-D}\ [f_1\ (1-C_2)+C_1\,(m_2-qz_2)] = -\dot{\mu}+\mu\rho \tag{4.13}$$
$$e^{-D}\ qz_1\,C_1 = \mu \tag{4.14}$$
$$e^{-D}\ [f_2\ (1-C_2)+C_1\,m_3] = -\dot{\lambda}+\lambda\rho \tag{4.15}$$
$$e^{-D}\ C_1 = -\lambda \tag{4.16}$$
$$-e^{-D}\ [f-C] = -\dot{\psi}+\psi\rho \tag{4.17}$$
$$e^{-D}\ C_1\,m_1 = -\psi. \tag{4.18}$$

All functions are evaluated at t.

Equations (4.13) to (4.16) refer to the optimal investment and debt policies and have similar interpretations with that of the optimality conditions (3.9) to (3.12) in the previous chapter. The dilution factor $e^{-D(t)}$ appears in all equations since the program maximizes the wealth of the *original* shareholders, i.e. those who held 100% of total equity at $t=0$. Their share at t is equal to $e^{-D(t)}$, according to (4.5).

Equations (4.17) and (4.18) refer to the optimal dilution policy. Combining them, we can easily find the following condition:

$$C_1\ m_1 = S \quad => \quad C_1\ \frac{\partial m}{\partial(A+N)} = \frac{S}{E}. \tag{4.19}$$

All functions are evaluated at t.

This reveals an important arbitrage condition. Each period insiders will continue to trade in the equity market until the present value that they attach to an equity claim, S/E, is equal to the marginal return from selling shares, taking into account that the extra revenue reduces also the costs of internal finance, C. The interesting feature of this condition is that it links share prices with *equity market*. It relies only on the argument that insiders will explore every opportunity to make an arbitrage gain, by selling shares, say, when they believe these are overvalued in the market. Prices of shares will then fall and so will insiders' marginal costs of internal finance until (4.19) holds. Since this argument proves to be important for our subsequent analysis, some further comments are here in place.

First, notice that (4.19) only holds if insiders are not constrained in the number of shares they can buy or sell. In our simple model, by hypothesis, all shareholders at any moment in time belong to the decision making group. Thus, A and N cannot be negative, for the market holds no shares to sell. In an alternative specification we could allow for the case where not all shareholders have access to inside operations. Decision making power would rest only with a subgroup of owners, who would not necessarily be constrained from buying back equity when market prices were depressed. Departing from the above simple framework, however, may raise another more fundamental constraint for A and N. If there are separate subgroups of owners with different access to inside operations of the firm and possibly conflicting interests, present insiders may wish to hold a minimum share of total equity for fear of losing the control of the firm. When this constraint binds, insiders will stop short of meeting all the demand for shares when market prices are overvalued and (4.19) will hold as an inequality.

Second, condition (4.19) links the market price with the present value of equity, but does not imply that the two are equal, as is the case of models with a strongly efficient equity market. First of all, in the left hand side of (4.19) appears the *marginal* revenue from equity sales. If the demand is downward slopping, as was depicted in 4.1, the marginal revenue would normally be lower than the observed prices. Second, even this marginal revenue deviates from the present value of an equity claim by a factor that depends on the marginal costs of internal finance, C_1. Insiders who are already retaining much of their income in the firm, have a high marginal cost of internal finance and are therefore more willing to sell in the stock market, some times even at prices below the present value they attach to a share, as (4.19) shows. Conversely, they may be willing to buy even at high prices, if they find themselves with excess liquidity. Note in this juncture that the existence of the unobserved costs of internal finance are essential to the making juncture that the existence of the unobserved costs of internal finance are essential to the making of the stock market under asymmetric information. Without them outsiders would only have to observe which way insiders were willing to trade in order to find out whether market prices are over- or undervalued, as in Majluf and Myers (1984). The unobservable costs of self-financing introduce the necessary noise and permit trading not only for matching purposes but also for speculation.[9] Each period an unidentifiable number of insiders is expected to be willing to sell, not because they believe that shares are overvalued in the market, but because they find the implicit costs of the necessary savings in the firm too high. For outsiders part of the attraction in buying shares derives often from the belief that they have identified such a seller in advance of the rest of the market.

The optimality condition (4.19) is part of the dynamic system (4.13)-(4.18) and the optimal dilution rate, or the number of shares sold, can only be found by solving the entire investment-finance problem. Nevertheless, a tentative conclusion is that the number of shares offered in the market by the insiders each period will be, ceteris paribus, inversely related to the ratio of the present value attached to an equity claim (before any offer) over the opening market price of such a claim. This in turn justifies why the size of the offering may be used as a negative signal by the outsiders, as was argued in the previous section.

We can next turn to the stationary equilibrium of the dynamic system (4.13)-(4.18). The first four conditions deliver the same optimality relations, (3.15) and (3.16), derived from the model of the previous chapter. Hence, the introduction of an equity market leaves the optimal static capital and debt of the firm unaffected. The reason is easy to see. Under our assumptions all shareholders at any moment in time agree on the optimal policy to be followed by the firm. Thus, despite the fact that the ownership structure changes with the introduction of an equity market, the decision making rule for a static optimum remains the same. As we will see, the equity market is important only because of its impact on the adjustment process outside the static equilibrium.

[9] Note that it is not only present but also future costs of internal finance that enter in (4.19), through S, about which the outsiders are even less likely to have reliable information.

Conditions (4.17) and (4.18) deliver a third stationary condition that refers to the market price of equity:

$$m_1 = \frac{1}{\rho} f \quad \Rightarrow \quad \frac{\partial m}{\partial (A+N)} = \frac{1}{\rho} \frac{f}{E^{\bullet}}. \tag{4.20}$$

All functions are evaluated at the stationary equilibrium.

This reveals that, for the firm to settle in an unconstrained static equilibrium, the equity market would have to behave in the long run as if it were strongly efficient. To see this, notice that the marginal revenue from selling shares, $\partial m / \partial (A+N)$ is equal to the opening price of equity $\bar{n}$, when $(A+N)=0$ (at the stationary equilibrium). The right hand side represents the discounted average net profitability or else the stationary present value attached to an equity claim by insiders. The two would be equal in a strongly efficient stock market where all traders faced the same opportunity cost, ρ. The same, however, could follow from a backward looking equity market, as was argued in the previous section (see (4.10)). In other words, the concept of long run static equilibrium, which has proved useful in capital theory, is not necessarily inconsistent with a perception of an equity market that is neither as well informed nor as forward looking as it has usually been assumed in investment models. We thus continue to use it as an organizing concept below.

Concluding, we can note that so far our departure from the neoclassical approach has left deliberately much of its long run static properties intact. At the static equilibrium the optimum capital is determined by the rental cost of capital and its marginal profitability; the cost of debt and equity are equal at the margin; and the ownership structure of the firm is of no relevance. An alternative specification could undoubtedly change some of these results. They do represent, however, the conventional wisdom in capital theory and probably an intuitive set of conditions for a notional static equilibrium. Our purpose is to show that this static analysis does not exhaust the economic issues related to investment. The dynamic path of investment is not affected only by "technological" factors, such as the capacity in the capital goods' industry or installation costs, but also from financial factors which are affected by economic conditions. In the next section we turn to such dynamic issues. The focus is on the financial costs model, where the introduction of a source of equity finance can be expected to have the major effect on investment.

4.3 The optimal path

Following the established methodology for infinite horizon problems, we consider the optimal path that converges to the stationary equilibrium. This convergence also replaces the transversality conditions in our problem. Much of the analysis in this section refers to a firm in the neighbourhood of such an equilibrium. Note that *at* the static equilibrium the stock market price is by hypothesis equal to the present value attached to an equity claim by the insiders. Hence, our formal analysis here is largely restricted to the case where opening prices reflect correctly the "fundamentals", but demand is not necessarily perfectly elastic. This proves to be sufficient for an extension of our financial costs investment model. Using somewhat loose terminology, we can say that in our formal analysis below we examine the effects on investment of the introduction of an equity market which is efficient but not necessarily perfectly competitive. In the end of the section we discuss briefly and informally the consequences of share market opening prices drifting away from fundamentals.

Substituting out the costate variables and linearizing around the stationary values of capital and debt, K^* and B^*, derived from (3.15) and (3.16), the system (4.13) - (4.18) becomes:

$$\mathbf{G}\begin{bmatrix}\ddot{K}\\ \ddot{B}\\ \ddot{D}\end{bmatrix} - \rho\,\mathbf{G}\begin{bmatrix}\dot{K}\\ \dot{B}\\ \dot{D}\end{bmatrix} + \mathbf{Q}\begin{bmatrix}K-K^*\\ B-B^*\\ D\end{bmatrix} = 0, \tag{4.21}$$

where,

$$\mathbf{G} = \begin{bmatrix} q^2C_{11}+qz_{11} & -qC_{11} & -m_1qC_{11}\\ -qC_{11} & C_{11} & m_1C_{11}\\ -qC_{11}m_1 & m_1C_{11} & -m_{11}+m_1^2C_{11}\end{bmatrix}$$

and

$$\mathbf{Q} = \begin{bmatrix} f_{11} & f_{12} & 0\\ f_{12} & f_{22} & 0\\ 0 & 0 & 0\end{bmatrix}$$

All functions in G and Q are evaluated at the stationary equilibrium.

The system (4.21) is more general than (3.21), considered in the previous chapter, and encompasses the latter as a special case when $m_1 = m_{11} = 0$, i.e. when insiders derive no revenue by selling shares. We examine next the finance costs model in which all external sources of finance are imperfect (in the way defined above) and insiders face convex costs of internal financing. Initially we assume again that there are no convex installation costs, i.e. $z(\dot{K}, K) = \dot{K}$.

As was the case before, with no convex flow costs on debt or fixed capital the firm can freely choose its gearing ratio each period so that the marginal return to capital is equal to the effective interest-based rental cost of capital:[10]

$$f_1 = -q f_2 \quad \Rightarrow \quad \Pi_1 + q\, b\, g^2 = q\,(\delta + i + 2bg).$$

All functions are evaluated at t.

This is the same condition as in (3.25), which implies that the firm's optimal debt policy remains unaffected by the introduction of equity trading. Given the level of total equity, $E(t)$, at any moment in time, fixed capital is equal again to $K(E(t))$, determined by (3.25) and the stock identity ($qK = E + B$) and depicted in diagram 3.4 of the previous chapter.

The impact of the equity market is felt instead through the rate of equity accumulation along the optimal path $K(E)$. Insiders have now the choice of accelerating the growth of their firm by selling equity claims to the market, whilst keeping their own equity accumulation constant. Around the stationary equilibrium and using the linearized version (4.21) of our model the unconstrained optimal ratio of external to total flow of equity finance is equal to:[11]

$$\frac{A + N}{q\dot{K} - \dot{B}} = \frac{m_1\, C_{11}\, E^*}{m_1^2\, C_{11} - m_{11}}. \tag{4.22}$$

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[10] From (4.13) - (4.16) and noticing that $z_1 = 1$ and $z_2 = 0$, we have that

$$(1 - C_2)\,(f_1 + q f_2) + C_1\,(m_2 + q m_3) = 0.$$

Further, from (4.11) and (4.10) we find that $m_2 + q m_3 = \frac{1}{\rho}(f_1 + q f_2)$.

Thus the condition above follows.

[11] See appendix in the end of the chapter.

All functions in the right hand side of (4.22) are evaluated at the stationary equilibrium. If the demand function for equity is linear, as in (4.8), (4.22) becomes:

$$\frac{A+N}{\dot{E}} = \frac{\bar{n}\, C_{11}\, E^{*}}{\bar{n}^{2}\, C_{11}\, E^{*} + h}$$

For a firm with non-increasing returns to scale, this ratio takes values between zero and one.[12] Thus, around the stationary equilibrium the optimal unconstrained sales of equity take the same sign as equity accumulation; they are positive when equity is growing and, in line with the non-negativity constraints of our model, they are restricted to zero when the firm is de-accumulating. Additionally, we can clearly see that the external source of equity finance plays a more important role in equity accumulation the more elastic the demand curve for equity is (the lower h is) and the faster the marginal costs of internal finance, C_{11}, rise.

With an extra source of equity finance available, the firm can be expected to grow faster towards the long run static equilibrium along the optimal path $K(E)$. Formally, this can be shown to be the case by solving (4.21) to find the path converging to the equilibrium. For capital this takes the form of a flexible accelerator model:[13]

$$K(t) = -[\,K^{*} - K(0)\,]\; e^{-k_4 t} + K^{*} \quad => \quad \dot{K}(t) = k_4\,[\,K^{*} - K(t)\,], \tag{4.23}$$

where $-k_4$ is the negative eigenvalue of the system:

$$k_4 = -\frac{\rho}{2} + \left[\frac{\rho^2}{4} - \frac{\Pi_{11}}{q(1-g^{*})}\,\frac{dK}{dE}\left(\frac{1}{C_{11}} - \frac{m_1^2}{m_{11}}\right)\right]^{\frac{1}{2}} \tag{4.24}$$

All functions are evaluated at the stationary equilibrium.

(4.23) and (4.24) describe a dynamic investment model without installation costs. As in the equivalent model of the previous chapter, convex financial costs lie behind the partial adjustment to the long run equilibrium. The two terms in the parenthesis of the right hand side of (4.24) give

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12 When h=0 it takes the maximum value $1/\bar{n}$, which, according to (4.10) and in conjunction with stationary conditions (3.15) and (3.16), is smaller than unity if the firm has decreasing returns to scale and equal to unity for constant returns to scale.

13 See appendix in the end of the chapter. For (4.24) the same transformations have been used as for (3.26) in the previous chapter.

tion of this last term k_4 is identical to the adjustment coefficient k_3 in (3.26). Thus, financial factors, such as the net income of owners, claimed to have an impact on the flexible accelerator coefficient in the previous chapter, can be expected to play a similar role in the model under consideration. The analysis of the financial costs model in section 3.3 carries through when equity trading is introduced provided only that the demand for equity is not perfectly elastic ($m_{11} \neq 0$). Additionally, a direct comparison of k_4 with k_3 reveals that, ceteris paribus, equity trading raises the rate of adjustment.[14] With an extra source of equity finance the firm can expectedly proceed faster with its accumulation projects. Also, not surprisingly, this new source has a greater impact if the firm faces high costs of internal finance to start with. As (4.24) reveals, the effects of internal and external sources of equity finance are interrelated.

Concerning now the additional factor, m_1^2/m_{11}, introduced with equity trading, a few more comments are in place. The nominator of this factor is the square of the marginal revenue from equity sales multiplied by the total equity of the firm.[15] Evaluated at the stationary equilibrium, this is equal to the square of the opening price multiplied by total equity, i.e. $(\bar{n}E)^2$, or else the square of the stationary market value of total equity of the firm. Note that equity market information is related in this case to the adjustment coefficient but not the static optimum and enter in this investment model *alongside* with all other information concerning, say, the marginal profitability of the firm, the rental cost of capital or the internal finance costs. Additionally, since opening equity prices reflect the *average* net profitability of equity, the introduction of equity trading cannot but enhance the effect of factors, such as say fixed costs on the adjustment process, since they influence the average but not the marginal return of capital.

Turning next to the denominator, we can easily see that this depends on the elasticity of the demand function for equity claims. For instance, if the demand for equity each period takes a linear form, such as (4.8), at the stationary equilibrium m_{11} is equal to $-hE$. The higher h is, the

[14] Note that the ceteris paribus assumption also includes the hypothesis that the opportunity cost of investment does not change when an active equity market is introduced. An argument against this hypothesis for instance could be that an active equity market facilitates capital outflows and increases the opportunities for investment abroad.

[15] $m_1 = \dfrac{\partial m}{\partial (A+N)} E$

Turning next to the denominator, we can easily see that this depends on the elasticity of the demand function for equity claims. For instance, if the demand for equity each period takes a linear form, such as (4.8), at the stationary equilibrium m_{11} is equal to $-hE$. The higher h is, the more sharply prices fall with any equity offering. Consequently insiders restrict the finance drawn from the equity market and the rate of adjustment falls accordingly, as (4.24) reveals. An inelastic demand curve limits the importance of the equity market as a source of finance. The implication of this is rather clear. Thus, *the impact of equity trading on accumulation can be expected to be weaker, the thinner and less competitive the equity market is.* At the one limit, as we have already seen, when h tends to infinity and the demand for equity tends to become vertical, k_4 can be approximated by k_3, where equity trading was ignored. On the other hand, if the demand for equity became perfectly elastic (h=0), the optimal policy for the firm would be an immediate jump to the stationary equilibrium, or, if there were convex installation costs, the adjustment coefficient k_2 would re-emerge from (4.21). Thus, the non-perfect elasticity of the demand function for shares proves to be one of the most important aspects of this analysis, often ignored in investment models that deal with equity markets.

To summarize, the introduction of a non-perfectly elastic demand for equity claims of the firm from outsiders has left the main argument of the financial costs model intact. After adjusting to the optimal capital-equity ratio, $K(E)$ (depicted in diagram 3.4), the firm proceeds to the stationary equilibrium with a rate determined by the costs of raising the necessary equity (in the absence of convex installation costs). Even with share trading available, the rate of adjustment is still influenced by the same "financial" factors affecting the net income of insiders. Around the equilibrium, where by hypothesis the stock market price reflects closely what insiders consider as fundamental value of a claim, the capital adjustment coefficient is given by k_4 in (4.24) and this replaces k_3 in the investment model (3.28) when there is equity trading. For the disinvestment process we can retain our assumptions that insiders face no convex costs when the firm is de-accumulating equity (C_{11}=0), while the costs of dismantling fixed capital rise in the margin ($z_{11}\neq 0$ for $\dot{K}<0$). [16] Solving (4.21) we find in this case that the disinvestment process follows

[16] The possibility of selling of complete production units rather than dismantling them could be important

again the installation costs model with adjustment coefficient k_2, defined in (3.24). Thus the introduction of equity trade has no effect on the de-accumulation of capital around the stationary equilibrium.

The analysis above stresses the role of the equity market for investment *as a source of finance*. Stock market information concerning the position (opening price) and slope of the demand for equity proves to be relevant because it indicates the terms under which the insiders can attract outside equity finance. As such, it has to be used in empirical work in conjunction with all other relevant variables suggested so far and in a fashion similar to that of information concerning the internal costs of finance. This, it has to be added, is different from the neoclassical interpretation of the Q investment approach, where market values are used as useful summary statistics for a number of unobserved variables. This point cannot be made more forcefully than observing that under the neoclassical model, where the debt market is assumed to be perfect,[17] (4.21) produces a flexible accelerator model with adjustment coefficient k_1, defined in (3.23), where *share market information has no role to play*. Thus, according to this interpretation, the Q approach does not capture any structural or "causal" relation between the equity market and investment. This is clearly different than the suggested use of stock market information in the model examined above. We return to the issue of Tobin's Q in the next section.

One shortcoming of the analysis in this section is its focus on the neighbourhood of the stationary equilibrium, where by hypothesis stock market prices are close to the present value of shares. If the market is not strongly efficient, market prices may fluctuate, drifting often away from what insiders consider to be the true present value of a claim. From one point of view the problems encountered in this case are not very different than those that arise from the fluctuations of other prices in the model, such as the capital goods price q. A truly dynamic model, such as (4.13)-(4.18), would show that at any moment in time investment depends on the entire path of these prices from the present to the terminal date of the problem. Our analysis around the station-

in this case. For a gradual adjustment to the stationary equilibrium one would have to assume that when such occasions are available, the market is oligopsonistic and therefore prices fall with the size of the sold unit.

[17] $f_{12}=f_{22}=0, f_{11}=\Pi_{11}$

ary equilibrium obscures somewhat this issue by focusing on a single vector of prices, that of the stationary equilibrium.[18] Nevertheless, fluctuations in equity prices have been the focus of some controversy in investment literature so as to warrant some special examination. Below we argue that our main results on the role of the equity market as a source of finance for investment can be expected to hold even when we allow for "irrational" fluctuations in share prices.

The argument is somewhat similar to that of Fisher and Merton (1984).[19] Consider the case where equity prices are above the present value attached to equity by insiders. As was mentioned earlier, insiders will be induced to sell until (4.19) holds. Ceteris paribus, this will bring down current costs of internal financing and, in line with our previous argument, it can expected to induce higher investment. Conversely, low equity prices will induce insiders to buy back shares from outsiders (if they hold any), limit their net income available for new placement in the firm, and slow accumulation by raising the costs of self-finance.[20] The argument is valid even if, say, the rise in market prices was unexpected and temporary. Though investment may take time to plan and implement, insiders will still use the opportunity of high market prices to sell and accumulate liquid or other assets, which can subsequently be used to finance investment. Thus, it is not only present but also recent past fluctuations in equity prices that can affect the internal costs of finance and thus investment. The last observation points to a more general issue raised in the formal model above. Stock price fluctuations can be expected to have a stronger impact on investment if the firm faced high costs of internal finance to start with. The effect of a price change on the costs of internal finance at the margin is lower for a firm with plentiful internal resources either, say, because of past accumulated assets or because of high present profitability. Thus, the distribution of wealth and income is important for the rate of capital accumulation, even with the

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[18] The difference between share and other prices at the stationary equilibrium is of course that the latter can take any single value within some limiting restrictions, while for the former we have assumed that it coincides with the present value of an equity claim.

[19] See section 2.3.

[20] This argument of course covers at best only half of the story. Changes in the stock prices do not only affect the present cost of financial placements in the firm, but also the shadow value of capital, as can be seen from (4.13). While the comparative dynamic analysis is difficult, it seems intuitive to argue that at times of stock market booms insiders have the possibility to attract more equity finance from the market and thus support a faster accumulation rate than when the stock market is depressed.

introduction of an equity market. Finally, fluctuations in opening prices of equity can be expected to have a smaller impact on investment, the more inelastic the demand (or supply) of equity by outsiders is. If it takes a small intervention in the market by the insiders in order to restore the prices to the optimal condition (4.19), then the total equity finance raised in any period will not be significant enough to influence investment. Clearly, if insiders face constraints or prohibitive additional costs in trading on shares of their own firm, stock prices may remain high or low with no impact on investment.

The above informal argument supports our earlier analysis on the role of the equity market as a source of finance. An additional point raised is that if market prices do drift away from fundamentals, then there is no assurance that during any particular period they will be high, thus supporting investment, or low, thus hindering it. Of particular interest in this context is the question of whether these price fluctuations above and below the "fundamental value" tend to coincide with economic cycles, in which case the equity market may not only be predicting, but also enhancing, swings in investment.

In the next section we turn to a different interpretation of the relation between market values and investment. In this case stock market information are not useful because of their relevance to finance, but as summary statistics of relevant unobserved variables.

4.4 The informational content of share prices and the Q investment model

In section 2.3 we have examined the role of the market value of the firm in an empirical investment model. The standard neoclassical interpretation has been that market values are important, if not sufficient, statistics for unobserved variables central in the investment process and, thus, valuable statistics for investment. In particular, under a number of linearity assumptions, Tobin's Q has been shown to be equal to the shadow value of capital, μ, over its replacement cost, q, thus containing all the necessary information about the future expected marginal return of capital net of every cost. Combined with costs of adjustment, Q would seem to be the only piece of information one needs for an investment model. The main theoretical objection to this approach has centered on the underlying linearity assumptions which have already been discussed in 2.3. Here we focus on another, less publicized issue, that of the assumption of strong efficiency in the capital market, implicit in the neoclassical interpretation. Tobin's Q is re-examined within the framework developed above with inefficient (or even irrational) capital markets.

Following Hayashi (1982), we impose a number of linearity assumptions that allow us to link the average with the marginal (shadow) value of capital. Specifically, we assume that the net profitability function, $f(K, B)$ and the revenue function from sales of equity, $m(\dot{D}, K, B)$, are linearly homogeneous in K and B.[21] Further, we take the installation costs function, $z(\,)$, and the internal finance costs, $C(\,)$, to be linearly homogeneous in their two arguments and assume that insiders have no income from other sources, $y=0$, and the firm faces no fixed costs.[22] Multiplying (4.13), (4.14), (4.15) and (4.16) with K, $\dot{K}$, B and $\dot{B}$ respectively, summing over and time integrating, we derive the following condition:

$$S(t) \; = \; \mu(t) \; K(t) \; + \; \lambda(t) \; B(t). \tag{4.25}$$

The present value of equity is equal to the shadow value of capital multiplied by total capital minus the shadow cost of debt multiplied by total debt. This condition is identical to that found by Chirinko (1987b).[23] The differences in the underlying theory, however, are worth stressing. In the model considered here debt is not a quasi-fixed choice variable. It is rather equity finance that the firm faces costs in accumulating. Since a unit of debt is a perfect substitute fora unit of equity, at the optimum the shadow cost of the former will be equal to the cost of raising a unit of the latter. Also expectedly, the shadow value of capital will also be inflated by the current cost of raising an extra unit of financial capital. This can easily be seen if we substitute the shadow values of capital and debt from the optimal conditions (4.14) and (4.16) to derive the following equation:

$$S \; = \; C_1 \, z_1 \; qK \; - \; C_1 \; B. \tag{4.26}$$

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[21] Note that $m(\dot{D}, K, B)$ in (4.11), with $\bar{\pi}$ defined in (4.10), fulfills this condition.

[22] For the neoclassical model some of these assumptions are not necessary. See section 2.3.

[23] See equation (2.21).

All functions are evaluated at t.

Note that both (4.25) and (4.26) hold, given our linearity assumptions, irrespectively of whether there exists an equity market or not and of how closely market prices of equity reflect the "fundamentals". Based on (4.26), we consider next the neoclassical and an alternative interpretation of of Tobin's Q.

Consider first the neoclassical approach where the financial system is taken to be strongly efficient. In the context of our model this means that the bankruptcy-free firm under consideration can borrow all it needs at a constant cost, equal by definition to the opportunity cost of capital. This allows the firm to finance all its transactions at a constant cost irrespectively of the convexity of the costs of internal finance, as we saw in the previous chapter. Debt will adjust each period until the marginal gain from an extra unit borrowed and the shadow price of debt are both equal to unity, i.e. $C_1=-\lambda=1$. Consequently, (4.26) can be written as follows:

$$z_1 = \frac{S + B}{qK}. \tag{4.27}$$

In words, the marginal cost of an extra unit of fixed capital is equal to the average (and under our linearity assumptions also marginal) present value of it. To derive Tobin's Q we only have to note that with a strongly efficient and competitive equity market the market value of equity will be equal to its present value, i.e. $nE=S$. Substituting in (4.27), we derive net investment (over capital) as an implicit function of Tobin's Q at any moment in time:

$$z_1(\dot{K}, K) = \frac{nE + B}{qK}. \tag{4.28}$$

This step by step derivation of the Q investment model highlights the role of the various assumptions. The linearity assumptions bring the average and marginal capital values in line. The assumption of a strongly efficient financial system plays a double role. First of all it ensures that one pound worth of new placements in the firm costs to the owners precisely one pound, regardless of their costs of internal finance. Second, it ensures that in a strongly efficient and perfectly competitive equity market prices are always equal to the present value of equity. The two sets of assumptions put together deliver (4.28), where Tobin's Q appears as an exclusive explanatory variable for the rate of net investment.

We consider next what happens if we relax the second set of assumptions concerning the strong efficiency of the financial system. Both internal and external costs are increasing at the margin and one pound worth of new placements does not necessarily cost a pound to the owners. The marginal cost of an extra unit of internal finance along the optimal path is given by C_1, which may be different than unity. Rearranging (4.26), we derive the equivalent to (4.27) when the financial system is not strongly efficient:

$$z_1 = \frac{1}{C_1} \frac{S}{qK} + \frac{B}{qK}. \tag{4.29}$$

All functions are evaluated at t.

Compared with (4.27), we notice that the present value of equity is weighted with the marginal cost of internal finance. If the latter is high along the optimal path, accumulation may be proceeding at a slow rate even though the present value of the firm is observed to be high. This is in line with our earlier arguments concerning the importance of the costs of internal finance for the rate of adjustment.

Now, having relaxed the assumption of a strongly efficient and perfectly competitive equity market, we can no longer take market prices of shares to necessarily coincide with the present value attached to an equity claim by the insiders. The market forms its expectations using a different set of information than that of the decision maker of the firm. Nevertheless, market prices and present values are linked, as we argued earlier, through an arbitrage mechanism that induces insiders to sell when market prices are high and buy when they are low. Provided that none of the constraints on equity transactions binds, as was explained in section 4.2, condition (4.19) holds along the optimal path. Combining it with (4.29), we find that the following condition holds at any moment in time along the optimal path:

$$z_1 = \frac{m_1 + B}{qK}. \tag{4.30}$$

m_1 is the marginal revenue from selling equity in the market multiplied with the total equity of the firm. With a linear demand function such as (4.8), (4.30) becomes

$$z_1(\dot{K}, K) = \frac{nE + B}{qK} - h\,\frac{A + N}{qK}. \tag{4.31}$$

All function are evaluated at t.

(4.31) has very interesting implications. Firstly, note that nE is the market value of total equity. Hence, the first term in the right hand side represents again Tobin's Q. (4.31) reveals that the rate of net capital accumulation is related to Q, *despite the fact that the equity market in this model is inefficient or even irrational*. We can interpret this relation in the following way. Assuming momentarily that debt remains always equal to zero, insiders have two decisions to make: What the total investment in fixed capital will be and how much of it will be externally financed. Expectedly, along the optimal path the marginal costs and returns from the flows involved in the two decisions will be equal. Thus, as we have seen in (4.19), given the investment decision, the marginal return from equity sales will be equal to the average present value of an equity claim. On the other hand, (4.26) reveals that when debt is zero and equity transactions in the market are given, the marginal cost of a unit of capital, $qC_1 z_1$, will be equal to its average present value S/K. Combining the two, we derive (4.30) (with B=0). Or, in other words, if the internal financing were to remain constant, insiders would continue to sell equity to the market until the marginal revenue from selling a claim for a unit of real capital is equal to the marginal cost of buying and installing such a unit. The above verbal argument can be appropriately adjusted when debt is not zero, as (4.30) reveals.

Additionally, (4.30) and (4.31) suggest that Tobin's Q needs to be adjusted if the demand for shares of an individual firm is not perfectly elastic. The second term in the right hand side of (4.31) captures such an effect. It depends on the total primary and secondary distributions of equity during the period under consideration, $A(t)+N(t)$, over the total assets of the firm, $qK(t)$, and the slope of the demand curve, h. Thus, if prices fall sharply with any substantial offering, high rates of Q may well be observed along an optimal path with low rates of capital growth. A corollary of this is that, ceteris paribus, the Q approach to investment can be expected to perform worse in thinner, less competitive stock markets. An adjustment to take account of the downwards slopping demand curve is in this case essential.

The above analysis seems to strengthen the theoretical underpinnings of the Q approach to investment, since, with some adjustments, it can be expected to hold even when we relax the assumption of a strongly efficient equity market.[24] However, one should not fail to observe that in this case its interpretation is rather different and arguably less appealing than that within the neoclassical model. In the latter approach the informational content of Q follows directly from the assumption that outsiders share the same information and more or less the same predictions with the insiders. In an empirical model that has no other information about expectations, the market value of equity would be a valuable statistic, even if the linearity conditions mentioned above did not hold precisely. On the other hand, the link between Q and investment is rather more indirect in the case of an inefficient or an irrational market. Here the argument lies on an additional assumption that equilibrium market prices reveal information of both trading sides.[25] This would require that insiders are actively involved in the market of claims of their own firm (what is actually prohibited by the regulations of some stock markets), face no substantial unobserved costs trading in it and, most importantly, they face no constraints in buying and selling shares of their firm of the kind mentioned in 4.2. Thus, if, say, control is an issue and insiders are reluctant to sell for fear of a future takeover, market prices may remain high with no effect on the policies of the firm. Much of the share trading observed may be taking place between outsiders with no inside information being revealed in this case.

A second weakness of the Q model from our point of view is that it cannot discriminate between the different models considered above. Conditions (4.30) and (4.31) hold irrespectively of what the marginal costs of internal finance, C_1, or the lending conditions are. To take an example, (4.31) would equally hold if insiders had access to unlimited internal finance at a constant cost and if they faced sharply increasing costs of self-finance. The reason is simple. The same arbitrage mechanism is in place in both cases: Insiders will trade until the marginal revenue from

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[24] Note, however, that the same criticism concerning the underlying linearity assumptions is valid here as in the case with a strongly efficient financial system.

[25] On similar issues see Stiglitz (1982).

selling a claim to a unit of real capital is equal (in the absence of debt) to the marginal cost of buying and installing such a unit. Hence (4.30) and (4.31) hold irrespectively of the costs and constraints faced by insiders in other sources of finance, which (4.31) cannot test for.

To summarize this section, we have considered Tobin's Q and the market value of equity as a source of inside information rather than an indication of availability of external equity finance. Our analysis has offered qualified support to the argument that stock market prices contain useful information even in an inefficient or irrational equity market. The argument, however, appears less appealing and bound to more constraints than that under a strongly efficient equity market. A tentative conclusion of this and the previous chapter is that stock market information may be useful both as an indicator of availability of external finance and possibly because it reveals something about insiders' expectations. The former is related to the position and elasticity of the demand curve for equity from the outsiders, the second for the supply curve of the insiders. Both are useful only if there are no constraints that restrict insiders from buying or selling shares of their own firm.[26] Finally, the analysis in both cases has suggested that market values have to be used in conjunction with other information rather than as sufficient statistics to the exclusion of every other explanatory variable.

4.5 Conclusions and extensions

The standard argument in support of an active stock market has always been that it has an important role to play in financing capital accumulation. This is at curious odds with much of the established investment literature, where "technological" and not financial costs are thought to be responsible for the partial adjustment of capital to the long run optimum. Implicitly or explicitly this literature assumes that the firm has access to unlimited financial capital at a constant cost from at least one source. If this is the debt market or internal financial channels, then the equity market's financial role would be insignificant. If it is the stock market itself, then the question arises as to how it is possible that the equity market does not suffer by the same inefficiencies

[26] Note that this restriction would not affect the validity of the Q model if the equity market was assumed to be strongly efficient and competitive. Quoted prices in transactions between outsiders, for instance, would reveal the same information as those between insiders and outsiders.

implicitly assumed to affect other financial channels, such as the debt market.

The approach in the last two chapters has been that all external sources of finance do indeed suffer from the same type of informational inefficiencies and principal-agent problems between the decision makers and the rest of the creditors or potential creditors. As a consequence outsiders raise the cost at the margin and restrict the access to external finance available to insiders in any period. Combined with increasing costs of internal finance (or quantity constraints in it), this delivers a dynamic theory of investment where convex installation costs are no longer necessary.

The stock market has a distinct role to play in this process because equity claims have rather different characteristics than debt. An equity claim in our model entitles its owner to have access to the inside operations of the firm. This is clearly the most extreme and most interesting case to deal with and alternative cases that would make equity be more like debt can also be considered. The new shareholder's capital provides a safety for debt, rather than competing with it for a share in the income of the firm. It thus lowers the agency costs and allows further debt to be contracted. Therefore, attracting equity finance from the market can promote investment more vigorously than contracting further debt. This advantage comes with a price. Potential shareholders need more information than debt-holders in order to evaluate the claim that they are going to buy. While the debt-holder needs only some indication of the probability of bankruptcy that can be acquired, say, by observing the gearing ratio and few other information of the firm, potential shareholders have to make more accurate predictions about the whole distribution of the net future returns, not just its lower tail. With the "fundamental" value more difficult to assess, share prices are also expected to fluctuate more than bond prices. Signaling problems with the familiar out of equilibrium paths may be more common in the equity market. Hence, the financial function of the stock market can be expected to come only at the price of some increase in variance of the flow and cost of new funds.

Note that in the case of both debt and equity it is the *asymmetry* rather than the *incompleteness* of the information that is responsible for this increase in financial costs. What the formal model in this chapter reveals is that this non-perfect elasticity of the flow demand for equity is a sufficient condition, as far as the equity market is concerned, for the existence of financial costs of adjustment. It is, further, one of the important variables affecting the flexible accelerator coefficient of a firm using the equity market as a financial source, though it is not one of the variables often discussed in the context of investment models.

On the issue of the informational content of the stock prices, we have formally extended and adjusted the Q approach to the case where the stock market does not have the same information and predictions as the insiders. This extension was related to the argument that equilibrium market prices reveal something of the information of the trading parties. The often mentioned linearity conditions necessary for the Q approach are only one of the problems here. More importantly, we believe, one has to question whether the decision makers of the firm are actively involved in the trading of the shares of their own firm (privately or through the firm) to the extent that they can influence the stock prices perceptively.[27] This question is also relevant for accessing the role of the stock market as a source of finance. If instead quoted prices refer mainly to transactions between outsiders, then they can be used in connection to investment only if we believe that outsiders' predictions are neither as backward looking nor as erratic as our previous analysis has suggested.

A number of assumptions were necessary for tractability reasons without being essential to the main arguments of the last two chapters. Most important among them are the specification of the costs of internal finance, that of the equity pricing mechanism and the assumptions necessary for unanimity among the shareholders in this chapter. The first two captured the convexity of the costs related to internal and external equity finance, essential for the financial model of investment. As was argued earlier, however, this convexity has an intuitive interpretation and could be introduced in our model with alternative, more appealing but less tractable specifications. On the other hand, the assumptions related to unanimity among the shareholders are not essential to the argument. The questions of control and information arising when they are relaxed can only be discussed satisfactorily after the institutional and legal background of the economy under con-

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[27] Note that in many stock markets such trading is actually prohibited.

sideration has been examined in some more detail. The same holds true for possible extensions of the model to consider issues such as taxation or more elaborate lending mechanisms. Some institutional characteristics relevant to the Greek economy are introduced to the model in chapter 6 in order to derive a empirical investment model suitable for our purposes. Before, however, we need to specify the model underlying the marginal profitability of capital, which was so far completely ignored.

Technical Appendix

We consider here the solution of the dynamic system (4.21) when $z_{11}=0$.

The characteristic equation of (4.21) when $z_{11}=0$ is as follows:

$$(k^2-\rho k)\,[-m_{11}\,(q^2 f_{22}+f_{11}+2qf_{12})\,C_{11}\,(k^2-\rho k)+|\mathbf{H}|\,(m_1^2 C_{11}-m_{11})]=0. \tag{A4.1}$$

All functions are evaluated at the stationary equilibrium.

$|\mathbf{H}|$ is the determinant of the Hessian matrix of $f\,(K,B)$. From the previous chapter we know that $|\mathbf{H}|>0$ and $(q^2 f_{22}+f_{11}+2qf_{12})<0$. Also, from (4.11) we have that $m_1>0$ and $m_{11}<0$. Thus, (A4.1) has one negative, one zero and two positive roots. The negative root, k_4 is given by (4.24), applying the transformations used for (3.26) of the previous chapter.

The convergent paths of the three variables K, B and D can be written as follows:

$$\begin{aligned} K(t) &= c_1 e^{-k_4 t}+K^* \\ B(t) &= c_2 e^{-k_4 t}+B^* \\ D(t) &= c_3 e^{-k_4 t}+D^*, \end{aligned} \tag{A4.2}$$

where c_1, c_2, c_3 are arbitrary constants. D has no unique stationary equilibrium, D^* is path depended. The flexible accelerator rule (4.23) follows easily from the first of these optimal paths. Also, time differentiating and re-arranging we can find that:

$$\frac{\dot{D}}{qK-B}=\frac{c_3}{qc_1-c_2} \tag{A4.3}$$

To definitize the constants we only have to substitute the solutions (A4.2) into the homogeneous version of (4.21) to find:

$$[\mathrm{G}(k_4^2-\rho k_4)+\mathrm{Q}]\begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix}=0.$$

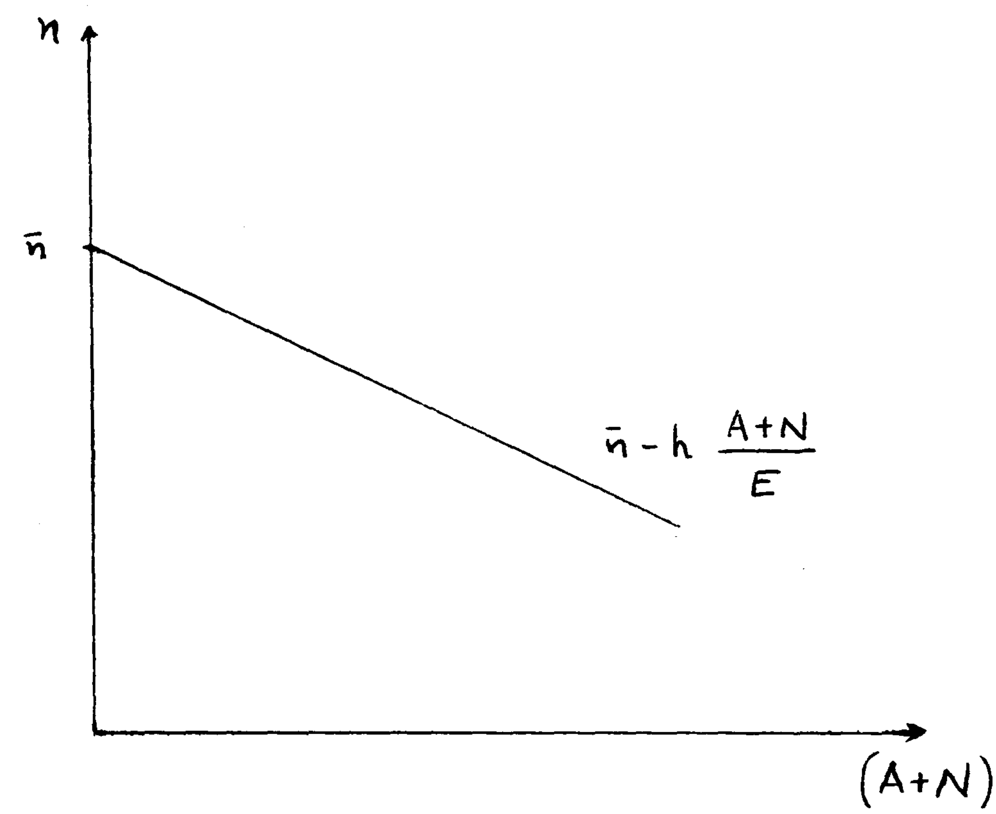
From where we get that

$$\frac{c_3}{qc_1-c_2}=\frac{m_1 C_{11}}{m_1^2 C_{11}-m_{11}}. \tag{A4.4}$$

Combining (A4.3) and (A4.4) and noticing that $\dot{D}=(A+N)/E$, we derive (4.22).

Diagram 4.1

The Flow Demand for Equity.



Chapter 5

THE MARGINAL PROFIT OF CAPITAL

In this chapter we digress from our main theme of finance and investment in order to examine the factors affecting the marginal profit of capital, $\Pi_1(K)$. The analysis is done with an eye on the empirical investment model for Greece in the next chapter. We are therefore concerned with the tractability of our specification and its relevance for the Greek economy, but we attempt to set our model within a more general context and refer to some of the issues of concern in this area.

In section 5.1 we review the relevant literature and identify the main areas of controversy. In section 5.2 we discuss the main features of our model. In section 5.3 we derive an expression for the marginal profitability of capital when there is stochastic demand. We also specify the steady state investment path predicted by our model. In the Appendix we briefly refer to the case of variable factor proportions.

5.1 A review of the literature

So far in our analysis we have concentrated almost exclusively on the main theme of finance and dynamics of capital accumulation. Choice variables other than capital, such as labour or output, were assumed to have been maximized and did not enter explicitly the dynamic problem. The concave profit function, $\Pi(K)$, used throughout was consistent with a variety of theories concerning the production technology and the output and input markets. Before going on to an empirical implementation of any investment theory, however, one needs to spell out the underlying model in order also to specify the parameters that can be expected to enter in the profit function, $\Pi(K)$. This is the subject matter of this chapter, starting in this section with a review of the main issues raised in the literature in connection to this problem.

The topic of the underlying theories on market structure and production technology has been a controversial one. The main aspects of this controversy have already been mentioned in our survey in section 2.1. They concerned mostly the theoretical underpinnings and the a priori predictions about the role of output and of relative prices in an empirical investment model. An additional issue is the possible link between the average and marginal profitability of capital. This is of particular interest for our purposes since we wish to distinguish between this link and the effect of profitability on the liquidity and availability of internal funds of the firm. We thus start from this latter issue.

The average profitability has been the focus of much of the recent macroeconomic policy discussions on investment, but has been less central for the main body of the micro-investment literature which has tended to keep issues of marginal and average profitability apart.[1] The two are clearly equal under the linearity conditions mentioned in the case of the Q model, i.e. when input and output markets are perfect and the production function exhibits constant returns to scale. Equality apart, however, we may still ask whether the two variables are likely to be closely related when the linearity assumptions do not hold. We recall that this is an issue also relevant to the Q investment approach. To fix ideas, consider the following simple formal model.

[1] Exceptions to that can be found in Bernanke (1983), Abel and Blanchard (1986a) and Funke (1986).

Suppose a firm faces a Cobb-Douglas type production function and a constant elasticity demand function:

$$
\begin{aligned}
Q &= F(K,L) = A\,K^{\alpha}L^{\beta}, \qquad \alpha+\beta \le 1, \\
p(Q) &= \zeta\, Q^{\eta}, \qquad -\infty < \eta \le 0.
\end{aligned} \tag{5.1}
$$

Its profit function is as follows:

$$
\Pi(K) = p(Q^*)\,Q^* - wL^*, \tag{5.2}
$$

where L^* is the optimal level of labour, given the level of capital. It can be found by the following condition:

$$
[p_1 Q^* + p\,]\,F_2 = w, \tag{5.3}
$$

where $Q^* = F(K, L^*)$. To find the marginal profitability of capital, we only need to take the partial derivative of $\Pi(K)$ in (5.2) (due to the envelope theorem) and use (5.1) and (5.3) to acquire:

$$
\frac{\partial \Pi}{\partial K} = [p_1 Q^* + p\,]\,F_1 = \frac{(1+\eta)\,\alpha}{1-(1+\eta)\,\beta}\;\frac{\Pi}{K}. \tag{5.4}
$$

Equation (5.4) gives the result we need. The marginal profitability of capital is linearly related to its current average operating surplus. The coefficient in the right hand side varies with the elasticity of the demand function and the elasticity of output with respect to each factor of production. In the production and demand function of (5.1) these are constant, implying that an observed variance in the average gross operating surplus of a firm will accurately indicate an underlying change in the current marginal profitability. Of course the above result needs modification if more general production or demand functions are used and it does not hold if output is exogenously fixed.[2] Nevertheless, (5.4) clearly makes the point that in a wide range of circumstances the average operating surplus of a firm can be potentially a useful indicator for the more fundamental variable of marginal profitability. On the other hand, it has to be mentioned that Π/K cannot be taken as an exogenous variable, unless the above mentioned linearity conditions are

[2] It is worth emphasizing, however, that constant elasticity demand functions and Cobb-Douglas production functions have been widely used in investment models and the former at least are generally not considered unduly restrictive.

assumed to hold. In this, then, it is akin to the Q ratio and its introduction in an investment equation would suffer from the same simultaneity problems as when output is introduced while markets are assumed to be perfect. For our purposes it is interesting to note that the variable likely to be related to the marginal profitability is the gross operating surplus *before* any deductions for fixed costs or financial costs or any additions of income from other sources. This, as we will see below, is important when we consider the role of profitability in financing investment.

If we wish to go beyond the information that the average profitability provides and search for the determining factors of marginal profitability, as much of the existing literature has attempted to do, the issues of the production technology and market structure become even more central to the analysis. Investment literature has mainly concentrated on two aspects of these issues, the labour-capital substitutability and the output market structure. The reason for this has much to do with the way output and prices have originally been introduced in Jorgenson and his collaborators' studies. The optimal conditions (2.4) and (2.6) in section 2.1 seem to suggest that the elasticity of the optimal capital with respect to relative prices depends only on the elasticity of substitution, σ. Thus, rather misleadingly, the introduction of prices in investment equations and the criticism of early models for failing to do so has been identified exclusively with the issue of the capital-labour substitutability.

As was already mentioned in section 2.1, however, prices also enter Q^* and have a scale as well as a substitution effect. According to the textbook neoclassical analysis and the Marshall conditions, the demand for any factor of production depends on a number of factors including the demand elasticity.[3] To make this point more forcefully, notice that the optimal static capital depends on relative prices, even if the production function is of the Leontief type with no factor substitutability, provided that output is not exogenously fixed.[4] Of course if output is exogenous, the only role left for prices is that of affecting factor intensities. [5] Thus, the exclusion of prices

[3] See for instance Layard and Walters (1978), ch. 9.

[4] For instance, if the firm faces the demand function of (5.1) (with $\eta<0$) and l and κ are the fixed labour- and capital-output ratios respectively, the optimal static capital is given by

$$K^* = \kappa \left[\frac{wl + c\kappa}{(1+\eta)\,\zeta} \right]^{\frac{1}{\eta}}. \tag{5.5}$$

from the early accelerator models was the result of assuming both no factor substitutability and an exogenously given output level.

The role of prices and output in investment models has continued to present difficult problems in the more recent literature. Output has continued to be used in empirical equations not always with a clear justification and consequently the role of relative prices came to be identified with factor substitutability. The implications of such reasoning, however, are important and have not always been spelled out clearly. To quote Summers: "When output is included in the equation, the only question under study can be the effects of tax policies on the capital stock holding the level of output constant. But as policymakers will recognize even if some economists do not, this procedure assumes away the fundamental question. The reason investment incentives are proposed is the hope that they will lead firms to invest more *in order to produce more output*. No one would propose an investment incentive if they thought it would have no effect on the level of output chosen by the firms. If this were true they could only produce unemployment."[6]

A rather striking by-product of this is that when output is assumed to be exogenous, the optimal capital and consequently investment is in theory positively related to the wage rate, while the output price has no impact whatsoever.[7]

It is difficult to find any explicit testing of these predictions, even within models that have assumed output to be exogenous. The usual practice has been to introduce the wage rate-rental cost of capital ratio as a composite factor in the empirical implementation of the model, so that the separate effect of wages cannot be identified. Alternatively, a mark-up or an assumption that in the long run the output price is equal to marginal cost was employed to substitute the wage rate

[5] Even in this case, however, it has long be noticed that the elasticity of K^* with respect to the relative prices is not necessary equal to the elasticity of substitution between, say, capital and labour. For example, in a cost minimization problem with a Cobb-Douglas production function, such as the one considered earlier, the optimal static capital is given by

$$K^* = \theta\, Q^{\frac{1}{\nu}} \left(\frac{w}{c}\right)^{\frac{\beta}{\nu}} \tag{5.6}$$

where θ is a constant and ν in the superscripts are the returns to scale.

[6] Summers (1987), p. 172. Emphasis in the original.

[7] See for instance equation (5.6) in the earlier footnote. This result does not necessarily hold if inputs other than capital and labour are also considered. We return to this issue in the next section.

with the output price.[8] Both types of specification do not allow one to pass a clear judgment on the effect of wages on investment. Schramm (1970) and Gould and Waud (1973) that have introduced wages separately came to contradictory conclusions, though the positive effect found by the latter, as well as other results of their non-linear estimation, have to be considered with much caution, as the authors suggest, also because they imply unreasonably strongly increasing returns to scale.

There have been a number of other attempts to incorporate some demand variable while also allowing for a role for relative prices. Gould and Waud (1973) introduced an imperfect output market. This has allowed for both a substitution and a scale effect for factor prices. The position of the demand curve can be taken as exogenous in such a model, but the level of output is an endogenous variable. This presents, however, a measurement problem, since the shift parameter, ζ in (5.1), is not normally observable and in general it cannot be simply proxied by the endogenous output. Gould and Waud use real GNP (while their study refers to investment of individual two digit industries) to avoid the problems of endogeneity.

A more recent attempt to incorporate prices, output and other variables in an *aggregate* investment equation have been along the lines of models with multiple regimes. Jorgenson's approach, with the perfectly elastic demand for output and supply for production factors and financial capital, can be thought of as representing the "neoclassical regime". Optimal capital and thus investment depend in this regime only on relative prices:

$$KC = KC\left(\frac{c}{p}, \frac{w}{p}\right). \tag{5.7}$$

In the "Keynesian regime" output is demand constrained and thus, as we have seen, the optimal capital can be written as follows:

$$KK = KK\left(Q_d, \frac{w}{c}\right). \tag{5.8}$$

Clearly if the optimal output supply in the neoclassical regime (determined as a function of

[8] For the two different approaches see for instance Coen (1971), Abel (1978), Muet (1979), Bishoff (1971), Brunkel (1986). Artus et al (1981) use both in the two macro-econometric models METRIC (for France) and SYSIFO (for Germany).

relative prices) is equal to the effective demand of the Keynesian regime, we have $KK = KC$. If the effective demand is smaller than the notional supply, then $KK < KC$ and the optimal capital is determined by (5.8). (5.7) applies when demand is higher than supply and thus $KK > KC$. Thus, to summarize, the optimal capital of any single firm will be determined by the following condition:

$$K^{*} = \min [\, KC \,, KK \,]. \tag{5.9}$$

The main idea of the multiple regime models has been that while a single firm may find itself in one or another regime, as (5.9) reveals, aggregate investment will be a weighted sum of investment from firms in both regimes and, thus, it will be affected by both the determinants of KC and KK. Various models follow from this procedure differing not only in the usual issue of the underlying technology, but also in the specific aggregation process followed[9] and, importantly enough, in the number of other regimes considered. Concerning the latter of the two issues, constraints on labour and finance have also been introduced, the latter affecting investment rather than the optimal capital. In Muet (1978) and Artus and Muet (1985) credit constraints were captured either with the introduction in the investment equation of retained earnings (for the internal finance) or with a string of interest rates and other financial variables (for external finance). These were found on the whole to have a significant impact on investment.

The multiple regime models are an interesting extension to the existing literature, not the least because they allow a flexibility in dealing with a number of different environments and, further, because they attempt to deal with the largerly ignored and difficult issue of aggregation. The price for this has been that their structure had to be kept relatively simple, avoiding many of the difficult dynamic issues involved. Concerning the question of output in empirical investment equations, these models present similar difficulties to Gould and Waud's model in the choice of the appropriate variable. Even if we are dealing with aggregate investment, Q_d in (5.8) refers to the effective demand of *demand constrained firms*. Unless all firms are in the Keynesian regime, in which case (5.7) is redundant, the logic of the model implies that Q_d cannot be identified with

[9] See Lambert (1986), Gerard and Vanden Berghe (1985), Sneessens (1987).

the total industrial output Q. The latter is the output of both demand constrained and unconstrained firms. An indicator of the former is required, or at least information about the *total notional* demand, a percentage of which is the effective demand of the constrained firms. Empirical models in the field have ignored these problems, substituting the demand of the quantity constrained firms, Q_d, with the total industrial output Q.

A second issue concerns the relevance of the multiple regime models in the long run. The implicit assumption that firms will continue to be in the same regime in the future is questionable. The question that immediately arises is why some firms always face a constraint and others never do. More reasonably, if constraints are a fact of life, then every firm is likely to face one or more in the future and therefore it has to take output demand, as well as labour and credit supply into consideration, irrespectively of its present condition.

The above argument points towards a stochastic rationing framework, such as the one developed by Malinvaud (1983, 1987) and Lambert and Mulkey (1987).[10] The principal idea of this model runs somewhat as follows. The firm faces a stochastic demand and factor substitutability is restricted ex post.[11] Thus, there is always a probability that the firm will end up either demand or supply constrained, or, in other words, that it will end up in versions of the two main regimes considered above. If demand constrained, the gains from extra capital will come exclusively from its ex ante substitution of other factors (labour). If supply constrained, there is also an output effect; more capital will allow the firm to meet more of its demand and the extra gain will be higher, the higher profitability is. In either case prices play a role and so does expected demand as well.

The analytics of such a model will be considered in more detail in a somewhat different setting in the last section of this chapter, where the idea of stochastic demand is used as one of the building blocks for our specification of the marginal profitability of capital. We start in the next section by explaining the main features of the input and output markets of our model.

[10] An earlier version can be found in Nickell (1978, p. 72) and Malinvaud (1980, pp. 28-37), (1982).

[11] In all of the cited papers the model is essentially static and this avoids all the complications that a putty-clay technology raises in a dynamic context. Substitutability is allowed before the level of demand is known with certainty, but not ex post, when demand has realized.

5.2 Input substitutability and output markets

In this and in the following section we set up a simple model in order to specify the factors affecting the marginal profitability of capital. The main premises of the model are as follows. Firms face a stochastic demand (in both domestic and foreign markets) for their output each period. They treat all input and output prices as exogenously given. Also, they face a Leontief production function.[12] Ex post (after the demand level has been revealed), they can meet demand either by producing the goods or by importing them from abroad. Also, ex post they cannot adjust the capital stock (until the next period), so capacity is fixed, but they can vary the other inputs if, say, demand falls below capacity. Thus, ex ante the marginal profitability of capital depends on the probability that demand will exceed capacity and the relation of the production costs per unit of output with the cost of importing the same unit from abroad.

It is clear that an important and somewhat unfamiliar element of our model is the assumption that firms can substitute production with imports of finished goods. It may not be immediately obvious, but this is in fact a case of substitutability between various inputs. It is, thus, of more general interest than what our model suggests, especially since the issue of substitutability between capital and inputs other than labour has hardly been considered in the investment literature.[13] We explain this point with the following simple example, suitably adapted from Berndt and Wood (1979).

We extend the static optimization model considered in section 2.1 (see equation (2.2)) to include a vector of other inputs, **M**, and a related row vector of prices, v. We assume that output demand, Q_d, is exogenously given and the output function is linearly homogeneous. Further, for the moment and for expositional purposes, we assume that economic profits are zero and the output function is weakly separable in two linearly homogeneous sub-functions, one the production function Φ with arguments K and L, and one the input function X with argument the **M** vector. Thus, if $\Psi(\,)$ is the output function with the usual concavity properties, we can write:

---

[12] We consider briefly the case where input-output ratios are only fixed ex post (after demand has been revealed), but vary ex ante. The model with the Leontief production function is, however, the one used in the empirical application in the next chapter and therefore we focus on this.

[13] An interesting exception can be found in Pindyck and Rotemberg (1983a, b).

$$Q_d = \Psi(Q, X),$$

where

$$Q = \Phi(K, L), \tag{5.10}$$
$$X = X(\mathbf{M}). \tag{5.11}$$

The cost minimization problem can then be represented by the two diagrams in the end of this chapter.

In diagram 5.1 the optimal capital and labour, say K^1 and L^1, are chosen, given Q^1 and their prices c and w. The value added is given by the following equation:

$$VA = wL^1 + cK^1 = sQ^1, \tag{5.12}$$

where s can be conceived as the composite "price" of Q. Under the linearity conditions we have,

$$s = s(w, c) \; , \; s_1 > 0 \; s_2 > 0. \tag{5.13}$$

In a similar way the optimal combination of inputs within the vector **M** can be chosen, given v and the level of X^1. This also defines a composite price for X, say $\bar{p}$, as a function of v in a way similar to (5.13). In diagram 5.2 Q^1 and X^1 are the optimal choices given the output function Ψ, the total output Q_d and the relative prices s and $\bar{p}$.

Consider next a fall, say, in the wage rate that shifts the price ratio, as in diagram 5.1. Given the level of Q^1, the optimal capital-labour ratio falls due to the substitution effect. This is the effect referred to by Summers in the previous section and one of the main issues of controversy in the investment literature, as was mentioned. Clearly, however, this does not represent the total effect. The fall of w reduces s and moves the optimum to O^2 in diagram 5.2. The resulting scale effect is shown in 5.1 by the shift from H^2 to H^3 and in our example it reverses the negative substitution effect.

For production theory this point is trivial and it would not be worth mentioning if it were not the case that investment models refer to input prices almost exclusively in the context of the labour-capital substitutability. The choice to abstract from this scale effect can only be attributed to an implicit assumption that $\Psi()$ is a Leontief type output function, with Q and X being perfect complements. An easy and clearly plausible way of substituting capital (and possibly labour) with other inputs, however, is for the firm to reduce its degree of vertical integration, buy intermediate goods from other firms and restrict its manufacturing functions in increasingly higher stages of production. The same process can clearly take place in the economy as a whole. Buying finished goods to resell them in the output market is then just one aspect of this process. We turn to this commercial activity of the firm next.

We may now reinterpret X in diagram 5.2 to be imports of finished goods to be resold in the domestic market. Q is instead now the quantity of finished goods produced by the firm, using the inputs K, L and M. Q_d is the total demand in both the domestic and the foreign markets. The 'output' function $\Psi(\,)$ is simply

$$Q_d = Q + X. \tag{5.14}$$

In terms of our previous example, this 'output' function is depicted in in diagram 5.2 by a straight line with slope equal to -1 and intercept Q_d. The price ratio is determined by the import price $\bar{p}$ and the average per unit cost of production s.

The type of output markets that we have in mind in this set up are markets where individual firms take prices as given, because of price collusion or price leadership by large international competitors. At the same time, they command some distribution channels and can therefore expect a certain level of demand. Part of these distribution channels may be abroad, but we are mostly concerned firms oriented towards the domestic markets. If the firms operate in markets where output prices are different, the price p will have to be thought of as a weighted average of the equivalent market prices. The demand each period is stochastic because of noise at the market level and possibly because of some transitional shifts in market shares. In principle the analysis can be extended to consider stochastic prices, but we do not attempt this here. Another interesting but non-trivial extension that we do not consider here is to allow the firm to choose ex ante (before the demand is revealed) the output price or some other relevant variable (advertising, R&D) that will affect the first (or higher) moments of the demand distribution.[14] We restrict

[14] Malinvaud (1987) considers the optimal choice of capital with a familiar downward slopping and with a kinked demand curve in a static model with a stochastic factor affecting the demand curve.

ourselves to the most simple fixed-price framework that allows us to derive an empirically tractable expression for the marginal profitability of capital.

The command of distribution channels gives the opportunity to the firm to have a commercial as well as a production activity. Intra-firm trade of finished goods for resale can clearly take place between domestic firms in this case, but it is more likely to take place between firms that do not normally compete in the market where the goods are resold. In fact, importing finished goods from abroad to meet domestic demand when this exceeds capacity may well be part of a policy of defending the domestic market share.[15]

Additionally, domestic manufacturers can be expected to involve in such downstream expansion if they enjoy cost advantages over independent commercial firms (possibly representing foreign competitors). This has been the case in Greece, where manufacturing firms had preferential access to bank credit (for loans financing both fixed and working capital) and enjoyed tax and other incentives compared to commercial firms (especially those in import trade). A number of studies and official reports have attributed the involvement of the manufacturing sector in commercial activities in Greece to the credit system.[16] Characteristically, Halikias wrote: "...there is evidence to suggests that easy bank financing to manufacturing industry, combined with restrictions on the financing of trade...led to a shifting of the competition among industrial firms from the sphere of prices (and quality of the product) to the length of term of the commercial credits which these firms extend to their clients." (Halikias 1978, pp. 213-214). "Another adverse effect of qualitative credit regulations is the tendency to establish more and more mixed enterprises engaged in heterogeneous activities, some of which qualify for bank financing, whereas others cannot be financed by the banks." (Halikias 1978, p.227). The protectionist policies in the early periods of growth in the sixties may have also contributed to the absence of a well developed import trading sector independent from manufacturing.

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[15] This idea is familiar in the context of multinationals. See Sugden (1983) and Cowling and Sugden (1987).

[16] See Halikias (1978), ch. 4, OECD "Economic Surveys: Greece" 1985/86, pp. 57-59 and "Report of the Karatzas Committee" (1987), p. 24. In section 6.1 we refer in more detail to the credit and other policies in Greece.

Returning, then, to our diagrammatic example above, we can see that with an 'output' function such as (5.14) we are likely to find most of the time corner solutions. What makes our problem more interesting is that in the next section we depart from the essentially deterministic analysis carried so far and consider the effects of a stochastic demand $\tilde{Q}_d$.

5.3 Stochastic demand and the marginal profitability of capital

In this section we digress from the essentially deterministic analysis of the previous chapters and introduce a stochastic demand. We consider this a worthwhile departure from our earlier framework, for it allows us to derive a tractable expression for the incremental return of capital that includes the expected capacity utilization and the profit margin as determining factors of the marginal profitability.[17] The model in this section and in the appendix draw from the static analysis of Malinvaud (1983, 1987) and Lambert and Mulkey (1987).

The introduction of uncertainty in demand requires some careful consideration of the timing of events. The continuous time model of our analysis is not particularly helpful in this respect, but some of the main underlying ideas can still be captured within it. Thus, firstly inventories are not considered here, but the assumption is that probable demand fluctuations are considerably larger than that which usual inventory levels can smooth out. To put it differently, $\tilde{Q}_d$, which is a flow concept, refers to a longer period than what existing inventory stocks can have an appreciable impact on. Second, we assume that imports of final goods, labour employed and material inputs other than capital can be adjusted in line with actual demand conditions. On the contrary, the capital stock is quasi fixed, in the sense that it has to be decided upon before the actual demand is known. With a Leontief production function this means that capacity is fixed at Q_s when demand has been revealed. In the appendix we consider some issues arising when factor ratios can vary ex ante but not ex post.

Assuming that the unit cost of importing a good, $\bar{p}$, lies between the unit production cost and the domestic market price, p, the firm will produce the good rather than import it for resale.[18]

[17] We continue to abstract, however, from issues of risk aversion.

[18] The possibility that $\bar{p}$ lies outside this range is ruled here out not because it is implausible, but because it is less interesting a case. If $\bar{p}$ is below the unit production cost, the firm will choose in principle to move into import trade and cease production. If $\bar{p}$ is above the domestic market price, it may choose not to meet

Thus, production each period is the minimum between demand and capacity. Imports bridge the gap between the two, if there is excess demand. Existing capacity is underutilized and the employment of variable factors falls, when the contrary is true. Let $g(Q_d)$ be the density probability function and $G(Q_d)$ the equivalent cumulative probability function describing the decision makers' believes about the stochastic demand. Ex ante, the expected level of production, $E\{\tilde{Q}\}$, and of imports, $E\{\tilde{X}\}$ will be given by the following expressions:

$$E\{\tilde{Q}\} = \int_0^{Q_s} Q_d\, g(Q_d)\, dQ_d + [1 - G(Q_s)]\, Q_s \tag{5.15}$$

and

$$E\{\tilde{X}\} = E\{\tilde{Q}_d\} - E\{\tilde{Q}\}. \tag{5.16}$$

We can now write down the expected gross operating surplus of the firm, which we will use to derive the marginal profitability of capital. Though we are considering here a Leontief production function, we include in the Lagrangean below a more general constant returns production function which will be useful for what follows in the appendix. The firm chooses ex ante the capacity level to maximize the following Lagrangean:

$$\Lambda = pE\{\tilde{Q}_d\} - \bar{p}E\{\tilde{X}\} - (wl + \mathbf{vm})\, E\{\tilde{Q}\} + \phi F(\frac{K}{Q_s}, l, m). \tag{5.17}$$

l is the labour-output ratio and $\mathbf{m}$ is the vector of material inputs-output ratios. The first term in the right hand side is the expected revenue, the second the expected total cost of imports and the third the expected total variable cost. The variable ϕ is a Lagrange multiplier and $E\{\tilde{Q}\}$ and $E\{\tilde{X}\}$ are given by the expressions (5.15) and (5.16) above. The first order condition for an optimal level of capacity, Q_s is as follows:

$$\frac{\partial \Lambda}{\partial Q_s} = (\bar{p} - wl - \mathbf{vm})\,(1 - G(Q_s)) - \phi F_1 \frac{K}{Q_s^2} = 0. \tag{5.18}$$

We also write the first derivative of Λ with respect to the capital stock, K,

$$\frac{\partial \Lambda}{\partial K} = \phi \frac{F_1}{Q_s}, \tag{5.19}$$

excess demand with imports, in which case p will replace $\bar{p}$ in the formulas below.

from where we can substitute ϕ in (5.18) to find the expected marginal profit of capital:

$$E\{\Pi_1(K)\} \;=\; [\,(\bar{p} - wl - vm)\,\frac{Q_s}{K}]\;\;(1 - G(Q_s)) \tag{5.20}$$

The precise interpretation of the first term follows below. For the moment we can say that, disregarding the difference between the output price, p, and the cost of imported goods, $\bar{p}$, the term in brackets may be interpreted as operating surplus of the firm *at full capacity* per unit of capital stock. Multiplied by the probability that demand will exceed capacity, this defines the expected marginal profitability of capital.

Concerning the import unit cost $\bar{p}$, note that its difference from the output price p can be interpreted as a trade margin. Thus, the first term in parenthesis, $(\bar{p}-wl-vm)$, is the "manufacturer's profit" per unit of output, i.e. the profit that the firm would have made as a manufacturer if it were in competition with importers making zero profits. Its difference from the unit gross profit margin of the firm can be expected to be higher, the more monopolized the domestic output market is.

The last term, $(1-G(Q_s))$, is the cumulative probability of excess demand. This is a function of the capacity, Q_s, with intercept equal to 1 and the shape of an inverse "S", tending to zero as Q_s increases. Lambert and Mulkey (1987, pp. 9-10) examined such a function for the case of a lognormal stochastic demand function and derived the following expression:

$$(1 - G(Q_s)) \;=\; \left[\;1 \;+\; h\;\left(\frac{E\{\tilde{Q}_d\}}{Q_s}\right)^{-\sigma}\right]^{-1}, \tag{5.21}$$

where h and σ are positive constants, both depending on higher moments of the distribution function of demand. The term inside the parenthesis is the expected capacity utilization. Taking logs and linearizing around $E\{\tilde{Q}_d\} = Q_s$, we find the following expression:

$$\log(1 - G(Q_s)) \;=\; -a_0 \;+\; a_1 \log\left(\frac{E\{\tilde{Q}_d\}}{Q_s}\right), \tag{5.22}$$

where a_0 and a_1 are positive constants. This is a convenient log linear expression for the probability of excess capacity as a function of expected capacity utilization. Combining (5.22) with (5.20) and expressing capacity, Q_s, as the ratio of capital stock over the (fixed) capital-output ratio, κ, we find finally a log linear expression for the expected marginal profitability as a function of the "manufacturer's" profit per unit of output and the expected demand per unit of capital:

$$log\,(E\{\Pi_1(K)\}) \;=\; -a_0-(1-a_1)\,\log\kappa + log\,(\bar{p}-wl-\text{vm}) + a_1\log(\frac{E\{\tilde{Q}_d\}}{K}) \qquad (5.23)$$

This last expression will be used in our empirical model in the next chapter. Despite the simple structure of the underlying model, we can see that (5.23) includes the factors usually thought as relevant for the marginal profitability of capital. Moreover, the log-linear equation was derived directly from the underlying model with few intervening approximations.

Before concluding this section, we finally consider how (5.23) can be used to derive the steady state path of investment. This is also relevant for the empirical model below. We assume that there are no adjustment costs along the steady state path and we, thus, use the familiar optimality condition $E\{\Pi_1(K)\}=c$, where c is the user cost of capital.[19] Let γ be the rate of growth of the expected demand along the steady state path and notice that relative prices will be constant along such a path. Using the above optimality condition and (5.23), we find that along the steady state path the gross investment over capital is given by the following:[20]

$$\frac{I}{K} \;=\; \gamma+\delta. \qquad (5.24)$$

From (5.24) and the steady state optimality condition it follows that along the steady state path we can write:

$$a_1\,logI\,-a_1\,log\,(E\{\tilde{Q}_d\})-log\,(\frac{\bar{p}-wl-\text{vm}}{p})+\log\frac{c}{p} \;=\; ct, \qquad (5.25)$$

where ct is a constant. Condition (5.24) will be used to characterize the steady state path of investment in the next chapter.

To summarize, we have set up a model in this chapter in order to derive an explicit expression for the marginal profit of capital. The main features of this model are as follows. Prices and factor proportions are assumed to be given for the individual firm. Demand is stochastic each

[19] See (3.18) in section 3.2.

[20] To derive this, we only need to substitute $E\{\Pi_1\}$ with c in (5.23) and time differentiate. See Bean (1981).

period. The optimal capital stock has to be chosen before demand is revealed. Firms can import from abroad and resell in the domestic market finished goods in order to cover any excess demand. Thus, ex ante the marginal profit of capital depends on the cumulative probability that expected demand will exceed capacity (and thus the extra capital will be used) and the "manufacturers" profit margin. This relation is expressed in the form of tractable log-linear equation, which we will use next to derive an empirical investment model.

Appendix: Optimal factor ratios

The Lagrangean in (5.17) can be used to consider the possibility that factor ratios are adjusted ex ante, but not after demand has been revealed. Note that this introduces an ex post fixity in the production coefficients different from the one considered in vintage models. The optimality conditions for such a problem are given by (5.18) and the following:

$$\frac{\partial \Lambda}{\partial l} = -wE(\tilde{Q}) + \phi F_2 = 0, \tag{A5.1}$$

$$\nabla \Lambda(\mathbf{m}) = -\mathbf{v}' E(\tilde{Q}) + \phi \nabla F(\mathbf{m}) = 0, \tag{A5.2}$$

where $\mathbf{v}'$ is the transpose of the row vector $\mathbf{v}$ and $\nabla \Lambda(\mathbf{m})$, $\nabla F(\mathbf{m})$ are the vectors of partial derivatives of the equivalent functions with respect to the elements of the $\mathbf{m}$ vector.

These conditions seem somewhat unfamiliar, but it can easily be shown that they are generalizations and extensions to the usual deterministic results. To see this, we use a steady state approach and set the marginal profit of capital in (5.19) equal to the rental cost of capital c. Combining this with (A5.1), we get

$$\frac{F_2}{F_1} = \frac{w}{c} \frac{E(\tilde{Q})}{Q_s}. \tag{A5.3}$$

This is the usual optimality condition that the marginal rate of technical substitution between two factors of production is equal to their price ratio. The latter is adjusted, however, by what can be interpreted as the expected degree of capacity utilization. The reason for such an adjustment is that while labour can be adjusted ex post, i.e. after the actual demand has been revealed, by assumption the cost of capital will have to be incurred regardless of the actual level of ex post production. Thus, the relative cost of capital has to be raised by a factor equal to the reciprocal of the expected degree of capacity utilization. Condition (A5.2) can be interpreted in a similar way.

It is clear, therefore, that the expected capacity utilization variable can be expected to play a significant role in this model, as in the one examined above. On the other hand, no empirically tractable expression for the marginal profit of capital can be derived from this more general model, unless some further assumptions are introduced here or at the stage of estimation. In this context, a Leontief production function would seem a reasonable restriction to impose.

Diagram 5.1

Optimal Capital-Labour Ratio.

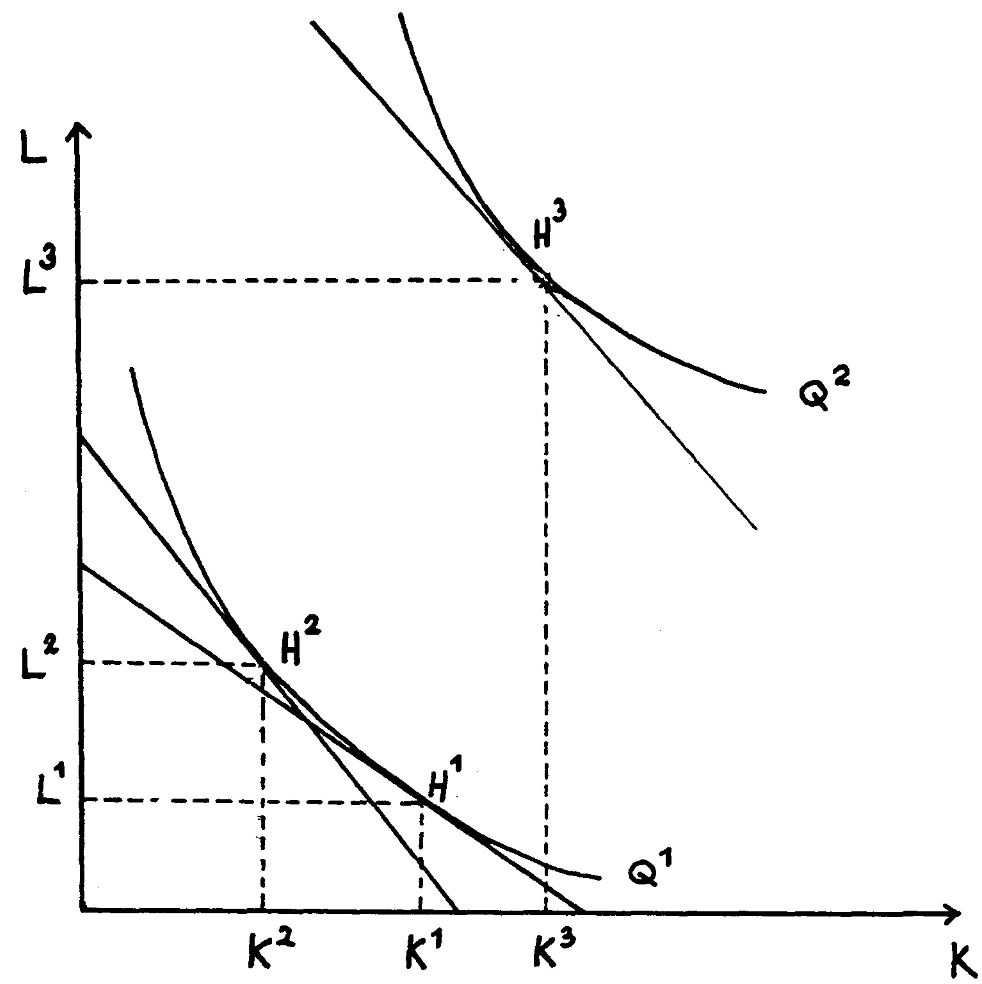
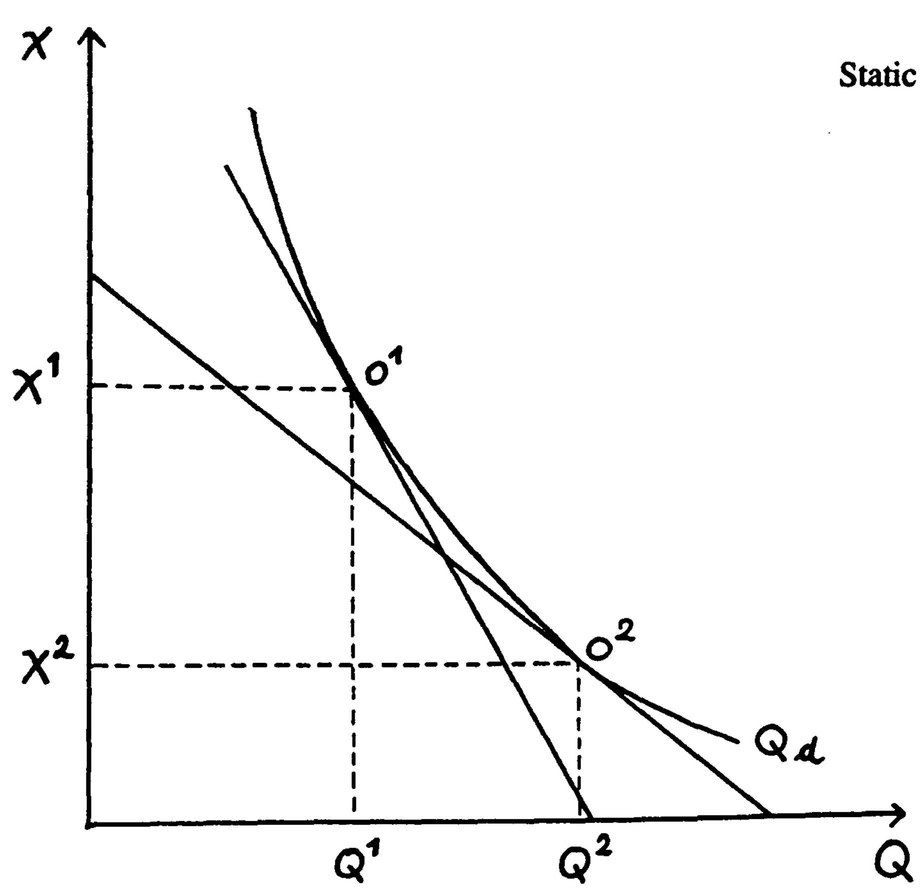


Diagram 5.2

Static Optimum.



Chapter 6

EMPIRICAL EVIDENCE FROM GREECE: 1973-1983

In this chapter we develop an empirical investment equation based on the theoretical models of the previous chapters and test it using panel industry level data from the Greek manufacturing sector for 1973-1983.

In section 6.1 we briefly describe the evolution of the Greek economy from 1960. The emphasis is placed on the structure and performance of the manufacturing sector, but some general information is also provided about the macroeconomic environment and the government policies over the period. In 6.2 we develop our empirical specification starting from the theoretical models of chapters 3 and 5 and taking into consideration some features of the institutional framework in Greece. In section 6.3 we discuss briefly the variables used and the econometric methodology before presenting and discussing the empirical results. For the estimation we use panel industry level data of the Bank of Greece for the period 1973-1983. Section 6.4 summarizes and concludes. Finally, Appendix A offers some further information on the investment incentives system in Greece and Appendix B describes in more detail the data set and variables used.

6.1 A description of the Greek economy: 1960-1983

Industrial development has been much discussed in Greece over the last decade partly as a reflection of what has widely been perceived as a crisis of the industrial sector over the same period. This discussion has usually picked the thread from the early 1960's when industrial growth in Greece took off and many of the characteristics of the industrial system were shaped. We also choose 1960 as our starting date and describe developments in three sub-periods: The early high growth period of 1960-1973 coincides with our pre-sample period and its description is intended to provide some insight on the state of the Greek economy and industry by the time of the first oil shock. The second sub-period covers the years between the two oil shocks during which many of the weaknesses of the Greek industrial system and economy began to show. Finally, our description of the period after 1980 focuses on the years up to 1983 where our data sample ends. The eighties as a whole is a period of severe difficulties for much of the industrial sector in Greece. The main aim of this section is to provide the necessary background information for the empirical model of section 6.3.

1960-1973

Over the period 1960-73 the Greek economy expanded fast and steadily. Subject to the usual qualifications about international comparisons, Greece ranked only second to Japan within the OECD in terms of growth rates of GDP and GDP per capita. In constant prices the former increased in this period by a factor of 2.5, high even in comparison with other less developed European economies. Gross fixed capital formation had a similar trajectory.[1] Further, until the end of 1972 inflation rates in Greece were among the lowest in the OECD. On the other hand, Greece suffered from a permanent imbalance in its foreign trade, most of the time worse than that faced by other growing economies. Over the period 1960-73 exports of goods in value terms were only an average 36% of imports. Capital goods accounted for roughly a quarter of these imports. Invisible earnings from emigrants' remittances, shipping and tourist receipts covered about 70% of the trade deficit, the rest was mostly made up by autonomous movements of capital.[2] Up until

[1] See OECD (1990), part six.

[2] See Bank of Greece (1984), tables 14-18.

1973 the Greek Drachma was pegged with a constant exchange rate to the USA dollar.

Reliable data on unemployment were not collected until very recently. Underemployment in the agricultural sector seems, however, to have been the main feature of the decade. A large part of the labour force was released from the agricultural sector and either emigrated abroad or migrated towards the urban centers, in particular Greater Athens, where most of the activity in the industrial and service sector has always been concentrated.[3] Studies at the time warned of prospective seasonal labour shortages in the countryside, but no such shortages in the industrial sector at least as far as unskilled labour was concerned. During 1966-72 nominal hourly wages in manufacturing establishments with over 10 employees rose with an average annual equivalent of 8.4%, the consumer price index rose annually by 2.4% and value added per worker at current prices rose by an annual equivalent of 12.3%.[4]

Rapid urbanization, economic growth and increased demand for better social services created a strong need for the necessary infrastructure. In areas like energy, water and to lesser extent transport and communications the public sector carried the bulk of the investment programs. In manufacturing, however, the direct public investment was negligible after 1963. Government investment as a percentage of total investment in manufacturing fell from an average 24% during 1960-63 to 1% during 1964-73 and remained at this level for most of the seventies and eighties.[5] Instead, the governments' goal seems to have been to provide the necessary legal and economic environment that could induce private activity. Foreign industrial investments enjoyed special protection under Art. 112 of the 1952 constitution (!) and laws introduced already since 1953. Both foreign and domestic industrial firms enjoyed a host of fiscal and financial incentives and duty protection against import penetration. Concerning foreign trade in particular, under the association agreement with the EEC exports from Greece to EEC members faced reduced duties since the end of 1962 and were almost uniformly set at inter-community levels since 1968, while import duties in Greece were allowed to be reduced progressively over an

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[3] See National Statistical Service of Greece (NSSG) "Statistical Yearbook of Greece", various issues under headings II Population and III Employment.

[4] See NSSG "Annual Industrial Survey", various years and Bank of Greece (1984), table 12.

[5] See Bank of Greece (1984), tables 5-6.

envisaged transitional period of 22 years (from 1962). Some of the financial provisions of the association agreement were frozen after the 1967 military coup in Greece, but most of the tariff agreements and indeed most of the fiscal and other economic policies of its predecessors remained in place throughout the years of the military regime between 1967 and 1974.[6]

We turn finally to the manufacturing sector in some more detail. Diagrams 6.1 and 6.2 in the end of the chapter show an index of the total value added and gross fixed capital formation in the manufacturing sector at 1970 prices over the period 1960-88 (1973=100). Both rise over the period faster than the equivalent aggregate items, but this partly reflects the initial small industrial base. In fact manufacturing investment never exceeded 15% of total investment and was half as much as that destined to residential construction and one of the lowest as a percentage of GDP in the OECD.[7]

Foreign investment played an important role in this expansion of the manufacturing sector, but how important it is difficult to say precisely. The data that exists suggests that at its peak around 1964-5 the gross inflow of capital from abroad being invested in industry (including mining, transport etc) could have been as high as one fourth of all industrial investment, falling later to one tenth of it.[8] There is no published data on the precise allocation of these foreign investments. Using information about equity holding, Giannitsis found that foreign or expatriate Greek interests were prominent in the following industries (two digit ISIC): Petroleum refining (32), basic metal industries (34), transport equipment (38) and miscellaneous industries (39).[9] Wood (25), plastics (30) and electrical equipment (37) had also important foreign presence.

The inflow of foreign capital may partly also explain the shift in the specialization observed in this first period. In table 6.1 in the end of this section one can see the share in total manufacturing value added at 1975 prices for different groups of industries for 1960-61, 1972-73 and 1980-

[6] See Freris (1986), ch. 6.

[7] See Bank of Greece (1984), table 5 and OECD "Economic Survey 1977" pp 28-32.

[8] See Bank of Greece "Monthly Statistical Bulletin", various issues. These data refer to industrial investment under the Law 2687/1953 that provided special protection for capital from abroad. The problem is that not all industrial capital inflows from abroad need to have registered with this law, nor on the other hand all registered inflows were necessarily controlled by foreign interests.

[9] See Giannitsis (1985), p. 273. Note that all four industries mentioned are not included in our data set below.

81. The comparison of the two first columns shows some evidence of a shift from the more traditional food and textile industries to chemicals and metal industries, though also the lower than average growth in the transport industry (dominated by shipbuilding) may be noted.[10] On the other hand, the machinery and equipment producing industries accounted by the end of the period for a low 8% of the manufacturing value added, despite their relative fast growth over the period (due mainly to electrical appliances). This was reflected in the fact that Greece imported much of the needed machinery from abroad, as much as 95% of its needs according to Kintis (1982).[11]

Another change was the increased volume of manufacturing exports. These increased their value share in total exports from 12% in 1961 to 45% in 1973.[12] Even so the export orientation of Greek manufacturing has remained rather low. Deleau (1987) contains some information on the export rates (exports over production) for each of the two digit industries and the total manufacturing sector. The latter rises from 2% in 1960 to 8% in 1970, 14.4% in 1975, 16.8% in 1980 and 18.5% in 1985.[13] These rates vary between industries with the basic metal (34), petroleum (32), leather and footwear (29),(24) and miscellaneous industries (29) reporting rates of around 30%, while the rest remain closer or much below the average rates. In the same table Deleau reports also import rates (imports over internal demand of the goods produced by each industry). For the manufacturing sector as a whole these remain relatively constant at around 22% for 1960-80 and rise after that to 28% by 1985. Some further information on structural characteristics is mentioned below.

1973-1980

The first oil shock coincides in Greece with a period of political instability in the end of which, in the summer of 1974, the military regime collapses after the Turkish invasion of Cyprus and the subsequent general military mobilization in Greece. In the run up to these events Greece had experienced an economic boom accompanied by expansionary economic policies. In 1973

10 Similar conclusions follow if other variables such as gross production or investment are used.

11 See Kintis (1982), p. 47.

12 See OECD "Survey", various issues. This includes exports in the following groups of the SITC classification: (5), (6), (7) (8) and (1) except "non-manufactured tobacco".

13 See Deleau (1987), table 2.6. Data on 1985 are reported as provisional.

internal and external inflationary pressures built up and the trade deficit deteriorated rapidly. Government policy was tighten, though the first signs of a slowdown in construction activity were already apparent in the end of 1973. A downturn in economic activity was experienced in the beginning of 1974 and it was then fueled by international events and the Cyprus crisis. GDP at constant prices rose by 8.3% in 1973, then fell by 1.8% in 1974. Manufacturing value added at constant prices rose by 17.5% in 1973, then fell by 2.8% in 1974. Gross fixed capital formation in all activities other than manufacturing also dropped sharply in 1974, investment in manufacturing followed a year later.[14]

Relative monetary stability returned by the end of 1974 and the civilian government by then in power reversed some of the restrictive policies, especially regarding building activity. Other early measures included the announcement that the Greek drachma would not any longer be officially linked to the US dollar from the beginning of 1975 and the application for early full membership in the EEC in June 1975. The harmonization process with EEC rules and policies was accelerated, the accession treaty was signed in 1979 and full membership was gained on 1/1/1981, with an eight year transitional period for the application of certain policies.[15]

The overall performance of the Greek economy from 1974 to the second oil shock is hard to summarize and even more to judge.[16] Output and gross fixed capital formation returned to growth path at rates above the average of the OECD countries, but below that of some member states.[17] Inflation remained between 10% and 20% throughout the period and there was little marked improvement in the trade balance. The Greek drachma lost ground vis a vis most major foreign currencies. In the labour market emigration ceased and this contributed to a modest growth of the labour force which was matched by an increase in employment, mostly from the public

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[14] Source: Bank of Greece (1984), tables 1,2,5,6. This one year lag between investment and output that appears to exist when comparing diagrams 6.1 and 6.2 may be due, among other reasons, to the fact that aggregate manufacturing investment series refer to completed projects, not work in progress. Our sample data below, where work in progress is included, shows a marked decrease in manufacturing investment in 1974 and a partial recovery in 1975, much in line with aggregate investment series in all other sectors of the economy.

[15] See Freris (1986), ch. 6.

[16] For a detailed survey of the period 1975-79, see "The Greek Economy: 1975-1979", Bank of Greece (1982), pp. 21-108.

[17] See OECD (1990), part six.

sector.[18] With the restoration of civil liberties trade union activity increased, particularly in the public sector that often acted as a reference point for the rest of the economy. Nominal hourly wages in manufacturing establishments with more than 10 employees rose from 1973 to 1980 by an average annual rate of 21.9%, the inflation rate was on average 14.6% and the nominal value added per worker grew by an annual 16.8%.[19]

Turning to the manufacturing sector, diagrams 6.1 and 6.2 show that value added rose every year after 1974 until 1980, but investment followed a more troubled path. Table 6.1 in the end of this section shows further that developments between sectors moved almost in the opposite direction than what had occurred in the previous period. The share in the total manufacturing value added of the textile and related industries (23,24,29) and of transport equipment (38) increased, while that of the metal industries (34,35) and machinery and equipment industries (36,37) fell. This, it may be noted, was to some extent contrary to what happened in many industrialized countries and marks a heavier specialization of Greece in what are now considered "weak demand industries".[20] Foreign direct investment in industry is likely to have fallen from its pre-1973 levels.[21]

Concerning other structural characteristics, it has often been mentioned that the manufacturing sector in Greece is characterized by a large number of very small establishments employing not many more than 5 employees. This is, however, misleading since, to take 1980 as an example, the 766 establishments with over 100 employees that represented a mere 0.6% of the total number accounted for 31% of total employment and 55.4% of total sales in the manufacturing sector. On the other end of the spectrum 97% of all establishments employed less than 20 employees and accounted for 50% of total employment and 24.3% of total sales.[22] A similar

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18 See OECD "Economic Survey" 1982, p. 17 and 1983, p.24.

19 Source: Bank of Greece (1984), tables 10 and 11 and NSSG "Annual Industrial Survey" for 1973 and 1980.

20 See Deleau (1987) and the "European Economy" 25, Nov. 1985.

21 Inflow of capital under 2687/1953 falls drastically after 1974. Other items of the capital flow account under the general headings "other enterpreneurial capital" and "long term credit" increase, however, over the period. Since the destination of these flows is not known, no secure judgment can be made about foreign investment in manufacturing.

22 See NSSG "Annual Industrial Survey" 1980.

polarization between few large establishments and a large number of small units was found at the three - digit industry level by Giannitsis (1985), using information on the horse power of units in 1978 and may suggest a high degree of market concentration. However, reliable information on concentration is missing mainly because of the lack of reliable published firm-level data.[23]

An important feature in the development of the manufacturing system has been the role of the banking system as the main source of external financing. In the period under consideration this dependence on bank lending increased further and net long bank borrowing as a percentage of total gross manufacturing investment rose from an average 26% in 1973-76 to 41% in 1977-79 and 51% in 1980.[24] Reliable information on other sources of finance for the whole industry are not available. The information published by the Federation of Greek Industries (FGI) concerning the balance sheets of a variable sample of companies shows that long term debt from non-bank sources accounted for about a fourth of long term debt in the beginning of the period under consideration, fell to less than a sixth by 1980 and remained low thereafter.[25] Public issues of new equity capital from manufacturing firms were insignificant during all the period. Trading in the Athens Stock Exchange has been very thin after 1972-73 with only about 60 manufacturing firms being listed at all. Information on share transactions outside this organized market is scant, but judging from what is considered to be a rather stable (family based) ownership structure, one would be justified to ignore equity trading altogether.

The reliance of the manufacturing sector on banks for much of its external finance was fostered by the credit policy of successive governments. Ceilings on lending rates were often set at or below inflation rates and a string of regulations on the lending policy of the banks were imposed favouring the financing of activities such as long-term industrial investment and exports and penalizing lending to commercial concerns for imports.[26] Whether this system succeeded in

[23] Profit-loss accounts in Greece include no information on sales, output or labour costs. Balance sheets are in historic cost basis.

[24] Financing from special credit institutions is included. Investment and finance to handicraft (small scale industry) is included. These numbers may be somewhat misleading as far as large industry is concerned because of the increased attention that handicraft received after 1978. If investment and finance to handicraft is excluded the above ratios are 26% in 1973-76, 33% in 1977 and 46% in 1980. Sources: Bank of Greece "Monthly Statistical Bulletin" and NSSG "Annual Industrial Survey", various issues.

[25] See Federation of Greek Industries (1986), table 18.

[26] See Courakis (1981).

providing the necessary finance where and when it was needed is debatable. Reports and other studies have pointed out that regulations were consistently circumvented and distorted by both banks and firms.[27]

Banks tied loans to the use of other services by the borrowers and thus raised the effective interest rates above the ceilings set by the authorities. Also, according to Halikias (1978) "...it may be argued that the detailed credit regulations, which have been in force since the early postwar years, prevented the creation within the Greek financial institutions of appropriate mechanisms and competent personnel to evaluate the economic prospects and the financial needs of their clients and thus to judge whether, and to what extent, outstanding or further expansion of bank credit would be justified on economic grounds. This may explain why the Greek commercial banks rely extensively on real estate or collateral security..."[28] Manufacturing firms, on the other hand, used their privileged access to bank loans in order to finance and control other activities, such as commerce and imports, that had no such access.[29] It is possible that this financial intermediation by the manufacturing firms may have turned from a profitable activity to a liability in the early eighties, when a number of wholesalers and retailers run into financial difficulties.

Post-1980

As was the case with the first oil shock, international events at the turn of the decade combined with domestic developments to produce a sharp downturn in economic activity. Prices had already started to rise faster in Greece in the beginning of 1979 and by the end of that year inflation was running at around 25% on an annual basis, prompting the authorities to announce a tightening of policy for 1980. In the event fiscal and monetary policy were more expansionary than in previous years and, with signs of an economic slowdown, they were further relaxed in the beginning of 1981. Bank long run credit to manufacturing over gross investment reached a record 61% in 1981, the PSBR at a cash basis as a percentage of GDP at market prices reached also a

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[27] See Halikias (1978), Courakis (1980) and (1981), Xanthakis (1986), OECD "Economic Survey" 1985/86, Report of the Karatzas Committee (1987).

[28] Halikias (1978), p. 225.

[29] See Halikias (1978), ch. 4, OECD "Economic Survey" 1985/86, pp. 57-59, Report of the Karatzas Committe (1987), p.24.

record 14.8%.[30] Even so, following also the international events, a downturn in economic activity was not prevented, starting from 1980 in residential construction and 1981 for many manufacturing industries.

The socialist government in power from October 1981 also followed an expansionary policy up to the end of 1985, though, to start with, in the first two years fiscal and monetary policy was more moderate than that of the election year of 1981. Long run borrowing over gross investment in manufacturing was a high 55% on average between 1982 and 1985.[31] With the exception of a few lending rates at the lowest bands, ceilings on nominal rates were preserved at or below inflation rates and short run bank credit to manufacturing as a percentage of manufacturing value added remained at or above the 1978-81 levels. Thus, the reported difficulties of many firms in financing even their working capital in 1982 and 1983[32] cannot be attributed to any apparent excessive tightening of the credit policy of banks. Rather, it is likely to have been related to internal cash flow problems of the firms. A source for such problems could well have been a sharp drop in their net profitability. Aggregate data on net profitability which are consistent over time do not exist in Greece for that period. Using, however, the aggregated data for the 11 industries for which our data sample extends up to 1983, we find that net nominal profitability (before deductions for depreciation) fell in 1982 by 30%, the real profits fell by 44%.[33]

There is a number of sources that may have contributed to such a drop. Demand conditions in foreign and domestic markets and the reintroduction of a wide range of price controls at home in the end of 1981 may have been responsible for a 8.5% fall in real revenue (sales) of the firms in our sample. Value added in the aggregate manufacturing sector also fell, as can be seen in diagram 6.1. At the same time production costs per unit of output rose. Apart from the costs of

[30] Sources: Bank of Greece (1984), table 5a and "Monthly Statistical Bulletin", June 1985, OECD "Economic Survey" 1985/86, table 6, p. 18.

[31] For sources see previous footnote. One qualification concerning the credit expansion ratio reported is that it includes loans to handicraft, for which credit policy was more accommodating in 1982 than for the large scale industry. Given the small share of handicraft in total investment and finance, however, any credit squeeze of the medium to large firms compared to earlier years could only have been very moderate.

[32] See OECD "Economic Survey" 1983-84, p. 30.

[33] For a description of the sample and for the precise definition of the variables, see Appendix B of this chapter.

certain materials, labour costs accelerated fast in 1982, following a 40% increase in minimum wages and a reduction of weekly hours of work introduced by the new government in the beginning of 1982. Nominal hourly wages in establishments with over 10 employees rose by 33.5% in 1982 and 19.2% in 1983, while inflation was running at around 21%.[34] Finally, fixed and financial costs did not adjust downwards with the fall in economic activity. In the aggregated data of our sample fixed and financial costs rose as a percentage of total revenue from 12.5% in 1981 to 14% in 1982.

By 1983 an increasing number of firms were unable to service their debt and a public body, "The Organization of Rehabilitation of Firms", was set up to support and supervise highly leveraged firms that were deemed to be viable. The organization had powers to appoint a new management and temporarily freeze the servicing of all debt. Until 1985 a number of mainly large firms came under the control of the Organization after the application of their owners or the lender banks and have remained so to date.

Developments in the Greek economy after 1983 are not relevant to our empirical work below. To complete the picture, we can mention briefly that policies continued to be expansionary with the exception of 1986-87 when a "stabilization programme" was applied with, among other things, a strict incomes policy. Compared with other OECD countries, the Greek economy in the eighties has been characterized by lower than average growth and higher than average inflation rates (unemployment data for Greece being too unreliable for international comparisons). Large public and external debt have become endemic problems. Up to 1988 real output in the manufacturing sector has remained around the 1980 level and investment only reached that level again in 1988.

The period 1973-83 that we are examining below is clearly important for the development of the manufacturing system in Greece. It includes almost a complete one and a half cycle in investment and by the end of it an initially fast growing manufacturing sector enters into crisis. The interpretation of this phenomenon has been the issue of considerable discussion in Greece

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[34] See Bank of Greece (1984), tables 11 and 12.

which goes beyond the scope of this thesis. The main factors other than the international events have been summarized by Deleau (1987) as follows:

- Macroeconomic inflationary disorder (with adverse impacts in terms of uncertainty and cost of labour).
- Industrial specialization based towards weak growth markets.
- High external financing of investment by firms, with negative and cumulative leverage effects.[35]

In the empirical model below we also focus on the three related issues of production costs, demand and financial conditions.

Finally, before leaving this section we can briefly refer to the results of recent econometric studies of investment in Greece. Manassakis (1982) used a pooled sample of two-digit industry level data (constant sample of firms) for the period 1967-77 (excluding 1974). The reported log linear investment function included only relative prices, capital stock and a quick assets ratio. In the preferred equation the lagged real wage rate and cost of capital were found to be statistically significant with elasticities of -0.3 and -0.07 respectively. Louri-Dendrinos (1986) used balance sheet data aggregated at the two-digit industry level (variable sample of firms) for three regions of Greece and 1971-1981.[36] A separate equation was estimated for each industry pooling the data of the three regions over 11 years. The model was similar to that used by Feldstein and Flemming (1971) with an additional "regional" variable measuring urban population. This latter variable as well as gross profits (a proxy for output) and an investment incentives variable were found to be significant in most equations with various elasticities. Finally, Dutta and Polemarchakis (1988) used aggregate industrial data for 1962-86. A linear corporate savings function and a separate log linear investment function were estimated. The former was found to be positively related to value added and negatively related to financial expenditure (debt multiplied by one plus the real lending rate), real wages and the price of capital. Investment was found to be positively related to value

[35] See Deleau (1987), p. 33.

[36] See also Louri (1989).

added (elasticity of 1.8), change in the log of real wages and the inflation rate, while it was negatively related to the real interest rate and the disposable income.

In the next section we specify our empirical equation based on the theoretical models of chapter 3 and 4. In section 3 empirical results are presented and discussed.

Table 6.1

Percentage share in total manufacturing value added of different groups of industries			
Industries	1960-61	1972-73	1980-81
20-21-22	22.6	19.5	19.5
23-24-29	20.7	19.3	23.1
25-26	6.7	6.2	4.5
27-28	8.5	5.7	4.4
30-31	8.1	11.2	11.5
32	2.3	2.4	2.1
33	6.0	6.9	7.0
34-35	7.5	13.1	11.9
36-37	5.8	8.0	7.4
38-39	11.8	7.7	8.6
Total	100	100	100

Source: Deleau (1978). Value added at 1975 prices. International Standard Industrial Classification for Manufacturing:

20 : Food except beverages

21 : Beverages

22 : Tobacco

23 : Textiles

24 : Footwear and sewing

25 : Wood and cork

26 : Furniture

27 : Paper

28 : Printing and publishing

29 : Leather and fur

30 : Rubber and plastic

31 : Chemicals

32 : Petroleum and coal

33 : Non-mineral metallics

34 : Basic metal

35 : Metal products

36 : Machinery except electrical

37 : Electrical equipment

38 : Transport equipment

39 : Miscellaneous

6.2 The transition from theory to empirics

In this section some of the features of the models examined in the last 3 chapters are combined to derive an empirical investment equation whose main purpose is to test for the effect of financial factors on investment. As noted above, finance has been put forward as one of the possible important factors affecting investment in Greece over the period under consideration. The other two factors that we will also be looking at are the demand conditions and production costs.

We first summarize the main arguments of chapters 3 and 4 distinguishing between the two main lines of approach already considered: The case where all available information is assumed to be revealed to all participants of the financial market and the one where there is asymmetric information between the decision maker of the firm and the market. We build on the analysis of chapter 3 and amend it to take account of the tax and incentive system in Greece. The model thus specified forms the basis for an empirical investment equation. We consider first the optimality conditions from the installation costs model. We search for a tractable expression for the shadow value of capital and specify an empirical model based on installation costs. This is then amended to take account of the financial costs of adjustment present when there is asymmetric information.

When all available information is assumed to be revealed to all traders in the financial market, signals and screening devices become unnecessary, for every potential creditor has all the information to evaluate the effect of the firm's policies on the "fundamentals". In the absence of distortionary taxation and of bankruptcy costs, financial policies do not affect the return of the firm as a whole (though they may affect the distribution of this return between alternative claims), nor are they related to investment, as we have seen. To put it differently, the way a firm decides to split a given future return in various types of claims cannot affect its overall value or cost of capital. Further, since the method of financing does not matter, the availability of internal funds is also irrelevant. Thus, current (and past) profitability plays no role on the financial side of the investment decision. The alternative approach, which has been the focus of our analysis, has stressed the non-full disclosure of information in the market. Private information is not immediately disseminated and the asymmetry in information between owner-managers and other creditors or potential creditors of the firm introduces principal-agent problems. These account for the rising costs and/or quantity constraints of financial capital from external sources. The choice of financial instruments is not irrelevant in this case. They reflect the cost and return for the shareholders of different sources and uses of funds. In the particular model considered earlier, for instance, higher gearing reflected higher marginal cost of borrowing and higher opportunity cost. If the rising cost of external finance is combined with a flow of internal finance that is quantity constrained or only available at a rising marginal cost, we can derive a dynamic theory of investment where adjustment costs are of a financial nature. The speed of adjustment depends in this case on the flow of earnings and new credit from external sources. Thus, two types of variables that seem irrelevant to investment within the perfect information model are introduced in this approach; variables referring to the financial structure and to the cash flow of the firm.

Both types of variables are familiar in the empirical investment literature, but, as was mentioned in chapter 2, their interpretation is disputed, firstly because of the possibility that they proxy relevant omitted variables of the full information model, and secondly because of the lack of a formal underlying theoretical framework. We thus start by considering first the installation costs model in order to determine what the empirical equation should be like in the absence of any financial imperfection. We then extend this to capture some of the issues raised by our financial costs model. Our analysis follows from chapter 3, where the possibility of external equity finance has been ignored. While this can be extended to include an equity market, as we have seen, we will follow all previous research on Greece and ignore equity financing altogether. As was mentioned in the previous section, its role over the whole period seems to have been negligible.[37]

The model in chapter 3 was built on the assumption that the installation and financial costs arise from *net* investment. The main purpose of this assumption was to keep the analysis at the stationary equilibrium as close as possible to the original neoclassical model. This condition does

[37] Note that even in economies with active share markets, such as the UK and the USA, the importance of these markets in the financing of investment is widely questioned. See for instance Mayer (1988).

not play any important role in what follows and since there is no particular reason to distinguish replacement from other investment, we assume below that both installation and financial costs depend on gross investment, I. We continue to assume, however, for simplicity that there are no adjustment costs of any kind along the steady state path. We next extend this model to take account of the tax and incentive system applicable to Greece in the period under consideration.

Incentives and Taxes

Corporate taxation was based on a two rate system with different tax rates for dividends and retentions. For certain types of equity claims dividends could be taxed at the personal tax rate.[38] We will denote the two tax rates with $\tau_d(t)$ and $\tau_r(t)$ respectively. A tax on turnover and contributions on employee insurance and pension funds will not be introduced explicitly, but are taken into account by adjusting the respective relative prices.

Turning next to the investment incentives, we can notice that throughout the period under consideration there has been a proliferation of laws, legal decrees and ministerial decisions introducing new incentives or altering existing ones.[39] The main incentives were briefly the following.

On the fiscal side manufacturing firms enjoyed a lower tax rate on retentions for the acquisition of fixed capital and higher annual tax allowances for depreciation than other firms. These incentives varied on a regional basis but not among the various manufacturing industries. Since in our theoretical model so far we have assumed that firms hold only fixed capital assets, the first of these incentives can be introduced simply by adjusting appropriately the tax rate τ_r. Concerning the depreciation allowances, we follow Hayashi (1982) and Chirinko and King (1985) in distinguishing between those that depend on past investment expenditures from those that are affected by current investment decisions. Within the present value formula the former are represented by a constant, which we can ignore with little loss of generality. The latter, can be written as $\Delta(\rho, \tau_r)\, qz(I, K)$, where $\Delta(\rho, \tau_r)$ is the present discounted value of the tax savings due to deprecia-

[38] These were registered shares and all shares traded in the Athens Stock Exchange.

[39] In the appendix A to this chapter we briefly review the main investment schemes. More details are given in Louri-Dendrinos (1986), Giannitsis (1985) and OECD "Economic Survey" for Greece, various issues, from where we also draw.

tion per pound of current investment expenditures.

The financial incentives included low interest bank loans and interest rate subsidies for loans (from banks or from other sources) contracted for the financing of fixed capital investment.[40] These define a new category of debt with a lower interest rate than the market one. We focus on the first of the two, but a similar analysis can follow for the interest rate subsidy. We distinguish between bank long term loans with a low interest rate, denoted by B, and other debt D. The interest rate on the first is r_b, while on the latter we continue to denote the effective interest rate with r. We assume that B is retired at an exponential rate d. The existence of interest subsidized loans clearly created opportunities for arbitrage gains. Consequently the authorities had to restrict access and control the use of these loans. Despite all the anecdotal evidence, there is to our knowledge no well documented study concerning the criteria used to allocate these loans. For our purposes it suffices to assume that each firm knew and took as exogenous the percentage of low interest loans it could receive at any moment in time for each monetary unit spent on fixed investment. If this percentage is γ_b, then we can write,

$$\dot{B} = \gamma_b \; q \, z(I, K) - dB. \tag{6.1}$$

We examine the above incentives within a model with convex installation costs. The results are then used to amend the financial costs model. We define θ as the cost of one unit of retentions in terms of lost dividends, i.e.

$$\theta = \frac{1-\tau_d}{1-\tau_r}. \tag{6.2}$$

Also, to keep notation simple we define r' to be the marginal cost of non-subsidized debt, i.e.

$$r' = -f_2 = \frac{drD}{dD}. \tag{6.3}$$

and $f(K, B, D)$ as the gross profit minus interest charges and fixed costs, i.e. $f = \Pi(K) - r_b B - rD - FC$.

[40] Investment grants were also available in some regions over some of the period considered, but as we explain in appendix A, they are not relevant for the incentives package considered in our empirical equation. They can easily be introduced in the model by adjusting appropriately the price of capital q.

The Installation Costs Model

The present value of the total equity invested in the firm is given by

$$S(0) = \int_0^{\infty} e^{-\rho t} \left[(1-\tau_d)\, f(K,B,D) - \theta[\,(1-\Delta-\gamma_b)\, qz(I,K) - \dot{D} + dB\,] \right] dt. \tag{6.4}$$

ρ is here the nominal, net of tax opportunity cost. Shareholders will choose at time $t=0$ the optimal investment and financial policy of the firm maximizing $S(0)$. If μ, λ_b and λ_d are the shadow values of capital, of low interest debt and of other debt respectively, we can find after some manipulation that the following conditions must hold for an interior solution:

$$\mu = \int_t^{\infty} e^{-(\rho+\delta)(s-t)} \left[(1-\tau_d) f_1 - \theta\,[1-\Delta-\gamma_b\,(1+\frac{\lambda_b}{\theta})]\, q\, z_2 \right] ds, \tag{6.5}$$

$$\mu = \theta\,[\,1 - \Delta - \gamma_b\,(\,1+\frac{\lambda_b}{\theta})\,]\, q\, z_1(I,K), \tag{6.6}$$

$$\lambda_b = -\int_t^{\infty} e^{-(\rho+d)(s-t)}\ [\,(1-\tau_d\,)\, r_b + \theta\, d\,]\ ds, \tag{6.7}$$

$$\theta = -\lambda_d = \int_t^{\infty} e^{-\rho(s-t)}\,(1-\tau_d\,)\, r'\ ds. \tag{6.8}$$

All functions are evaluated at t.

Despite the extra notation these optimality conditions have the same interpretation as the ones derived in 3.2. We start by explaining briefly the expression in square brackets in (6.6), that also appears in (6.5).

Assume for the moment that investment is financed entirely by retentions except for a percentage γ_b that is covered by low interest bank loans. θ in front of the brackets is what the shareholders lose in terms of dividends for each drachma retained in the firm. For one drachma worth of investment shareholders lose θ times one minus the discounted future tax gains from depreciation, Δ, and minus the last factor in brackets due to financing γ_b of this investment with low interest loans. This last expression can be explained as follows. The gain in terms of increased dividends of acquiring one extra unit of low interest debt is θ, the cost is the shadow cost of debt λ_b.

Expression (6.7) determines the shadow cost of low interest debt, λ_b. If we assume static expectations for the variables involved, this can simply be written as follows:[41]

$$\frac{\lambda_b}{\theta} = -\frac{(1-\tau_r)\, r_b + d}{\rho + d}. \tag{6.9}$$

(6.9) reveals that the gains from low interest debt are related to the wedge between the opportunity cost of equity and the cost of borrowing after adjusting the latter for the tax concessions for interest payments.

Finally, we can consider the debt contracted in the free market. Note first that if the pegged lending rate r_b was such that $\rho = (1-\tau_r) r_b$, then $\lambda_b/\theta=1$ and the financial gains represented by the last factor in brackets in (6.6) would be equal to zero. In other words, if the cost of borrowing net of tax is equal to the opportunity cost of equity (net of tax), then there is no gain from using debt and the optimality condition (6.6) remains unchanged irrespectively of how investment is financed. Such an equality between the (marginal) cost of borrowing and the opportunity cost of internal funds holds for the debt contracted in the free market, which is why its cost does not appear in (6.6). To see this, we take static expectations in (6.8) and derive the following expression:

$$\rho = (1-\tau_r)\, r'. \tag{6.10}$$

To go a step further, in the full information model the marginal cost of borrowing r' can be replaced, as we have seen, with the constant market lending rate, i,[42] so that (6.10) serves as a useful expression for the net of tax opportunity cost of equity in terms of the observable free market rate i and tax rate τ_r.

Expressions (6.9) and (6.10) provide a simple way of adjusting the price of capital to incorporate the particular features of the financial, tax and incentive system under study, when perfect information is assumed. Combining them with (6.6) we find,

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[41] A similar expression can be found in Chirinko and King (1985).

[42] This implicitly assumes that τ_r is equal to the (marginal) personal tax rate, in order to preserve the non-arbitrage condition on the side of the creditors. See Miller (1977) and the related discussion in section 2.4.

$$z_1(I(t), K(t)) = \frac{\mu(t)}{\theta(t)\ \bar{q}(t)}, \tag{6.11}$$

where,

$$\bar{q} \approx q\ [\ 1 - \Delta(\rho, \tau_r) - \gamma_b\ (1 - \frac{r_b}{i})\ ]. \tag{6.12}$$

All functions are evaluated at t.

(6.11) provides the basis for a testable investment model based on installation costs and perfect information in the financial system. $\bar{q}$ is the unit price of capital adjusted for the tax and incentive system under consideration. The approximation involved in (6.12) takes d, close to zero. It would hold precisely if the low interest loans could be replaced upon retirement with new loans of low interest again. The introduction of risk aversion in principle would not change this result much, in the sense that for a bankruptcy-free company we would only have to adjust the riskless opportunity rate upwards by a risk premium that does not depend on the current financial position or cash flow of the firm. The shadow value of capital, $\mu(t)$, is determined in (6.5). A tractable expression for this has to be derived in order to complete our empirical equation. This is what we turn to next.

The Shadow Value of Capital

To keep in line with most of the empirical models, we rewrite the shadow value of capital in the discrete time equivalent of (6.5). We use a price index $p(t)$ ($p(0)$=1) and the equivalent expected inflation rate π to express the shadow value in real terms in (6.14).[43] Also, we allow for a delivery and gestation lag of n periods[44] and we introduce explicitly the expectations operator conditional on information at t, E_t. Finally, we ignore as secondary the effect of an increase in capital on the future cost of borrowing and future adjustment costs, i.e. we set f_1=Π_1 and z_2=0 in (6.5). This significantly simplifies the analysis, without removing much fundamental from the

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[43] We treat the nominal discount rate, ρ, the inflation rate, π and the tax rates, τ_d and τ_r as constants, but the theoretical analysis can easily be amended to take account of varying rates. For instance, the discount factor $1/(1+\rho)^{j+n}$ in (6.14) can be replaced by $R(t+1, t+n+j)$ if nominal rates vary, where $R(t, t+j) = \prod_{i=0}^{j} (1 + \rho(t+i))^{-1}$ for $j \geq 0$ and $R(t, t-1)$=1 for all $t \geq 0$.

[44] When n=0, the investment becomes productive in the same period that it is ordered and paid for.

model. The optimality condition for capital in the discrete time equivalent of (6.4) can now be written as follows:

$$\mu(t) \;=\; E_t\,\{\; \frac{(1-\tau_d)\,\Pi_1(t+n)}{(1+\rho)^n} \;+\; \frac{(1-\delta)}{(1+\rho)}\;\mu(t+1)\,\} \tag{6.13}$$

$$=\; p(t)\;E_t\,\{\;\sum_{j=0}^{\infty}\;(1-\delta)^j\;(\frac{1+\pi}{1+\rho})^{j+n}\;\;\frac{(1-\tau_d)\,\Pi_1(t+n+j)}{p\,(t+n+j)}\;\}. \tag{6.14}$$

(6.14) reveals that the real shadow value of capital at t is equal to the expected discounted sum of the real marginal returns of capital from $t+n$ onward, discounted back to the end of period t (when investment ordered at t is assumed to be paid for). There are two related difficulties in evaluating $\mu(t)$ that become apparent from (6.14). First, the marginal return of capital, $\Pi_1(t+n+j)$, depends in general on the capital stock and thus on the current and future optimal investment policy of the firm. Second, parameters entering in (6.14) may not be constant over time, whichmakes the evaluation of an infinite sum difficult. Even worse, if these parameters are stochastic and they do not enter linearly in (6.14) (especially if both $R(\,)$ and $\Pi_1(\,)$ are stochastic), they cannot always be simply replaced by their expected value (as when there is certainty equivalence).

There are various ways of proceeding from this point suggested in the literature, apart from the one of using stock market data, as suggested in the Q investment models. First, one may assume that the profitability function, $\Pi(\,)$, is a linear function of capital and thus Π_1 is independent of K. This, as we have seen above, implies that there are constant returns to scale and perfect input and output markets. If additionally we take the discount rate to be constant and assume a specific stochastic process for $\Pi_1(\,)/p$, such as a first order univariate autoregression, we can derive an expression for $\mu(t)$ based on past values of Π_1/p, the real discount rate, $(\rho-\pi)$, and the depreciation rate δ.[45] Instead of assuming a constant discount rate, Abel and Blanchard (1986a) linearize an expression such as (6.14) around some long run value of the discount rate, $(\rho-\pi)$, and of the marginal profitability of capital, specify the stochastic process of the two variables and derive again an expression for $\mu(t)$ based on past values of both.[46]

[45] See Sargent (1987), ch. XIV.

[46] See also Bernanke (1983).

A second approach is based instead on (6.13). Assuming a zero delivery and gestation lag (n=0) and using the optimality condition for investment (6.11), we have [47]

$$\bar{q}(t)\, z_1(t) \;=\; (1-\tau_r)\Pi_1(t) \;+\; E_t\,\{\, \frac{1-\delta}{1+\rho}\; \bar{q}(t+1)\, z_1(t+1)\}. \tag{6.15}$$

If $z_1(\,)$ is assumed to be a linear function of investment, (6.15) can be the basis for a linear lead dependent variable investment model. Under rational expectations the anticipated future investment in the right hand side can be substituted by actual investment plus an error with zero mean and the model can then be estimated using instrumental variables.[48] Investment models based on such stochastic Euler equations allow a flexibility on the choice of the production function and the market conditions underlying $\Pi_1(\,)$, though they restrict somewhat the choice of the functional form of the adjustment costs function, $z_1(\,)$.

Both methods, and especially the one based on Euler equations such as (6.15), have been introduced to deal explicitly with empirical models derived from stochastic optimization problems. The difficulty is, however, that when such stochastic elements are introduced in a dynamic problem, the first order conditions on which the empirical models are based become hard to interpret as behavioural equations. They are optimal in general for a feedback rather than a closed loop solution and they are usually intractable, thus leaving unanswered the question of how the agents are supposed to form their optimal policy when faced with such a problem. A similar point was made in passing by Pindyck and Rotemberg, when they wrote that " Stochastic control problems of this sort are generally difficult, if not impossible, to solve. This, of course, raises the question of whether rational expectations provides a realistic behavioral foundation for studying investment behavior and factor demands in general." [49] Rather than following this methodology, then, we make below specific behavioural assumptions as to how policy makers may be forming a view of the (shadow) value of capital, which we subsequently incorporate into our investment

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[47] We have also assumed that the information set at t includes the realized values of all stochastic variables.

[48] Such investment models have been estimated by Pindyck and Rotemberg (1983a,b) and Shapiro (1986) using the generalized method of moments. Abel (1978) derives a similar equation by applying a Koyck lead transformation on an equation such as (6.14).

[49] Pindyck and Rotemberg (1983a fn. p. 1067).

model in (6.11).

We have noted that much of the difficulty for the researcher as well as for the investor in evaluating the infinite sum appearing in (6.14) derives from the fact that this depends in general on the future path of capital. This requires the investor to plan in principle the whole optimal path from now to infinity. An alternative more intuitive assumption would be that the agent plans instead paths of a smaller horizon (at the limit static), which he periodically revises. [50] As usual, the difficulty in switching from an infinite to a finite programme lies with the choice of a "reasonable" salvage value for the state variable (capital) at the terminal date of the latter programme. In the context of our investment problem we can assume that the firm chooses at t an investment project to be completed, say, by the beginning of $t+h$, planning *as if* it were to reach the steady state equilibrium at $t+h$. Along such a steady state relative prices do not change, the expected demand and capital stock grow at a constant rate g and in line with our model in chapter 5, the expected marginal profitability of capital remains constant. This then provides a convenient way of evaluating an infinite sum such as (6.14) from $t+h$ onwards and use this as the (marginal) salvage value of capital after the completion of the finite programme. Apart from being analytically convenient, this assumption seems also intuitively appealing. The firm reacts to changes in the environment by drawing finite plans assuming that after the plan is completed, it will return to a long run investment path. Plans can then be revised each period.

We consider here a particularly simple such problem, where the planning horizon h is equal to the delivery and gestation lag n. This makes the shadow value of capital, $\mu(t)$, in (6.14) independent of the future path of capital (after $t+n$). Together with the condition of constant relative prices, interest and inflation rates at some long run level, we find the following expression from (6.14)

$$\frac{\mu(t)}{p(t)} = \left(\frac{1+\pi_t}{1+\rho_t}\right)^{(n-1)} E_t \left\{(1-\tau_d)\frac{\Pi_1(t+n)}{p(t+n-1)}\right\} \frac{1}{(\rho_t-\pi_t+\delta)}. \tag{6.17}$$

Time subscripts denote long run prices and rates as perceived at t. When another plan is drawn in

[50] Apart from the open loop -feedback policies for stochastic control problems, this idea can also be found in the earlier literature on "rolling plans". See for instance Goldman (1968).

$t+1$, these can be revised, say, to ρ_{t+1}. The shadow value of capital at t is equal in this case to the value of a perpetuity with return each period equal to $E_t\{(1-\tau_d)\,\Pi_1(t+n)/p\,(t+n-1)\}$ from $(t+n)$ onwards and opportunity cost equal to $\rho_t-\pi_t+\delta$, discounted back to the end of period t.

An Empirical Model based on Installation Costs

(6.17) provides a tractable expression for the shadow value of capital. Combined with the optimality condition (6.11) for the case of a single period gestation lag (n=1), we can derive a basic model of investment with convex installation costs and perfect information in the financial markets:

$$z_1(I(t), K(t)) = \frac{E_t\{(1-\tau_r)\Pi_1(t+1)\}}{\bar{q}(\rho_t-\pi_t+\delta)} = \frac{E_t\{\Pi_1(t+1)\}}{c_t}, \tag{6.19}$$

where c_t can be defined as the long run rental cost of capital as of time t.[51]

The expression in the right hand side looks familiar from the static optimization problems. Indeed, if we set z_1=1, as is the case in such problems, (6.19) proves to be no much more than a static optimality condition for capital in this single period gestation model. Instead, the right hand side expression is here suggested as an approximation in a sequential optimization model for the shadow value over the replacement cost of capital, $(\mu/\bar{q})$, i.e. for the "marginal Tobin's Q". Its value is unity only in the steady state equilibrium where by assumption are no adjustment costs. Everywhere else and along the optimal path it is equal to the marginal installation costs. Clearly, one weakness of this approximation is that not much weight has been placed on the long run optimal conditions. A plan was assumed to be drawn as if expected profitability throughout the optimal path were to remain constant at next period's expected levels. We return to the issue of the long run equilibrium in the next section. The advantage of this approximation is that (6.19)

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[51] Note that if we use (6.12), ignore the depreciation allowances and assume that the retirement rate of capital is equal to that of the low interest debt plus the inflation rate ($\delta = d+\pi$), we get

$$c = \frac{q}{(1-\tau_r)}\,[\delta + (1-\gamma_b)\rho + \gamma_b(1-\tau_r)r_b - \pi]$$

The weighted sum of the opportunity cost and interest rate we get inside the brackets is similar to the kind of discount rates commonly used in investment literature. Here, however, it is derived from an explicit recognition that low interest rate credit is rationed. On the contrary, most of the neoclassical models where such weighted sums are used usually assume that the debt market is perfect.

relates easily to existing investment models.

If the installation costs function $z()$ is linearly homogeneous in its two arguments, investment over capital in (6.19) can be written as a function of the long term user cost of capital and the expected marginal profitability of capital. Further, the latter can be expressed as a product of two variables, as was seen in (5.23) of the previous chapter, so that we may specify a logarithmic investment equation of the following form:

$$\ln\left(\frac{q(t)\,I(t)}{p(t)}\right) = a + b_1 \ln\left[\frac{\bar{p}Q - wL - vM}{pQ}\right]_t - b_2 \ln\frac{c_t}{p_t} + b_3 \ln\frac{E_t(\tilde{Q}_d(t+1))}{K(t+1)} + b_4 \ln\left(\frac{q(t)\,K(t)}{p(t)}\right). \tag{6.20}$$

b_1, b_2, b_3, b_4 are coefficients to be estimated and expected to be positive.

Equation (6.20) includes all the main variables commonly encountered in investment models other than financial variables. The first right hand side term after the constant may be interpreted as a profit margin (value of output at competitive import prices minus production costs over production value at market prices), the second is the real user cost of capital, the third the expected demand over the capacity of the firm and finally the capital stock. Technology (the capital-output ratio) and uncertainty (variance) of demand, mentioned in the model of section 5.3, are assumed to remain constant in this specification. The user cost of capital and the profit margin refer to long run values, the demand variable refers to the first moment of the stochastic variable $\tilde{Q}$ at $t+1$, based on the information set available at t. Since these variables are unobserved, in the empirical specification they have been replaced by their current and past values.

The Financial Factors

Having specified an installation costs model, we turn finally to the issues arising when we allow for financial costs of adjustment and asymmetry in information in the financial market.[52]

Two major points were raised concerning the differences between the neoclassical and the

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[52] We continue to assume in our empirical model, as we did throughout our theoretical discussion that insiders do not hold debt claims of their own firm. In this respect see footnote 3 in section 3.1. Our data set actually shows that the banking system in Greece, the trading partners abroad and the public sector held almost all of the debt of the firms involved.

financial costs model developed in chapter 3. First, we argued that under asymmetric information firms were unlikely to face the same discount rate or a constant cost of borrowing. This determined an optimal stationary gearing from an equation similar to (6.10), with r' as a function of gearing g. As was already mentioned, it has been suggested in the literature that such an optimal condition could be used to derive a proxy for the unobserved opportunity cost: The more expensive forms of external finance the firm is observed to use, the higher is its unobserved opportunity cost, which could lead for instance to the hypothesis that a high gearing ratio reflects a high cost of capital. There are some difficulties with this approach, however.

Firstly, lending institutions are unlikely to be using in reality a single indicator such as gearing to determine the terms (and cost) of lending. Although the theoretical analysis of chapter 3 can be extended in principle to include other screening devices, the empirical analysis would need to test for the combined effect of a number of such indicators reflecting the financial position of the firm. Secondly, much of the literature on asymmetric information has stressed the fact that credit may be quantity constrained rather than being allocated with use of interest and other non-price mechanisms. Some indicators such as a high level of external borrowing may reflect in this case an improved creditworthiness and better terms of borrowing, rather than the opposite. Finally, in chapter 4 we made a differentiation between the discount rate of the owners and any extra costs or constraints related to the *flow* of new equity finance. It seems appropriate to retain this differentiation, especially since the two are likely to be affected by different factors and have different policy implications. Expensive external finance along the optimal path may simply reflect in this case good investment opportunities for which the necessary equity finance may take time to raise, but does not necessarily imply a high opportunity cost for the owners. In the empirical model of the next section we continue then to rely upon the neoclassical model for the definition of the appropriate discount rate and the user cost of capital, aware of the fact that we are omitting an important piece of information. Some of its effect can be expected to be captured by the included market rate and by the group dummies used in particular for our panel data set.

The second difference between the installation and financial costs model has to do with the adjustment process. We argued that the accumulation of internal funds plays an important role when the markets are imperfect and it is likely to involve flow (adjustment) costs that pertain to the dynamics of investment. A simple way of capturing such costs was suggested with the introduction of a cost function $C(R, f+y)$, akin to the adjustment costs function $z(I, K)$, where R is defined here as the internal flow of funds (retentions, depreciation allowances, new share finance from the existing owners) and $(f+y)$ is the cash flow available to the owners. The extension of this model to include formally the tax and incentives system is not as straight forward as in the case of the adjustment costs $z(\,)$. The main argument, however, does carry through and keeping in line with chapter 4, we may write the equivalent of (6.11) as follows:

$$C_1(R(t),\ f(t)+y(t)) \ = \ \frac{\mu(t)}{\theta(t)\,\bar{q}(t)}. \tag{6.20}$$

To specify an investment function from (6.20), we use the identity for uses and sources of funds and define γ as the ratio of the flow of net new borrowing from all external sources over the gross investment expenditures:

$$R \ \equiv \ qI - \dot{B} - \dot{D} \ = \ (1-\gamma)\ qI.$$

Thus, we amend the log-linear model in (6.19) introducing in logs the two additional variables, i.e. the cash flow $f+y$ and one minus the flow of new borrowing over total investment $1-\gamma$ to capture the effect of the internal and external financial constraints respectively.

All along we have used an asymmetric information framework to justify our assumption that lenders may condition the availability and cost of loans on the existence of adequate equity. This, of course, does not exclude the possibility that demands for collateral and other securities may have also reflected institutional inertia in the financial system, as was suggested in the quotation from Halikias (1978) in the previous section. Such inertia would enhance the effects the role of inside finance on investment.

In the next section we use the model developed in this section to specify and estimate an investment function for Greece. Our main concern lies with the financial variables introduced in the last part of this section, which are predicted to have no impact on investment within the investment models with strongly efficient financial markets.

6.3 Estimation and results from panel data

The empirical investigation is based on industry data on Greek manufacturing of the Bank of Greece for the period 1973-1983. The precise definition of the variables and other information concerning the sample can be found in Appendix B. Two issues related to the construction of the relevant variables are worth mentioning here, however. The first is the absence of reliable data on borrowing to finance investment. Borrowing data were needed to construct the two variables γ and γ_b defined in the previous section as net borrowing for investment from all sources and gross borrowing at pegged interest rates from the banking system respectively over total gross investment. In principal the two series can be constructed from the relevant balance sheet data on debt. In practice we found that a lack of strict accounting principles, difficulties in differentiating between loans for different purposes and serious problems of timing in the accounting entries resulted to a series with questionable informational content. Even when lagged the two variables were likely to pick most of their systematic variation from the denominator (gross investment) and have a very unclear interpretation. Therefore before starting the estimation we decided to exclude these variables until more reliable data are available. This in effect amounted to an assumption that there were no systematic differences in the access that various industries enjoyed over time to bank and other loans to finance their investment.

The second issue is related to the discount rate ρ. In line with the neoclassical model, any net of tax free market long rate would do as a proxy. Note that this would be the same for all industries. Over the period under consideration, however, every conceivable rate was pegged in Greece, often at levels below the inflation rate. Further, trading in domestic stock and bond markets was much too thin to provide any reliable indication of the true opportunity cost and free market lending rate faced by large firms. We were led therefore to the conclusion that despite the exchange controls, interest rates abroad would be a better indication of the free market lending rate and opportunity cost of capital of firms dealing and importing most of their capital goods from abroad. Yields on long term bonds abroad were translated into nominal yields in Greek currency using the exchange rates in the beginning and in the end of each period.

There is an interesting feature about this "constructed" nominal rate that is worth mentioning here. The use of a sluggish or pegged nominal rate tends to give a real rate which is negatively related to inflation, especially unanticipated changes in it. This would seem inappropriate for any approximation of long rates. Exchange rates on the other hand tend to be more responsive to inflation differentials between the two currencies involved, even if there is central bank intervention. Thus, our constructed yield can be expected to incorporate some of these differentials. Further, choosing two relatively stable currencies abroad (the DM and the SF) as our reference point, we may hope to eliminate much of the effect of unexpected inflation on real rates. Finally, exchange rates clearly reflect expectations and macroeconomic developments other than the inflation rates. This may not be altogether inappropriate for our purposes since such macro-considerations are bound to have had a bearing on the degree of uncertainty and the level of confidence in the Greek economy relatively to those abroad, what we would wish to incorporate in our cost of capital. From an econometric point of view our user cost of capital variable may therefore well capture some of the macroeconomy-wide shocks over the period.

We turn next to the specification of the equation. We started with a specification in mind that would allow for a different intercept for each industry (fixed effects). These could capture some of the cross sectional variation in technology, market structure, demand uncertainty, access to bank finance and possibly other time-invariable characteristics unaccounted for. These unobserved industry effects are likely to be correlated with the included variables, as we have seen, which is why a random effects model that incorporates them in the error term does not seem appropriate in this case.

The choice of fixed as opposed to random effects does not resolve all problems, however. The usual estimation techniques for panel data suffer from bias if the regressors include predetermined rather than strictly exogenous variables. [53] These are variables that are uncorrelated to future and present shocks, but not past ones, e.g. a lagged dependent variable or, in our case, the capital stock and the cash flow variables. The problems arising in the presence of such variables

[53] See Nickell (1981), Hsiao (1986) ch. 4 and Arellano and Bover (1989).

can be explained with the following simple, one variable fixed effects model. Consider

$$y_{it} = a_i + bz_{it} + e_{it}, \quad i = 1,...,N \ , \ t = 1,...,T, \tag{6.22}$$

where $cov(z_{it}, e_{it}) = 0$, but $cov(z_{it}, e_{it-1}) \neq 0$. In particular, we can think of z_{it} as being determined by y_{it-1}.

The commonly used within-groups estimator of b is an OLS estimator from the transformed equation

$$y_{it} - \overline{y}_i = b\,(z_{it} - \overline{z}_i) + e_{it} - \overline{e}_i, \tag{6.23}$$

where $\overline{y}_i$, $\overline{z}_i$, $\overline{e}_i$ are the within-groups time means of the equivalent variables. Note that this transformation gives identical results with a partitioned OLS estimation of (6.22). Thus the estimate of b in (6.23) is the same with the one derived from estimating (6.22) with the fixed effects a_i replaced with the equivalent group dummies. Since $(z_{it} - \overline{z}_i)$ and $(e_{it} - \overline{e}_i)$ are correlated according to our assumptions, this estimator is biased and inconsistent for $N \to \infty$. As pointed out by Nickell (1981), the bias in this simple model is of the order of $1/T$. For T around 10 this can still be important.

(6.22) looks somewhat more familiar if we take first differences:

$$\Delta y_{it} = b\,\Delta z_{it} + \Delta e_{it}. \tag{6.24}$$

The issues arising from the presence of a predetermined variable in (6.24) are clearly similar to those found in models with a lagged dependent variable and suspected autocorrelation in the error term. The correlation of the past shock e_{it-1} with the z_{it} variable is responsible for a biased and inconsistent estimator of b even when $T \to \infty$ and therefore instrumental variable techniques are required. Before resorting to such techniques, however, one may use the by now well established literature of testing for autocorrelation in the presence of lagged dependent (or predetermined) variables. We thus start with an OLS estimation of the model specified in the previous section in first differences and test for autocorrelation.

In the first of the two tables in the end of this section the first set of results is presented. We denote sales and net profitability at constant output prices by S and PRO respectively and the profit margin by PMA. The profit margin proxies the first variable of (6.20), the net profitability represents the cash flow variable of (6.21), as is explained in Appendix B. [54] For all other variables we use the earlier notation. Subscripts denote lags.

Current and past (one lag) values of all variables except capital have been originally included to capture something of the unspecified expectation formation mechanism. As it turned out from the lagged variables only sales over capital were statistically significant and/or had an important effect on the rest of the estimated coefficients.[55] All equations include a dummy with the value of 1 for 1975 for all industries and zero elsewhere. This is to capture the recovery of investment to normal levels after a temporary slump that could have been caused by the 1974 events described in the first section of this chapter.[56] Also, in the light of our earlier discussion we checked for a structural break after 1981. The results of the Chow test are reported at the bottom of the table.

Column (1) presents results for the model derived in the previous section in first differences. The asymptotic tests at the bottom of the table show no sign of first or second order autocorrelation.[57] From one point of view this is an encouraging result since the detection of autocorrelation would have meant inconsistent estimators, as was mentioned earlier. On the other hand, absence of autocorrelation in the first difference equation is possibly a sign of dynamic misspecification in the original levels equation. There are further indications of such a misspecification. The capital stock variable enters with an unexpected negative coefficient and is statistically significant at the 10% level.[58] Further, it remained so when a constant and/or a lagged dependent variable were

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[54] The profit margin was defined as one minus the variable costs (wages of production workers plus other variable costs) over production at market prices. The idea of using variable costs was that general costs and salaries of administrative staff are more closely related to sales and the size of the firm and therefore their inclusion would mean that the profit margin captures some of the effects of variations in the level of production (and demand). Nevertheless, we did also experiment with alternative definitions of the profit margin that included these variables with little effect on the reported results.

[55] For instance the joint significance test statistic for $\Delta ln(PMA)_{-1}$, $\Delta ln(c/p)_{-1}$ and $\Delta \ln(PRO)_{-1}$ in a model including all the variables of column (1) was $F(3,118)=0.506$. Including a lagged dependent variable it became $F(4,117)=0.379$. The results were similar when the significance of these variables was tested within the other models presented.

[56] The observations for 1973 and 1974 are used to construct the first differences and lagged variables.

[57] For the use of these tests see Godfrey (1988) and Kiviet (1986).

[58] This result and the later results on capital do not depend on the price adjustment of capital by the q/p factor.

introduced to control for a possible trend in the original model and some as yet unspecified dynamics. This variable clearly does not capture the originally intended impact of the size of the firm on the marginal installation costs, $z_1(I, K)$. Noticing that

$$\Delta \ln K_t \;=\; ln(\frac{K_t}{K_{t-1}}) \;\simeq\; \frac{I_{t-1}}{K_{t-1}} - \delta,$$

one may suspect the presence of a dynamic misspecification of a more complicated nature than what a lagged dependent variable could capture. Additionally, we also had a priori reasons to believe that our model did not place enough weight on the long run conditions, as was mentioned in the previous section. We thus amend our model with an error correction mechanism, using equation (5.25) in section 5.3 that describes the steady state investment path. Additional to the variables entering (5.25), we introduced also the lagged net profits ($ln(PRO)_{-1}$) to test for long run effects of the cash-flow variable.[59]

Column (2) in table 6.2 presents the error correction model including the capital stock variable entering in column (1). The magnitude of its coefficient and its statistical significance drops sharply. The absence of any independent effect from the capital stock variable is consistent with the financial costs model where adjustment costs depend instead on profits. It may also be consistent with some versions of the installation costs story, in particular with installation costs due to imperfections in the capital goods market, as was mentioned in 2.2. In column (3) this variable is omitted with little effect on the rest of the coefficients. The statistical significance of the variables entering the feedback mechanism increases, revealing a degree of collinearity with the capital stock variable, as was suspected.

The test statistics for autocorrelation rise in both (2) and (3), but remain below the critical values at the 10% level of significance.[60] A way of interpreting the first differences specification in (3) could be as a reparametrization of a general dynamic equation that includes lags of the dependent variable alongside with lags of the independent ones, rather than transformations of an

[59] Note that in the results presented below lagged nominal investment, $lnqI_{-1}$ has been deflated by the output price p, rather than the investment price q, as (5.25) suggests. This was to facilitate the analysis of the dynamics below and has no significant effects on the empirical results.

[60] The same conclusion follows from a χ^2 asymptotic test statistic.

underlying levels equation. According to Davidson et al. (1978, p.684), such a parametrization not only alleviates some of the possible multicollinearity problems, but it is also "... determined by the choice of a set of plausible decision variables which incorporate relatively independent items of information, allowing agents to assess their reactions separately to changes in each variable." Thus, according to the feedback model (3), investment this period is planned to be equal to investment in the previous period modified by how much investment was off its equilibrium steady state path the previous period (the error correction mechanism) and by the impact (short run) effect of the change in a number of variables to be examined in more detail below.

The introduction of an error correction mechanism in (3) allows for a richer set of dynamics and an examination of the long run properties of the model, but it also reintroduces the question of possible unobserved industry effects entering this equation. As can be seen from (5.25), these could capture industry differences in the long run investment-expected demand ratio other than those due to the profit margin and the user cost of capital. We tested for this possibility by re-estimating the model (3) including industry dummies (fixed effects) and using instrumental variables, as was suggested in the beginning of this section.[61] An asymptotic test statistic of $F(14, 102) = 0.497$ comfortably accepted the restriction of a single intercept for all industries imposed by (3). Thus, a single intercept model specification was preferred.[62]

With the exception of $ln(c/p)_{-1}$ and possibly $\Delta ln(PMA)$ all other variables in (3) have the expected sign and reasonable magnitudes. Analysis of variance shows that these two variables as well as the lagged logarithm of profits may be omitted. The constraint thus imposed is accepted by a test statistic of $F(3, 116) = 0.155$. Column (4) in table 6.3 shows the results for the derived preferred specification. Before commenting on this model we briefly examine a more general specification of the model, where sales are introduced separately from the capital stock variables.[63] The point of examining such a generalization is the following. As was mentioned in

61 The instruments used are reported in the end of Appendix B.

62 The estimated coefficients of the variables included in (3) remained relatively stable when this was re-estimated with industry dummies and instrumental variables. Their asymptotic t-statistics, however, were rather lower, reflecting the problems with finding a strictly exogenous set of instruments required in this case.

63 The same results are reached if sales and capital are introduced separately in the more general equation (3). We present them here after having restricted (3) because we wish to compare (5) directly with our preferred specification.

chapter 2, it has often been claimed that profits are only found to have a significant effect on investment because they proxy some demand variable, in particular output or sales. We are therefore keen to establish whether profits had an independent effect from that of the sales variable and in particular whether some of the short run variation attributed to profits was not in fact due to changes in the absolute level of sales (as opposed to sales per unit of capital (capacity)).[64] An interpretation for such a sales variable could presumably be given within a naive accelerator model. Indeed, if sales are assumed to grow in the long run with a constant growth rate, following the same steps as for (5.25) in section 5.3, we can find that a naive accelerator model predicts that no other variable than sales should matter in (5).

The relative stability of the coefficient of profits in (5) compared to (4) and the fact that the statistical significance of the profit variable is not affected by introducing a separate sales variable can be viewed, then, as strong evidence against the hypothesis that profits acted simply as a proxy to sales. The fall in the statistical significance of the variables entering the error correction mechanism reflects a degree of collinearity with the capital stock variables, as was suggested earlier. Finally, the hypothesis that capacity, represented by the capital stock, played no role is rejected at the 10% level of significance by a test statistic of $F(2, 117) = 2.59$. On the contrary the constraint imposed by (4) that sales over capital should appear as a single variable is comfortably accepted by a test statistic of $F(2, 117) = 0.214$.

The results of columns (1) to (5) give strong support to the hypothesis that net profits had a significant impact on investment independently of that of sales or of the profit margin. In line with our previous arguments, our interpretation of this result is that the net profitability of the firm is one of the most important sources of internal finance. Be it because of asymmetric information or institutional inertia specific to the financial system in Greece the cost and availability of external finance was subject to the availability of internal finance and thus investment was affected by the owners' net income from the firm. The impact elasticity of profitability was found to be lower than the suggested unity in the model of chapter 4 and very close to the values found

[64] I am grateful to D. Leech for bringing this to my attention.

by Fazzari and Mott (1986) and Fazzari and Athey (1987) for their cash flow variables. On the other hand, in line with our theoretical model and with some of the arguments in the literature, net profits were found ceteris paribus to have had an effect on the timing rather than the long run investment path.

Turning next to the effect of sales on investment, we can see from (4) that the relevant long run elasticity is 1.087. This is close to unity as suggested in our theoretical model. Indeed, a long run proportionality between investment and sales and investment and the profit margin is accepted by the model in (4) with a test statistic of $F(2, 119){=}0.194$ and the constrained specification can be found in column (6). The long run equilibrium can easily be worked out from the results in column (6). If sales over capital remain constant in the long run equilibrium and net profitability grows at the same rate g as sales, we can find that

$$\frac{qI}{pS} = PMA \ exp\left[\frac{0.83g + 0.328}{-0.186}\right].$$

To give an idea of the magnitudes involved, we could substitute g with the average growth rate of sales over the period of 0.038 and PMA with the average profit margin of 0.31. This would give a long run ratio of investment over sales of approximately 0.045, compared to the actual investment over sales ratio of 0.069.

The (short run) impact effect of sales on investment in the model of column (4) is 0.563 and the dynamic response over a number of periods is presented in diagram 6.3 in the end of the chapter. As it can be seen from this diagram, there was a small degree of overshooting in the first two periods after a change in sales, which was subsequently corrected to the long run equilibrium. It has to be noted, however, that this is a *ceteris paribus* exercise, which in this case carries among other things the implication that while adjustment takes place, the capital stock remains constant. Introducing the capital stock can be expected to reduce this initial overshooting and the subsequent correction. Nevertheless, both (4) and (6) predict a rather fast response of investment to changes in sales, profits and the user cost of capital with the full adjustment having been approximately completed by the end of next period after the original impulse. One has to take into account, however, that our data on investment includes work in process that may be leading the completion of the actual projects by anything of up to 15 months.[65]

Finally, we can turn to the last two remaining variables that enter in column (4), the user cost of capital and the profit margin. The t-statistics of both variables are close to the values of the t-distribution at 10% level of significance.[66] For the cost of capital this is hardly a surprising result given the approximations involved for the measurement of each of its components and the fact that by construction it has very little cross sectional variation. The absence of a long run effect may further reflect the fact that the discount rate used is more likely to have proxied the free market lending rate rather than the unobserved opportunity cost of the firms involved. The two are not necessarily the same under asymmetric information and, as we argued in chapter 4, lending rates are likely to have only short run effects on investment.

The poor performance of the profit margin was found to persist through different specifications including the case where the net profit variable was removed from the equation.[67] This result may be pointing towards the need for a more elaborate model of the output market and the production technology of the firm. On the basis of the evidence from equation (4) the profit margin had ceteris paribus only a long run effect on investment which moreover took a long time to work through. Its mean lag was approximately 4.8 years. The long run elasticity, on the other hand, was not significantly different than unity, as was mentioned earlier.

Finally, a general warning against placing too much weight on the above estimates is here in place for the following reason. The shadow value of capital was approximated under the assumption of perfect information. An implication of this was that the opportunity cost of capital could be replaced in our empirical model with a market interest rate. Another implication was that the publicly available information on sales and the gross profitability of capital were assumed to reflect accurately the information on demand and profitability available to the firm at the time of planning. The effect of cash flow was then tested within this model; it was tested, as it were,

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65 See Nickell (1978), ch. 12 section 3.

66 Note that these results do not improve when the two variables are introduced in levels rather than logs.

67 It also persisted when total gross profits rather than gross profits per unit of output were introduced in the equation.

under the null hypothesis that the financial system has the necessary information to efficiently allocate funds. Our argument rested on the fact that if such an allocation did take place efficiently, then the availability of internal finance would not have mattered. Our results suggest that internal finance did matter, as one would have expected if the financial system lacked the information or was otherwise inefficient in allocating funds. Thus, private information of the firms may have not been disclosed (in a credible fashion) to the banks and the market information and the information of the Bank of Greece may well not give the complete picture concerning the future prospects and opportunity cost faced by the firms at the time.[68] An important challange for the future is, thus, to define more precisely the nature of this private information and determine its possible interaction with the observed variables of our model.

68 Of course one may argue that the information about sales, investment etc that we are currently observing were not available to the banks at the time they had to approve the loans, while they were known to the firm which were unable to convey them credibly to the banks. This is, however, unlikely to have been the only type of private information that the firms had.

Table 6.2

Dependent Variable $\Delta ln(ql/p)$ 128 observations OLS estimates			
	(1)	(2)	(3)
$\Delta ln(S/K)$	0.725 (1.78/1.80)	0.513 (1.21/1.36)	0.525 (1.30/1.36)
$\Delta ln(S/K)_{-1}$	0.813 (2.86/2.35)	0.730 (2.35/2.29)	0.731 (2.36/2.30)
$\Delta ln(c/p)$	-0.092 (1.52/1.53)	-0.068 (0.95/1.11)	-0.069 (0.96/1.11)
$\Delta ln(PMA)$	-0.085 (0.49/0.52)	-0.017 (0.10/0.11)	-0.015 (0.08/0.10)
$\Delta ln(PRO)$	0.171 (2.72/2.60)	0.185 (2.72/2.71)	0.184 (2.77/2.60)
$\Delta ln(qK/p)$	-0.777 (1.76/1.89)	-0.075 (0.10/0.11)	
$ln(ql/p)_{-1}$		-0.211 (2.47/2.24)	-0.216 (3.20/3.34)
$ln(S)_{-1}$		0.178 (1.30/1.22)	0.186 (1.62/1.57)
$ln(PMA)_{-1}$		0.153 (1.13/1.13)	0.157 (1.22/1.27)
$ln(c/p)_{-1}$		0.035 (0.39/0.50)	0.031 (0.38/0.46)
$ln(PRO)_{-1}$		0.048 (0.57/0.58)	0.046 (0.56/0.57)
D 1975	0.361 (3.29/3.44)	0.311 (2.79/2.96)	0.306 (2.94/3.02)
CONSTANT		-0.508 (0.73/0.75)	-0.545 (0.93/0.99)
RSS	14.2588	13.2760	13.2772
$\bar{R}^2$		0.263	0.270
Tests			
(1) *Heter.* (*Deg. Freed.*)	1.640* (14,113)	1.218 (14,113)	1.204 (14,113)
(2) *Aut.* O(1) (*Deg. Freed.*)	0.214 (1,106)	1.819 (1,100)	1.887 (1,101)
(3) *Aut.* O(2) (*Deg. Freed.*)	0.486 (2,90)	2.037 (2,84)	2.119 (2,85)
(4) Chow (*Deg. Freed.*)	1.018 (23,98)	1.072 (23,92)	1.083 (23,93)

* signifies that the F-test statistic is above critical values of the F distribution at 10% level of significance. All other F-test statistics in the bottom of the table are below critical values at 10%. See notes at the end of the tables.

Table 6.3

Dependent Variable $\Delta ln(ql/p)$ 128 observations	(4)	(5)	(6)
$\Delta ln(S/K)$	0.563 (1.46/1.49)		0.613 (1.64/1.62)
$\Delta ln(S/K)_{-1}$	0.775 (2.72/2.51)		0.818 (2.98/2.67)
$\Delta ln(c/p)$	-0.087 (1.52/1.59)	-0.087 (1.50/1.59)	-0.083 (1.47/1.51)
$\Delta ln(PRO)$	0.170 (2.95/2.71)	0.179 (2.99/2.89)	0.170 (2.98/2.78)
$ln(ql/p)_{-1}$	-0.207 (3.17/3.25)	-0.181 (1.81/1.64)	
$ln(S)_{-1}$	0.225 (2.65/2.77)	0.196 (1.60/1.49)	
$ln(PMA)_{-1}$	0.185 (1.64/1.68)	0.171 (1.40/1.38)	
$ln(ql/(pS\ \ PMA))_{-1}$			-0.186 (3.35/3.39)
$\Delta ln(S)$		0.509 (1.21/1.31)	
$\Delta ln(S)_{-1}$		0.669 (1.95/1.81)	
$\Delta ln(K)$		-0.603 (0.59/0.59)	
$\Delta ln(K)_{-1}$		-1.057 (1.91/2.19)	
D 1975	0.326 (3.29/3.37)	0.357 (3.22/3.31)	0.321 (3.28/3.35)
CONSTANT	-0.664 (1.21/1.30)	-0.530 (0.77/0.78)	-0.328 (3.29/3.27)
RSS	13.3299	13.2812	13.3733
$\bar{R}^2$	0.286	0.276	0.295
Tests			
(1) *Heter.* (*Deg. Freed.*)	1.207 (14,113)	1.533 (14,113)	1.240 (14,113)
(2) *Aut.* O(1) (*Deg. Freed.*)	1.809 (1,104)	0.083 (1,102)	1.392 (1,106)
(3) *Aut.* O(2) (*Deg. Freed.*)	2.117 (2,88)	0.755 (2,86)	1.859 (2,90)
(4) Chow (*Deg. Freed.*)	1.064 (23,96)	1.023 (23,94)	1.028 (23,98)

Notes:

In parentheses in the main table are OLS absolute t-statistics and asymptotic heteroscedastic-consistent t-statistics.

Tests:

(1) : Asymptotic F-test for heteroscedasticity (non-constant error variance between industries). Degrees of Freedom in parenthesis.
Computed from an OLS regression of the squared residuals on 14 industry dummies and a constant and tests for the joint significance of the dummies.

(2) : Asymptotic F-test for first order autocorrelation. Degrees of Freedom in parenthesis.
Computed from an OLS regression of the residuals on the residuals lagged once and all the regressors of the original equation. It tests for the significance of the lagged residuals.

(3) : Asymptotic F-test for second order autocorrelation. Degrees of Freedom in parenthesis.
Computed from an OLS regression of the residuals on the residuals lagged once and twice and all the regressors of the original equation. It tests for the joint significance of the lagged residuals.

(4) : Chow stability test distributed as an F with degrees of freedom in the parenthesis.
Computed comparing the RSS of the regression over the whole sample with the RSS from the sub-sample 1973-1981.

Appendix A

The tax and investment incentives system

A number of laws and legislative decrees (L.D.) affecting the tax and investment incentives system came into power in Greece over the period under consideration. Some of these incentives were differentiated on a regional basis, with investment in the region of Greater Athens and at a second instance in other urban centers being usually least favoured. As we have no information on the regional allocation of investment in our sample, nor on the locality of the headquarters of the firms involved, we cannot take advantage of the regional structure of incentives to capture some of the possible cross-sectional variation in the cost of capital that this may have caused. Further, the relevant "incentives regions" were often redrawn making it difficult to calculate the time variation of some "average" support for investment, assuming for instance a fixed regional allocation of investment. The most straight forward way seems therefore to be to concentrate on the incentive package offered to firms in the region of Attica where the bulk of the industrial activity in Greece has been concentrated.[69] Below we list briefly the main relevant features of the tax and investment incentives system applicable in this region in the period under consideration.

Tax Allowances.

The basic tax rate on retentions including various surcharges was 0.3824 until 1975, 0.434 until 1981 and 0.484 after that. Law 849/1978 allowed for 25% of retentions allocated to fixed investment to be deducted from taxable retained profits. Law 1116/1981 reduced this to 20%.

Depreciation Allowances.

Straight line depreciation was allowed for up to 100% of the historic cost of an asset. The basic rates were set to 0.12 for equipment and 0.08 for structures. L.D. 1078/1971 increased these by 25% for the capital used in two shift per day and 50% for three shifts. The same rates were adopted by Law 289/1976 and Law 1116/1981.

Financial Incentives.

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[69] See Kintis (1982), chapter V and Louri-Dendrinos (1986).

Interest rate subsidies and investment grants were not available in the region of Attica. Maximum lending rates charged by the banking system for loans destined for fixed investment were, however, pegged throughout the period, often at levels below the inflation rate. Firms had to self-finance a minimum of 30% of their investment expenditures to be eligible for these loans.

Appendix B : Data sources and variables.

The sample was constructed by the Bank of Greece from individual firm data (the same firms each year) aggregated at the two-digit industry level as specified by the International Standard Industrial Classification (ISIC).[70] These were all firms that borrowed from the banking system above a certain threshold. The information originated from a questionaire of the Bank of Greece collecting data for the Currency Committee that was abolished in 1983. The necessary information was available for 15 industries over most of the period between 1973 and 1983. The industries are all those specified by ISIC except 28 (printing and publishing), 32 (petroleum and coal refining), 34 (basic metal industries), 38 (transport equipment) and 39 (miscellaneous manufacturing industries). Also not included in the sample are observations for 1982-1983 on 23 (textiles), 33 (non-metallic minerals) and 35 (metal products except machinery) and for 1983 on 26 (furniture). During these years leading firms of these industries included in the sample of the earlier years were unable to service their debt, were put under bankruptcy procedures and eventually came under the control of a public body, "The Organization of Rehabilitation of Firms", as was mentioned in 6.1.

The following are the definitions of the variables used in the empirical model. All variables were constructed using the above data, unless otherwise stated.

qI: Gross flow of investment expenditures in equipment and structures at current prices. It includes work in process.

K: Capital stock in the beginning of the period, constructed separately for equipment and structures using the above investment data and the balance sheet data for 1973. Depreciation rates and investment prices used are mentioned below. 1973 was chosen as the base year because the combination of low inflation and high investment activity in the years just preceding 1973 meant that distortions in historic cost balance sheet data on structures and equipment were likely to be smaller than in any other year of our sample.

[70] See table 6.1.

S: Total sales plus income from work performed on account of others minus turnover taxes at 1973 output prices. In line with our theory, this variable represents demand Q_d.

$PMA = (\bar{p}Q - wL - \text{v}M) / pQ$: Profit margin. Data on $\bar{p}$, the cost of a finished imported good (to be resold in the domestic market at the price of p) were not available and therefore $\bar{p}Q$ was proxied by pQ. The separate components of the profit margin are defined as follows:

pQ: Gross production at market prices. For the years 1973-1975 no separate data were available on production as opposed to sales. This was constructed from the available sales series using an average ratio of production over sales for the years 1976-1979.

wL: Total wage cost of production workers including employers' social security contributions.

vM: Other production costs. It includes raw materials, intermediate goods, energy and fuel and costs for work contracted outside the firm.

PRO: Net profits before income tax at 1973 output prices. Data on the income of the owners from others sources, y, were not available, so this was the closest proxy to the cash flow variable introduced in the financial costs model. Net profits were defined as total sales, (S), minus production costs, $((wL+\text{v}M)/p)$, minus general costs, minus purchases of finished goods to be resold in the same condition as purchased, minus interest payments on debt, plus income from other sources, all at 1973 output prices.

$c/p = q/p\ (i-\pi+\delta)\ (1-\tau_r)^{-1}\ (1-\Delta)$: Real rental (user) cost of capital. The individual components of this variable are defined as follows:

q: Price index of investment expenditures (1973=100). Defined as a weighted average of the price indices used in the National Accounts of Greece for private investment in structures and in equipment (see Bank of Greece (1984)), with weights the shares of structures and of equipment in total gross investment of each industry each year.

p: Price index of sales (1973=100). Constructed from the implicit deflator for GDP at constant market prices. Source: Bank of Greece (1984).

π: Inflation rate constructed using the price index p.

δ: Depreciation rate. Defined as the weighted average of the depreciation rates used in the National Accounts of Greece for structures (0.02) and equipment (0.067), with weights the shares of structures and equipment in total gross investment of each industry each year.

i: Net of taxes nominal interest rate. Defined as an average return of an investment of one drachma in the beginning of the period in government long term bonds in W. Germany and Switzerland plus a constant risk premium converted to Greek currency at the end of the period, i.e.

$$1+i = \frac{1}{2} \sum_{j=1,2} (1+yd_j) \frac{e_{jt}}{e_{jt+1}},$$

The individual components of the variable are defined as follows:

yd_j: Long nominal rates net of tax in W. Germany and Switzerland. Taken as four points and three points respectively above the equivalent long government bond yields in W. Germany and Switzerland. Source: IMF International Financial Statistics, various issues.

e_{jt}: Exchange rates (foreign over domestic currency) in the beginning of the period for the DM and SF. Defined as the average exchange rates for Dec. of the previous period and Jan. of the current period for DM and SF. Source: Monthly Statistical Bulletin, Bank of Greece, various issues. From Jan. 1981 the definition of the reported exchange rate series of the Bank of Greece changed somewhat. Thus, in the above formula for 1980 we used in the denominator, *ex.* $rate_{it+1}$, only the rates of Dec. 1980 and in the nominator of 1981, only the rates of Jan. 1981.

τ_r: Tax rate on retentions. See Appendix A.

Δ: Present value of depreciation allowances for one monetary unit worth of investment. As was mentioned in Appendix A, the legal rate for depreciation allowances differed for equipment and structures and for each shift that these were used. Only straight line depreciation was allowed up to 100% of the historic cost of capital. Using the discount rate and tax rate mentioned above and the different depreciation rates and implied number of years to complete 100% of the depreciation in a present value formula, we can find six different Δ's corresponding to three different shifts per day and two categories of capital, i.e. structures and equipment. These were combined in a weighted average sum, using for weights the information provided by the Bank of Greece sample on the percentage of time (hours) per shift that each industry operated (averaged for each industry over the whole period of our sample).

Instruments

The estimation of the model in (3) amended with 14 industry dummies reported in the text required strictly exogenous instruments due to the presence of regressors depending on current or past values of the predetermined variables K, PRO and lagged I. The instruments used were the following:

$\Delta ln(S)$, $\Delta ln(S)_{-1}$, $ln(S)_{-1}$, $\Delta ln(c/p)_{-1}$, $\Delta ln(PMA)_{-1}$, $\Delta ln(V)$, $\Delta ln(V)_{-1}$ and $ln(V)_{-1}$.

V is a profitability variable constructed to exclude all the factors entering in PRO that are affected in theory by the past investment decisions of the firm. In particular if A are the salaries of the administrative staff plus selling costs minus income from other sources (all assumed to be unrelated with past or current investment), V is defined as follows:

$$V = (pS - (wL + \mathrm{vM}) \frac{pS}{pQ} - A) / p$$

Thus, V excluding A is what the gross operating surplus of the firm would have been if all goods sold were produced by the firm in the current period.

Diagram 6.1

Value Added in Manufacturing at 1970 prices. Index (1973 = 1.0).
Sources: Bank of Greece (1984), table 2, p.184
and OECD "Economic Surveys: Greece 1989/1990", table B, p.113.

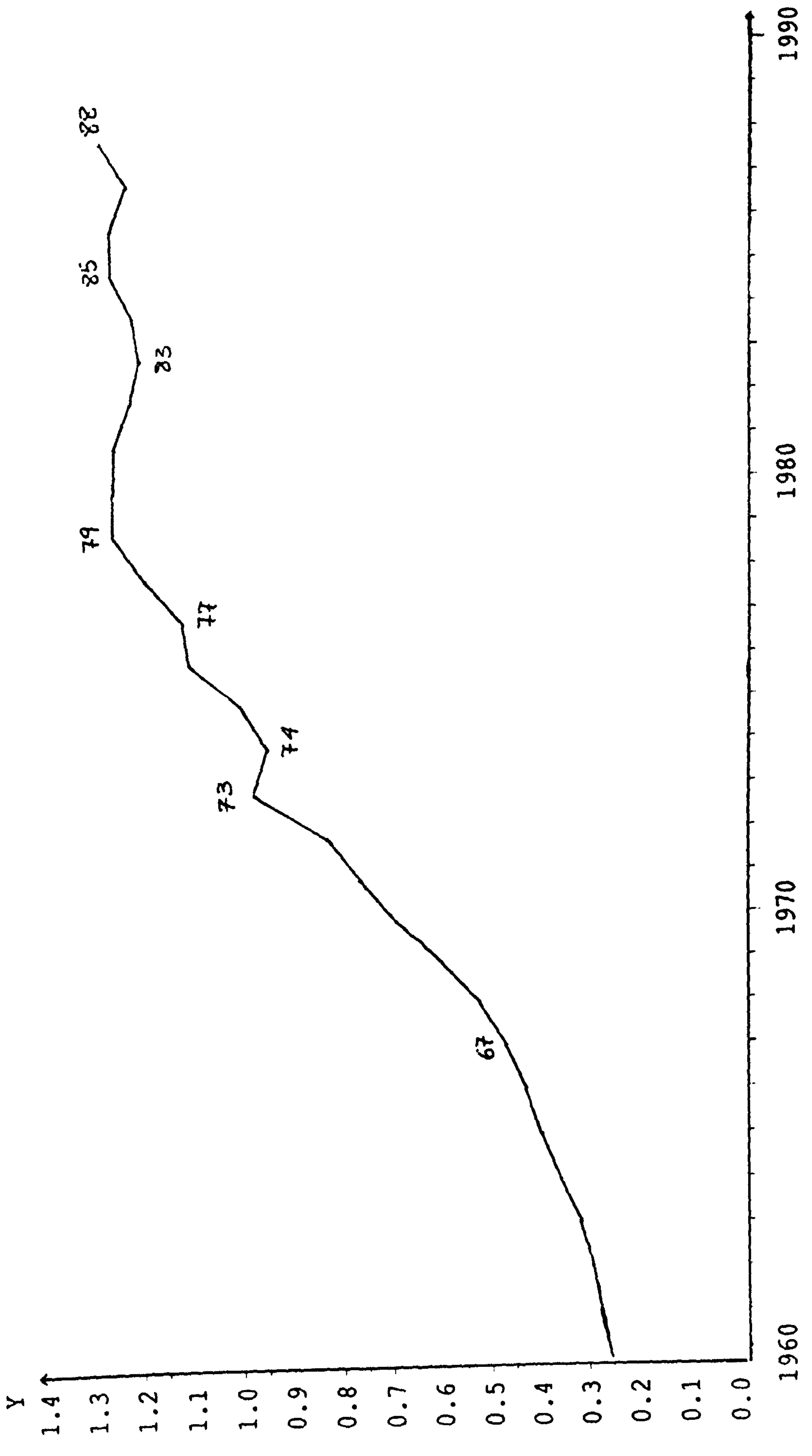


Diagram 6.2

Gross Domestic Fixed Capital Formation in Manufacturing
at 1973 prices. Index (1973 = 1.0).
Sources: Bank of Greece (1984), table 5, p.197
and OECD "Economic Surveys: Greece 1989/1990", table C, p.114.

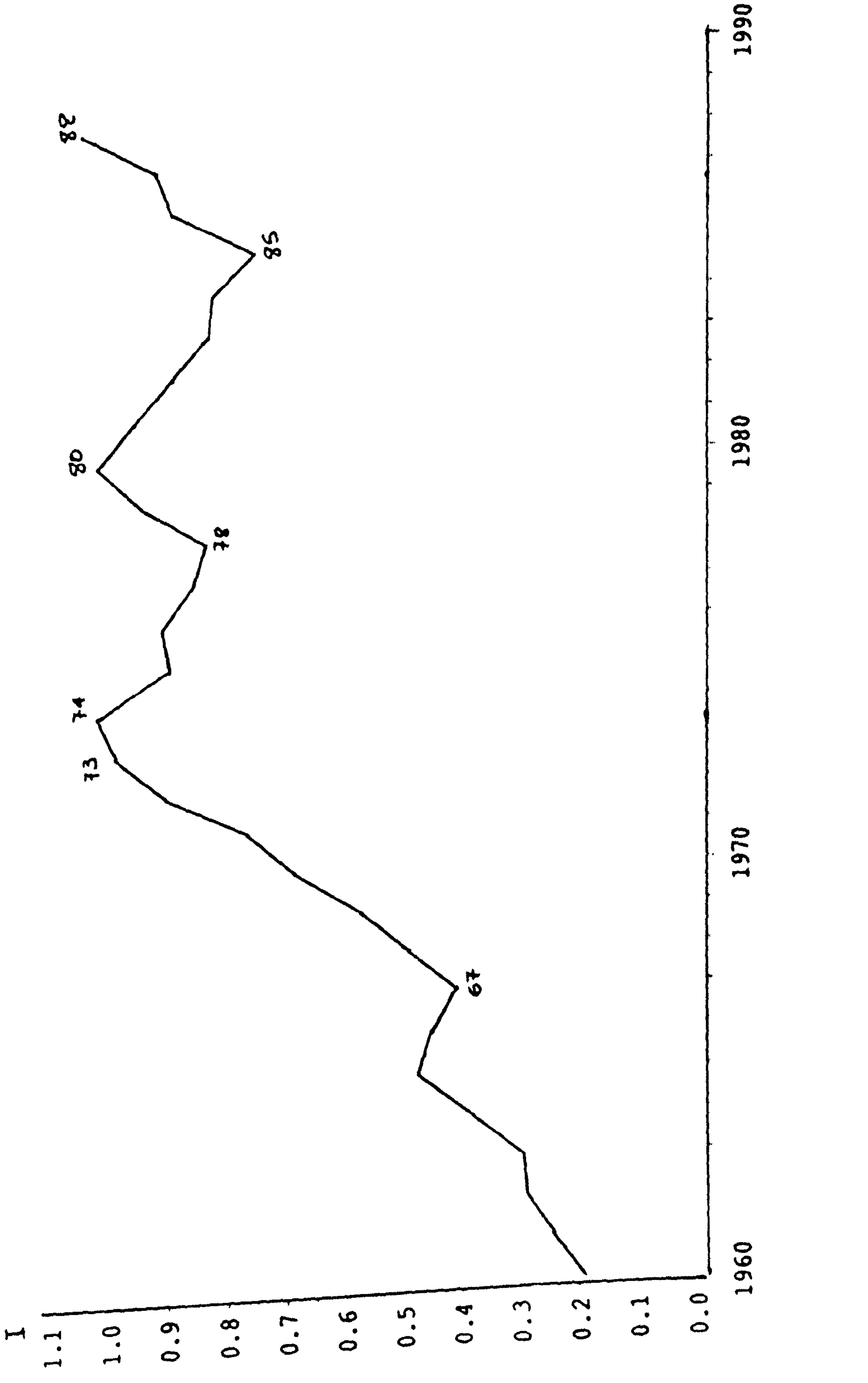
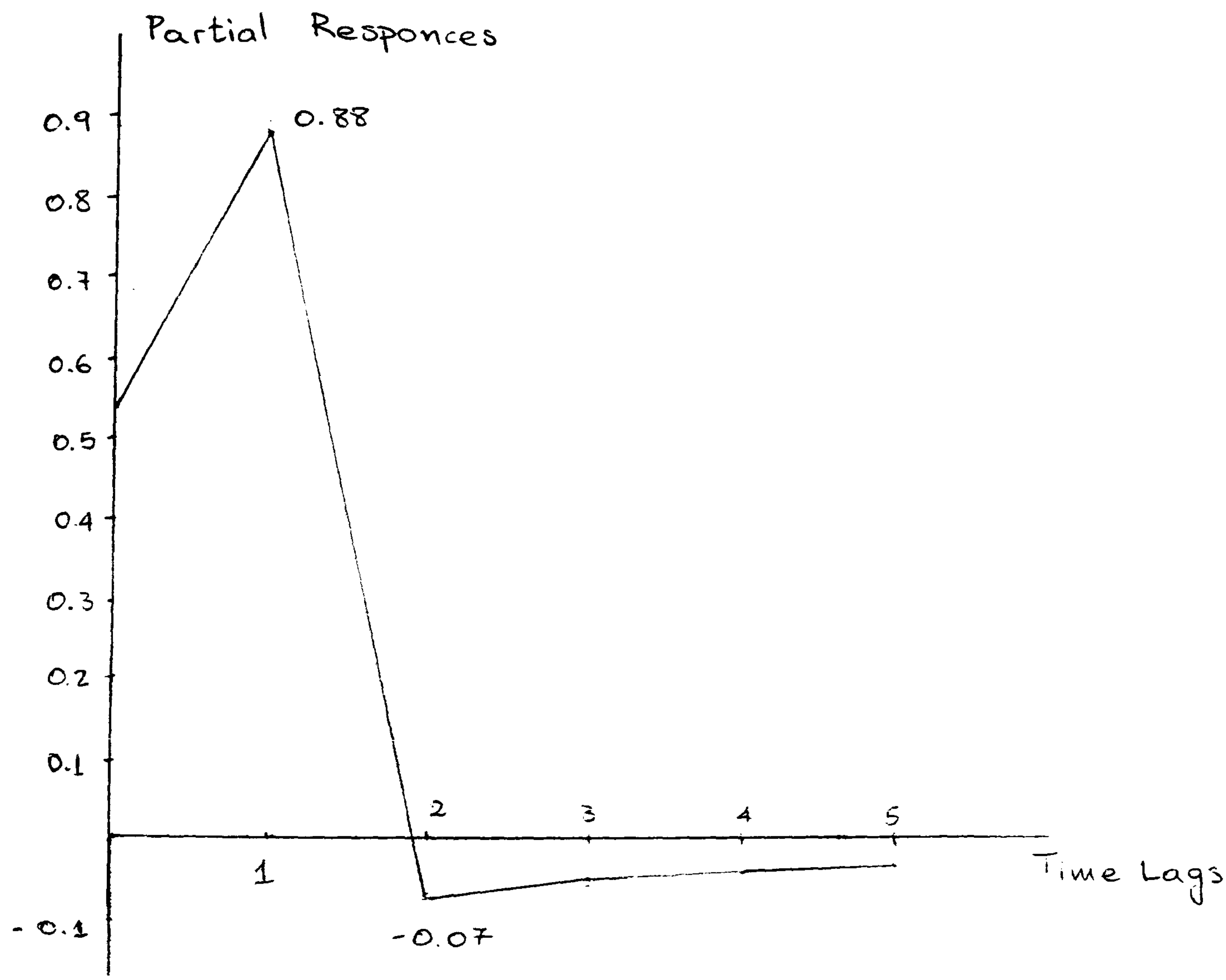


Diagram 6.3

Partial Percentage Responces of Investment to 1% change in Sales.
Source: Column (4) in table 6.3.



Chapter 7

CONCLUSIONS

The methodology and the assumptions used in this thesis do not differ radically from that of the standard neoclassical investment micro-models. The main new elements in our model were the rising flow costs or constraints that the owners were assumed to face when self-financing investment, the agency costs of debt that rise with the ratio of outside to inside finance and the increasing costs in raising flow equity finance from agents so far not involved in the inside operations of the firm because of adverse selection and signaling problems. On the strength of these assumptions we have derived an investment model where adjustment costs are of a financial nature. This means that a firm's investment path depends on its past and current performance and consequently also its current financial position. The relevance of this for the propagation of shocks is clear. In the introduction we also indicated how we believe this approach fits in a more general framework of examining questions of distribution and economic fluctuations in a decentralized system.

Our formal model is still not completely founded on generally accepted first principles[1] and at various junctures we pursued what seemed to us more relevant aspects of the problem, having implicitly in mind the context in Greece, and we have therefore disregarded others. One notable point in case is our disregard of managerial capitalism and how this could fit in our framework.[2] These points can only be left to future extensions. Rather than presenting here, however, a list of results and a much longer one of omissions, we prefer to draw attention to some specific points

[1] For instance, though the intuition behind the costs of self-finance we believe to be sound, their formalization is rather ad hoc.

[2] This partly also reflected our wish to stay out of the "dividend puzzle" controversy, which we find of no central relevance to our theme.

raised but not pursued in the thesis that may also be of interest for future research.

First, in section 3.4 we briefly considered in a diagrammatic analysis a model where financial adjustment costs co-exist with dismantling costs and each is relevant for certain ranges of values of capital stock and equity accumulation. We consider this - or equivalently the irreversibility of capital stock investments - to be a relevant feature of the world.[3] As was seen in 3.4, this implied an asymmetry between the investment and the dis-investment process with possible implications for an asymmetry in expansionary and contractionary policies. Further, we found that there might be circumstances where both costs are at play and a firm could be over-leveraged and under pressure to disinvest when in fact its stock of capital is below its long run optimal level. The case is relevant for Greece (and possibly other economies), for it was this kind of firm that the "Organization for the Rehabilitation of Firms", referred to in 6.1, was officially meant to discover and support. The theoretical micro-framework for such cases is largely missing, mainly because of the view that financial structure is either irrelevant or path dependent,[4] and thus no well defined long run optimum exists against which to compare over-leverage. In our model these firms eventually return to a growth path and to the same long run optimum, but the issue of over-leverage would be more important, one suspects, in a situation where the capital stock is path dependent. Such could be the case when market shares and technological advantages are permanently lost, if not defended.

From our examination of the equity market there are two issues worth pointing out. The first is the emphasis on the *thinness* of the stock market, which has to do with the price elasticity of the *flow* demand for shares of a single firm. Much of the literature on the equity market and investment is exclusively concerned with the question of whether and how far stock market prices reflect the "fundamentals".[5] As far as financing is concerned, however, it is of little use to the firm and the insiders if share prices to start with are not far off their "fundamental" value, but collapse every time there is a significant primary or secondary offering. Interestingly enough, we found

[3] See Nickell (1978), ch. 4 and ch. 6.

[4] See for instance the pecking order theory.

[5] See Fisher and Merton (1984).

that the same issue is of relevance to the Q investment approach. Further, Majluf and Myers' (1984) argument, referred to in 2.4, suggests that this inelasticity may even be a feature of large and competitive share markets, due to the underlying informational problems. Thus, the equity market may not be an important source of finance even in such economies. The literature provides some evidence to support this claim.[6]

The second point on the equity market is also relevant in this respect. In a world where only a core of shareholders has access to inside operations and formulates the policies of the firm, what matters are the share transactions between this core of shareholders and the outsiders. This is both true for the financial functions of the equity market and for the informational content of the stock market prices, as was argued. Thus, active trading among outsiders may be of little relevance to investment. Further, data on flotations of new equity is uninformative if nothing is known about the buyers and, most importantly, about *secondary* distributions by the insiders.

A number of other points have been raised in chapters 5 and 6, which we will not repeat here. We conclude with a note about policy. Policy issues have hardly received any attention, partly because a partial equilibrium model is not the most appropriate framework for this. The credit policy message that seems nevertheless to follow from this thesis is that it makes little sense to think in terms of general credit expansion for the economy as a whole or the sector of interest. The underlying problem is the inability of outsiders to distinguish between good and bad investments. As a consequence they may use criteria that misallocate resources. A general credit expansion may help little in this case and, as the case of Greece may serve to demonstrate, financial structures created in an environment of indiscriminate easy money may prove ex post inflexible and difficult to dismantle. As a long list of authors have pointed out, information is at the center of these problems.[7] But more than that, we would wish to argue that thinking about the role of alternative institutional arrangements (modes of production) in the context of information asymmetries and most of all in the context of control[8] over decisions may prove rewarding.

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[6] See Mayer (1988).
[7] See Zephirin (1990).
[8] See Grossman and Hart (1986).

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